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Financial Education or Incentivizing Learning-by-Doing? Evidence from an RCT with Undergraduate Students

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Financial Education or Incentivizing Learning-by-Doing? Evidence from an RCT with Undergraduate Students

Abstract

We study the effects of digital financial education interventions on undergraduate students' financial knowledge in a small-scale RCT. We test the substitutability or complementarity of two treatments: an online video financial education treatment and an incentive-based approach where students are issued pre-paid voucher cards worth 50 EUR to register with a broker specializing in robo-advised investment in Exchange Traded Funds (ETFs). Three months after the intervention, the video treatment enhanced financial knowledge scores by more than 0.5 standard deviations. Conversely, the vouchers showed no effect. The findings suggest that subsidies encouraging robo-advised investment into ETFs cannot substitute direct financial education in our setting, and there is no evidence for complementarity between these interventions.

JEL-Codes: G530.

Keywords: digital intervention, financial literacy, Financial knowledge, financial education, robo-advisor, ETFs.

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Conflicts of interest: none.

1 Introduction

Financial education has become an important policy tool to foster financial literacy and financial decision-making (Lusardi and Mitchell 2014, 2023). While the evidence regarding traditional classroom-based financial education suggests positive treatment effects on financial knowledge and behaviors, on average (Kaiser et al. 2022), a recent wave of studies has begun to explore the potential of digital financial education interventions as a complement to other forms of financial education delivery (Kaiser and Lusardi 2024). Digital interventions may be seen as especially promising, because low marginal costs per participant potentially allow for easier scalability and broader outreach without necessarily decreasing quality (Attanasio et al. 2019, Escueta et al. 2020).

To study the effectiveness of digital interventions, we conduct a field experiment with undergraduate students in Germany and randomly allocate them into one of four conditions (i) video-based financial education, (ii) receiving a voucher worth 50 EUR for an online broker specializing in robo-advised trading of exchange traded funds (ETFs), (iii) receiving both the video-based financial education intervention and the voucher, and (iv) a pure control group.

Our main hypothesis expects positive effects of the financial education intervention as well as complementarity of financial education and robo-advice due to the following reasons: First, previous research has shown that even brief online interventions can increase financial knowledge (Kaiser et al. 2022). Second, research shows that financial literacy and financial advice may be seen as a complement rather than a substitute (e.g., Calcagno and Monticone 2015, Litterscheidt and Streich 2020). Third, receiving 50 EUR as a windfall investment could serve as an important “teachable moment” (Miller et al. 2015, Kaiser and Menkhoff 2017, Zia 2023) allowing students to apply their newly gained knowledge to a real-world investment decision. Additionally, robo-advice may serve as a learning opportunity since clients may learn by imitating the allocation decisions by the robo-advisor, i.e., “learning-by-doing” (Chak et al.

2022, Hao et al. 2022, D’Acunto and Rossi 2023). The last two mechanisms could lead to increased information seeking and engagement outside the experiment, in turn raising financial knowledge.

Our results based on a reduced form analysis (i.e., the causal effects of being assigned to one of these experimental conditions) are unambiguous: Immediately after the course, the video-based financial education treatment increases financial knowledge, measured via the “Big Three” financial literacy test questions (Lusardi and Mitchell 2014), by about 0.3 standard deviation units relative to the pure control group average. This result is driven by an increased understanding of the concept of risk diversification. Three months after treatment, the treatment effect of the video-based financial education treatment persists and extends to a broader financial knowledge scale measuring both basic and advanced financial literacy (van Rooij et al. 2011). We find a very large effect of the video-based financial education program of about 0.5 to 0.6 SD units on this measure of financial knowledge with treatment effects being mainly driven effects on questions related to investing. The treatment effect of receiving both the video-based financial education intervention and the voucher is similar in magnitude and one cannot reject equality of coefficients of the combined intervention and financial education alone. In contrast, we find zero effects of only receiving the voucher.

In summary, we find that the provision of the robo-advisor vouchers is neither a substitute nor a complement for financial education in our setting. This result may be explained by high compliance with the video-based treatment and low utilization of the subsidy for the robo-advised ETF trading platform: Three months after the intervention, only 12.4 percent of the issued vouchers were redeemed even though there were no extra costs attached to opening the portfolio and maintaining the portfolio for the first year. This suggests that students in our sample were reluctant to invest in capital markets even if offered an initial investment of 50 EUR with the possibility to sell the investment at any time. In a broader sense, this result

suggests that financial knowledge may not easily be obtained by experience but may instead require formal financial education.

We contribute to two strands of literature. First, we contribute to the literature on effective financial education interventions and the importance of delivery approaches in explaining the heterogeneity in treatment effects of interventions (see Kaiser et al. 2022 and Zia 2023 for reviews). Recent studies have studied the importance of content (e.g., Drexler et al. 2014, Carpena et al. 2017), pedagogy (e.g., Abel et al. 2020, Batty et al. 2020, Kaiser and Menkhoff 2022, Kalmi and Rahko 2022), media (e.g., Berg and Zia 2017, Lusardi et al. 2017, Angel 2018, Rodriguez-Raga and Martinez-Camelo 2022, Frisancho et al. 2023) and delivery format (Attanasio et al. 2019, Brugiavini et al. 2020, Sconti 2022, Agasisti et al. 2023, Billari et al. 2023). We show that a low-intensity video-based online intervention can produce a large effect on financial knowledge of undergraduate students that persists three months after the intervention.

With this result, we also contribute to the limited amount of RCT evidence on effective financial education for the target group of *university students*: Choi et al. (2011) conducted an RCT with MBA students from Wharton and college students at Harvard University to study the causal effects of brief information interventions on investment decisions in choice tasks on investment in S&P 500 index funds. They found that, MBA students responded slightly better to information treatments compared to university students, yet both groups continued to prioritize irrelevant performance metrics over cost-efficiency which underscores low financial literacy and persistence of suboptimal investment behaviors, even among highly educated individuals. Skimmyhorn et al. (2016) study the effect of two different curricula (rules of thumb and principles based) in a field experiment of with highly educated undergraduate students at the United States Military Academy at West Point. Both curricula are implemented in in-person classroom sessions with. Treatment effects for both treatment versions range from 0.2 to 0.6

SD units, thus comparable to the magnitudes of statistical effect sizes in our study but with a much higher total intensity of 8 hours spread over an entire semester. Brugiavini et al. (2020) study the effects of a 20-minute video on the financial knowledge of Italian university students. They find an increase in financial knowledge of about 0.3 SD immediately after the intervention with no data on longer-term outcomes. While our video-based intervention appears to generate larger treatment effects on knowledge, it is also substantially longer (90 minutes) yielding support for the hypothesis of a non-linear relationship of intensity of interventions with the effect size as shown in Kaiser and Menkhoff (2020).

Second, we contribute to the nascent literature studying the complementarity of financial education with access to finance interventions. The available evidence from developing economies suggests limited complementarities of financial education and access to finance treatments (e.g., bank accounts and savings accounts) (Cole et al. 2011, Abarcar et al. 2020, Horn et al. 2022). In line with these findings from developing country settings, we find no evidence for complementarities of our interventions in a high-income country setting.

Additionally, we also find that subsidies for the robo-advised ETF investment platform cannot serve as a substitute for financial education when the goal is to create human capital in the domain of financial decision making of students. This contrasts with Hao et al. (2022) who find some evidence of learning from robo-advice and behaving differently in unsupervised accounts but is in line with evidence in Chak et al. (2022) who also do not find evidence of learning after exposure to robo-advice.

2 Experimental design

2.1 Setting and random assignment

The experiment is conducted with 189 students enrolled in a large introductory undergraduate class teaching the fundamentals of microeconomics at the University of

Kaiserslautern-Landau in the South-West of Germany. We conducted the study in the Winter term of 2022/2023. The students enrolled in this class do not study economics as their major but are enrolled in a variety of programs such as environmental science, psychology, teacher training, and interdisciplinary study programs. Students were told they could participate in an online study about personal finance, and they'd earn extra class credits as well as having the chance of winning a voucher worth EUR 50. Students could register for the study until November 2nd, 2022 (see timeline in Table 1).

< Table 1 about here >

We first randomly assigned one third of the baseline sample to receive the video-based financial education program (see section 2.2) and two thirds of the sample into pure control (see table S1 in the online appendix). The video-based financial education program was offered between November 16th, 2022, and November 22nd, 2022. Next, we conducted midline surveys from November 28th, 2022, until December 2nd, 2022. After completing the midline survey, we randomly allocated 50 percent of the entire sample of students to receive the ETF voucher treatment. The other 50 percent received a consolation prize consisting of an inexpensive ball-pen and chocolate. The ETF voucher and consolation prize were handed to students right after completing the midline survey in class. Finally, we conducted an endline survey between February 13th, 2023, and February 19th, 2023, i.e., about three months after the initial financial education treatment. There is no attrition from baseline to the midline survey but 33 out of 189 students did not respond to the endline survey, i.e., an attrition rate of about 17.5 percent. We probe post attrition balance in section 3.1 and study the determinants of attrition in the appendix with no evidence for compromises in internal validity of the experiment.

2.2 Description of interventions

Video-based financial education treatment (Treatment #1). The financial education treatment is comprised of publicly available videos on YouTube provided by the German non-profit foundation “Finanztip” and the private educational platforms “Finanzfluss” and “Finance fellows”, i.e., initiatives with the goal to foster financial literacy in Germany. The video collection covers a wide range of basic financial concepts, such as inflation, compound interest, or financial budgeting, each addressed through engaging video content. Additionally, all respondents had to pass a short multiple-choice test with one to three questions per video to ensure that the videos were indeed watched by treated individuals. The average time treated individuals spent on watching the videos and answering the questions is 89.3 minutes.

< Table 2 about here >

Table 1 lists the topics of the eight videos as well as the respective time length in minutes (in parentheses) and describes their content.

Robo-advisor voucher treatment (Treatment #2). The second treatment is a physical pre-paid voucher for an online robo-advisor offering ETF investment (Ben-David et al. 2017, Lettau and Madhavan 2018) via a smartphone app (see Figure 1).

< Figure 1 about here >

Qurion AG is a large digital asset manager in Germany, and the vouchers are available in German supermarkets and online. There is no minimum deposit, and the app offers passive investments into classical and sustainable funds, individualized investment advice, continuous risk management, regular rebalancing of the portfolio and unlimited change in investment strategies. There is no service charge in the first year for portfolios of up to 10,000 EUR and investors pay 0.48 percent per year in subsequent years. Thus, the voucher is effectively a subsidy for the entire second year service charge for an investment of 10,000 EUR.

3 Data and methods

3.1 Randomization balance

Table 3 lists means of key demographic characteristics for the three treatment arms as well as for the control group at midline which are not discussed for brevity. T-tests for equality of means indicate that proportions do not differ, on average, with any imbalances being what can be expected by chance. Reassuringly, tests of joint orthogonality confirm that the randomization worked well.

<Table 3 about here>

3.2 Measuring financial knowledge

To measure our main outcome (financial knowledge), we implement a broad set of items commonly used in the literature (van Rooij et al. 2011) (see Appendix Table S3). The administered measurement scale includes all “Big Three” test items (Lusardi and Mitchell 2014, Items No. 1, 3, 15), five “basic financial literacy items” (van Rooij et al. 2011, Items No. 1, 2, 3, 4, 5) and 11 “advanced financial literacy items” (van Rooij et al. 2011, Items No. 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16). Additionally, we included a question focused on measuring knowledge about ETFs (Item No. 17). We analyzed the psychometric properties of the measurement scale using both classical test theory and an item response theory (IRT) framework. We removed one item with insufficient discriminatory power and extreme difficulty parameters from the itemset (see Table S3 in the Appendix for details). Consequently, the final itemset and aggregate scale consists of 16 test items. Scale reliability is high and the scale includes items covering a broad range of difficulty levels with adequate discrimination. To extract individual financial knowledge levels, we estimate latent ability scores (Empirical Bayes Estimator) for each participant within an IRT framework: We estimate scores in a one-parameter logistic model for analyses relying on the basic test items and on two-parameter logistic models in all other analyses (Big Three, Advanced, and Aggregate Scale) (see Cai et al. 2016 for an introduction to IRT models).

3.3 Regression models

To study the impact of the described treatments on participants' financial literacy levels we compare the three treatment groups (T1 = Financial Education only, T2 = Voucher only, and T3 = Financial Education *and* Voucher) to the pure control group (C) at the time of the follow-up surveys. Since we randomized selection into the different treatment arms at the individual level, we can estimate unbiased intention-to-treat-effects (ITT) within a simple OLS framework. As shown in section 2.2 (Table 2), a randomly selected group of participants received the financial education treatment (T1) in the first phase of the study. Thus, we specify the following regression model to estimate the short-term treatment effect on financial knowledge:

$$y_i^{FL_{mid}} = \alpha_0 + \beta_1 T1_i + \mu_i \quad (1),$$

where $y_i^{FL_{mid}}$ denotes the financial knowledge score at midline by participant i extracted from the IRT model (see section 3.2 for details). The constant $\hat{\alpha}_0$ denotes the mean of $y_i^{FL_{mid}}$ in the control group. $T1_i$ is a binary treatment indicator that takes the value 1 if participant i was randomly selected into the video-based financial education treatment, 0 otherwise. Thus, $\hat{\beta}_1$ captures the intention to treat effect of being assigned to the video-based program. μ_i denotes the error term.

To evaluate the causal effects in phase 2 (see Table 2), where a randomly selected group of participants was exposed to the ETF voucher treatment (T2) or both the voucher and the video-based treatment (T3), we estimate the following equation:

$$y_i^{FL_{end}} = \gamma_0 + \delta_1 T1_i + \delta_2 T2_i + \delta_3 T3 + \varepsilon_i \quad (2),$$

which allows us to estimate the intention to treat effects of the two treatments separately ($\hat{\delta}_1$ and $\hat{\delta}_2$) as well as the ITT effect of receiving both treatments ($\hat{\delta}_3$) at endline. ε_i denotes the error

term. We report heteroscedasticity robust standard errors (HC3) and resulting 95 percent confidence intervals in all regression tables.

4 Results

4.1 Immediate treatment effects

We begin by assessing the effect of the video-based financial education treatment (T1) in the first phase, on a financial knowledge index based on the Big Three, and on the probability to answer each individual item correctly. As shown in table 4, our data suggests that the financial education treatment seems to improve financial knowledge right after treatment. Individuals who received the treatment show a noticeable increase in the Big Three Index by 0.29 standard deviation units relative to control, which is significant at the 5-percent-level (column 1). By checking whether the short-term effect also applies separately for the three single questions, we find that the effect on the combined measure in column (1) is mainly driven by the question on risk diversification (see columns 2-4).

<Table 4 about here>

4.2 Treatment effects after three months

Turning to impact of the program in the second phase, we investigate the effects of the financial education treatment (T1), the ETF voucher treatment (T2), as well as the effect of the combined treatment (T3) on financial knowledge levels at endline. For that purpose, we construct four different outcome measures: (1) The Big Three Index (Lusardi and Mitchell 2014), (2) the Basic FL index (consisting of five items as proposed by van Rooij et al. (2011)), (3) Advanced FL index (consisting of eight items, see van Rooij et al. (2011)), and (4) an aggregated index (consisting of the entire itemset, see section 3.2).

<Table 5 about here>

Table 5 presents effects of the three treatment arms on all four outcomes. While we do not find any effects on the Big Three Index as well as on the Basic FL Index three months after treatment (columns 1 and 2), the video-based treatment (T1) appears to affect advanced and aggregate financial literacy levels (columns 3 and 4) by a substantial magnitude of 0.47 and 0.57 SD units, respectively. While the treatment effect of the combined intervention (T3) is estimated to be larger than the video-based treatment alone, one cannot reject equality of coefficients. The voucher alone (T2) does not have an effect on any outcome. Thus, we find neither evidence of complementarity nor substitutability of financial education and the vouchers.

Next, we turn to an investigation of the treatment effects on single test questions.

< Table 6 about here >

In line with the short-term result on the knowledge of diversification and the contents of the video-based financial education intervention, treatment effects appear to be entirely driven by concepts relevant to investing (see Columns 7, 8, 10, 14 of Table 6).

4.2 Reflections on cost-effectiveness

The finding that the relatively brief and low-cost video-based intervention produces large effects on financial knowledge, motivates to reflect on the costs. Kaiser et al. (2022) provide cost estimates for field experiments studying diverse financial education interventions. The average intensity of these interventions is about 11 hours, on average and the overall cost-effectiveness ratio is about \$60 (2019 US-Dollars) per participant per 0.2 SD improvement in outcomes, i.e., an effect of 0.6 SD would be associated with an average cost of about 180\$ per student. As the video-based course was a collection of curated videos freely available online, the fixed cost for the “design” of the course was minimal and marginal costs to deliver the link to the video-collection to more students is near zero. Thus, the cost of the video-based intervention mainly comes down to the opportunity cost of time for students which will be

quite heterogeneous. Anecdotally, we do not find evidence of students enrolled in the experiment performing worse on the final exam of the microeconomics course, indicating that the treatment effects of financial knowledge do not come at the expense of learning in the core course limiting concerns about the opportunity costs of being exposed to the video-based intervention. As some of the concepts learned may even be useful for other coursework, the true opportunity cost (trading off against studying for other classes or leisure) may be even lower.

4.3 Reflections on external validity

Since our experiment is conducted with a small sample at a single University, it is important to spell out the potential limitations to the external validity of our results. We rely on the SANS (selection, attrition, naturalness, and scaling) framework by List (2020).

Selection. Regarding selection it is important to note that our experiment is conducted in medium-sized university in Germany with non-elite students (students self-report a “C” grade in math on average). Students in the principles of microeconomics class could volunteer to participate in the study and we randomized the interventions within the sample of students willing to participate in the study. Thus, the effects are likely much smaller if the intervention was rolled-out in the broader sample of students not interested in extra class-credit.

Attrition. There is no attrition from baseline to the midline survey but 33 out of 189 students did not respond to the endline survey, i.e., an attrition rate of about 17.5 percent. We probe post attrition balance in section 3.1 and study the determinants of attrition in the appendix with no evidence for compromises in internal validity of the experiment. Thus, the internal validity of the experiment is unlikely to be compromised and the composition of the post-attrition sample mirrors the baseline sample, indicating results are generalizable for the students enrolled at baseline.

Naturalness. The video-based intervention was delivered via the usual channels and platforms students were already familiar with, so the intervention was implemented very close to how the video-based course could be implemented if the intervention was scaled to more classes or universities.

Scaling. While the intervention is low-cost and in principle easily scalable, we expect treatment effects to be smaller if implemented at a larger scale. First, by design, we achieve perfect take-up and compliance with the video-based treatment. Students were told only to be eligible for class-credit if they completed the entire video-based course and passed exam questions related to the videos. Thus, the intention to treat effects (ITT) reported in this paper are identical to the treatment effect on the treated (TOT) for the video-based treatment arm. Thus, if the program was rolled out with incentivization, we expect lower take-up (and attention) and ITT effects will likely be smaller. Unfortunately, the design of the experiment did not allow for individual-level data on take-up of the ETF voucher. Yet, we know that only 12.4 percent of the vouchers (12 out of 97) have been redeemed when considering the aggregate number of vouchers in T2 and T3. Imposing the strong assumption of the financial education treatment not increasing voucher take-up (i.e., voucher take-up rates being equal in T2 and T3), one may scale the estimated ITT effect by the take-up of vouchers: the local average treatment effect (LATE) of using the ETF voucher alone (T2) is defined as the ITT coefficient divided by 0.124. Thus, the estimated LATE for T2 may be about 0.14 SD for the voucher for the aggregate FK index but since this is estimated with large standard errors (and the ETF voucher is high-cost), the finding that of higher (cost-)effectiveness of the video-based intervention would likely hold even if take-up rates would be much lower for the video-based treatment if operated at scale.

5 Discussion

This paper reported evidence from a pilot field experiment with German undergraduate students, showing that a brief video-based treatment can improve advanced and aggregate financial knowledge levels. After three months, the video intervention did not affect the Big Three Index or the Basic FL Index, which are widely used measures of financial literacy in the literature. This may indicate that the video content was more relevant or engaging for the topics covered by the advanced and aggregate indices, such as risk diversification. Alternatively, it may reflect a ceiling effect, as the baseline levels of the Big Three and Basic FL indices were relatively high among our sample.

Another finding is that the provision of a voucher for robo advice did not affect financial knowledge, either alone or in combination with the video treatment, i.e., we find no evidence of complementarity or substitutability between the two interventions. This could imply that the voucher was not appealing or salient enough to induce students to learn more about ETFs or other financial products. Further research is needed to explore the potential of robo advice and other fintech innovations to promote financial knowledge. Our study has several limitations: First, it is based on a small and non-representative sample of undergraduate students, who may have different characteristics and preferences than the general population. Thus, the treatment effects are likely different from those if this intervention was operated at scale. Second, it has a short follow-up period of three months, which may not capture the long-term effects of the treatments on financial knowledge.

Digital financial education has been discussed as a potentially promising intervention in prior literature, due to the low costs and high scalability of online platforms. Our findings suggest possible ways to improve financial education programs for younger individuals, such as using videos that cover relevant and engaging topics. However, more evidence is needed to assess the effectiveness and cost-benefit of different types of digital financial education, as well as the optimal design and delivery of such interventions. Future work could look at the

relative effectiveness of other digital interventions such as stock market simulations and other interventions able to induce experiential learning for undergraduate students in RCTs at a larger scale.

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Table 1: Timeline

Time	Event
2022/10/26 – 2022/11/02	Baseline Administrative Data & Randomization into Fin. Ed. Intervention (T1) vs. Control (C)
2022/11/16 – 2022/11/22	Fin. Ed. Intervention (T1)
2022/11/28 – 2022/12/02	Midline Survey and T2: Voucher Treatment (T2)
2023/02/13 – 2023/02/19	Endline survey

Notes: This table shows the timeline of the experiment.

Table 2: Video-based financial education treatment

Financial Budgeting (10:59)	This video emphasizes the importance of creating and maintaining a household budget, with practical advice on tracking income and expenses. It provides insights into effective budgeting strategies and its role in achieving financial goals.
Financial Planning (14:12)	This part of the course covers basic concepts of financial planning by emphasizing the need for setting short-term as well as long-term financial goals. The video guides viewers through steps for creating a budget book that potentially aligns with their aspirations.
Compound Interest (10:02)	The video on compound interest breaks down the mechanics of this financial concept. Through real-world examples, viewers gain a basic understanding of how compound interest can work for or against them over time.
Inflation (9:51)	This part covers the effect of price inflation on purchasing power and long-term financial planning. The video educates respondents on strategies to mitigate the effects of inflation and to make sound financial decisions in times of rising prices.
Investing (9:46)	The video covers fundamental principles of investing, risk tolerance, and different investment technologies. In addition, viewers are encouraged to explore various investment opportunities before deciding.
Borrowing (9:53)	The video discusses various types of credit, such as loans and credit cards, providing insights into interest rates, repayment terms, and the implications of debt. It further discusses various types of credit available to consumers in Germany.
Exchange-Traded Funds (9:05)	Treated individuals learn about the benefits, risks, and considerations when incorporating ETFs into their investment portfolio. The expected returns of investing in ETFs is underpinned by time series data.
Insurance (11:30)	This video discusses various types of insurance products as well as the necessity to take out an insurance. Viewers gain insights into basic principles, coverage, and how insurance fits into a comprehensive financial plan.

Note: This table describes the contents (and duration) for each video included in the online treatment.

Figure 1: Voucher treatment



Notes: The figure (translation: “Wealth to go: EUR 50 for your digital investment”) shows the voucher cards as they are sold in retail stores in Germany and as used in the experiment. The vouchers for the robo-advised ETF platform are issued as a physical gift card with a code on the back. Redeeming the code will deposit the pre-paid amount (50 EUR) into the account. After answering questions about their preferences and investment goals, the investors can choose the type of investment strategy at the time of opening the depot when first redeeming the voucher. Copyright by Quirion AG.

Table 3: Descriptive Statistics and Balance

Variable	T1: Fin. Ed. only	T2: ETF voucher only	T3: Both	Control	Equality of means (p-value)
<i>Panel A: Descriptive statistics for the full sample (N = 189)</i>					
Age	22.60 (6.117)	21.31 (2.353)	21.57 (2.255)	21.60 (3.451)	0.468
Female (0/1)	0.560	0.638	0.649	0.74	0.421
Math grade (1-6)	3.200 (1.291)	2.900 (1.284)	2.757 (1.164)	2.731 (1.332)	0.437
Economics grade (1-6)	2.480 (0.963)	2.069 (0.814)	2.324 (0.669)	2.121 (0.755)	0.101
Parent working in fin. services (0/1)	0.000	0.100	0.054	0.089	0.391
Risk attitude (0-10)	4.880 (1.964)	5.400 (2.180)	5.756 (2.139)	4.970 (2.276)	0.254
No. of books scale (1-6)	3.960 (1.485)	4.083 (1.608)	3.432 (1.482)	3.463 (1.521)	0.071
Reading comprehension (1-6)	4.120 (0.666)	4.016 (0.725)	4.216 (0.629)	3.940 (0.600)	0.202
In state student (0/1)	0.639	0.499	0.459	0.478	0.512
<i>Panel B: (Endline estimation sample at midline, N = 156)</i>					
Age	22.45 (6.661)	21.42 (2.351)	21.66 (2.266)	21.53 (3.426)	0.731
Female (0/1)	0.550	0.646	0.625	0.732	0.465
Math grade (1-6)	3.200 (1.322)	2.646 (1.194)	2.781 (1.156)	2.679 (1.295)	0.369
Economics grade (1-6)	2.400 (0.883)	1.936 (0.704)	2.344 (0.701)	2.222 (0.762)	0.043
Parent working in fin. services (0/1)	0.000	0.125	0.063	0.089	0.380
Risk attitude (0-10)	4.850 (2.084)	5.417 (2.122)	5.875 (2.121)	4.946 (2.235)	0.196
No. of books scale (1-6)	4.000 (1.414)	4.167 (1.655)	3.469 (1.565)	3.411 (1.523)	0.059
Reading comprehension (1-6)	4.050 (0.605)	4.063 (0.697)	4.250 (0.622)	3.911 (0.580)	0.118
In state student (0/1)	0.700	0.479	0.469	0.482	0.332

Notes: This table shows descriptive statistics (means and standard deviations in parentheses) for each group at midline for the full sample (Panel A) and the post-attrition sample (Panel B). The final column reports p-value testing equality of means across groups. Joint tests of orthogonality based on an ordered logit model for the full set of covariates result in $p = 0.347$ for the full sample at midline and $p = 0.268$ for the post-attrition sample. All tests are unadjusted for multiple hypothesis testing.

Table 4: Immediate Effect on the Big Three

	(1) Big Three FL index	(2) Item 1: Numeracy	(3) Item 2: Inflation	(4) Item 3: Diversification
Fin. Education (T1)	0.293** (0.138) [0.021, 0.565]	0.034 (0.067) [-0.098, 0.166]	-0.004 (0.060) [-0.122, 0.114]	0.210*** (0.059) [0.095, 0.325]
Mean (SD) of y_t in control group	0.000 (1.000)	0.740	0.8267	0.677
Observations	189	189	189	189

Notes: The dependent variable in Column 1 is financial knowledge measured via the Big Three and estimated via a 2-PL-IRT model. Dependent variables in Columns 2 to 4 are binary items indicating whether the individual Big Three questions were solved correctly. Robust standard errors in parentheses. 95 percent confidence intervals in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Treatment Effects at Endline

	(1) Big Three FK index	(2) Basic FK index	(3) Advanced FK index	(4) Aggregate FK index
Fin. Education (T1)	0.271 (0.223) [-0.170, 0.711]	0.117 (0.242) [-0.361, 0.595]	0.467* (0.253) [-0.033, 0.966]	0.573** (0.288) [0.005, 1.141]
Voucher (T2)	-0.031 (0.212) [-0.450, 0.388]	-0.180 (0.214) [-0.602, 0.242]	0.204 (0.184) [-0.158, 0.567]	0.017 (0.199) [-0.376, 0.410]
Fin. Edu. and Voucher (T3)	0.248 (0.191) [-0.129, 0.625]	0.062 (0.222) [-0.377, 0.501]	0.612*** (0.200) [0.216, 1.008]	0.628*** (0.217) [0.199, 1.057]
$T1 - T2 = 0$ (p-value)	0.213	0.255	0.2904	0.060
$T1 - T3 = 0$ (p-value)	0.920	0.838	0.577	0.857
$T2 - T3 = 0$ (p-value)	0.190	0.319	0.036	0.007
Mean (SD) of y_t in control group	0.000 (1.000)	0.000 (1.000)	0.000 (1.000)	0.000 (1.000)
Observations	156	156	156	156

Notes: The dependent variable in Column 1 is financial knowledge measured via the Big Three and estimated via a 2-PL-IRT model. Column 2 shows results on the Basic Financial Knowledge Index estimated in a 1-PL-IRT model. Column 3 shows results on the Advanced Financial Knowledge Index estimated in a 2-PL-IRT model. Column 4 shows results on the Aggregate Financial Knowledge Index including all items and estimated via 2-PL-IRT. Robust standard errors in parentheses. 95 percent confidence intervals in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Treatment Effects on Single Test Questions

	(1) <i>Numeracy</i>	(2) <i>Compound interest</i>	(3) <i>Inflation</i>	(4) <i>Time value of money</i>	(5) <i>Money illusion</i>	(6) <i>Stock market</i>	(7) <i>Stocks</i>	(8) <i>Mutual funds</i>
Fin. Education (T1)	0.061 (0.087) [-0.110, 0.232]	0.057 (0.126) [-0.192, 0.306]	0.046 (0.100) [-0.151, 0.244]	0.086 (0.135) [-0.182, 0.353]	-0.104 (0.121) [-0.342, 0.135]	-0.014 (0.124) [-0.260, 0.231]	0.118 (0.103) [-0.086, 0.322]	0.232* (0.123) [-0.010, 0.474]
Voucher (T2)	-0.068 (0.080) [-0.226, 0.089]	-0.080 (0.098) [-0.274, 0.113]	0.009 (0.079) [-0.147, 0.165]	-0.048 (0.099) [-0.244, 0.149]	-0.033 (0.082) [-0.195, 0.130]	0.057 (0.087) [-0.116, 0.229]	0.080 (0.083) [-0.084, 0.245]	0.024 (0.100) [-0.174, 0.222]
Fin. Edu. and Voucher (T3)	-0.027 (0.087) [-0.199, 0.145]	0.076 (0.105) [-0.131, 0.283]	0.134* (0.069) [-0.004, 0.272]	0.004 (0.114) [-0.220, 0.229]	-0.116 (0.100) [-0.314, 0.082]	0.067 (0.097) [-0.125, 0.259]	0.205*** (0.075) [0.058, 0.353]	0.263** (0.102) [0.063, 0.464]
$T1 - T2 = 0$ (p-value)	0.171	0.293	0.713	0.335	0.570	0.570	0.713	0.099
$T1 - T3 = 0$ (p-value)	0.384	0.890	0.358	0.585	0.928	0.538	0.358	0.806
$T2 - T3 = 0$ (p-value)	0.660	0.157	0.087	0.656	0.428	0.915	0.087	0.024
Mean of y_t in control group	0.839	0.643	0.804	0.464	0.804	0.714	0.732	0.518
Observations	156	156	156	156	156	156	156	156
	(9) <i>Bonds</i>	(10) <i>Returns</i>	(11) <i>Fluctuations</i>	(12) <i>Diversification</i>	(13) <i>Risk</i>	(14) <i>Diversification</i>	(15) <i>Bonds</i>	(16) <i>ETFs</i>
Fin. Education (T1)	-0.068 (0.135) [-0.335, 0.200]	0.204 (0.131) [-0.053, 0.463]	-0.175 (0.117) [-0.406, 0.056]	0.114 (0.090) [-0.064, 0.292]	-0.057 (0.135) [-0.323, 0.209]	0.261** (0.107) [0.048, 0.473]	0.121 (0.120) [-0.115, 0.358]	0.193 (0.134) [-0.072, 0.458]
Voucher (T2)	-0.060 (0.100) [-0.257, 0.138]	0.054 (0.100) [-0.144, 0.251]	-0.042 (0.071) [-0.182, 0.099]	-0.015 (0.083) [-0.180, 0.150]	-0.003 (0.098) [-0.197, 0.191]	0.182** (0.091) [0.001, 0.362]	0.009 (0.078) [-0.144, 0.162]	-0.149 (0.089) [-0.324, 0.026]
Fin. Edu. and Voucher (T3)	0.076 (0.113) [-0.146, 0.298]	0.335*** (0.101) [0.135, 0.535]	-0.000 (0.075) [-0.149, 0.149]	0.089 (0.082) [-0.073, 0.252]	0.049 (0.109) [-0.167, 0.265]	0.255*** (0.094) [0.068, 0.441]	-0.085 (0.075) [-0.232, 0.062]	-0.013 (0.108) [-0.228, 0.201]
$T1 - T2 = 0$ (p-value)	0.952	0.266	0.272	0.171	0.694	0.450	0.359	0.010
$T1 - T3 = 0$ (p-value)	0.331	0.333	0.159	0.788	0.467	0.954	0.088	0.159
$T2 - T3 = 0$ (p-value)	0.244	0.009	0.610	0.230	0.645	0.423	0.233	0.201
Mean of y_t in control group	0.518	0.446	0.875	0.786	0.607	0.589	0.179	0.357
Observations	156	156	156	156	156	156	156	156

Notes: Results from linear probability models. Robust standard errors in parentheses. 95 percent confidence intervals in brackets. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Supplementary Appendix

(online supplement not intended for publication)

to accompany

Financial Education or Incentivizing Learning-By-Doing?

Evidence from an RCT with Undergraduate Students

(Luis Ojeda and Tim Kaiser)

Table S1: Sample Sizes

	T1: FL course only	T2: ETF voucher only	T3: FL course & ETF voucher	Control	Total
Baseline	62	-	-	127	189
Midline	25	60	37	67	189
Endline	20	48	32	56	156

Note: This table shows the number of observations (individuals) per group and time-point.

Table S2: Determinants of attrition to endline

VARIABLES	(1) Attrition
Fin. Education (T1)	-0.0013 (0.0977)
ETF Voucher (T2)	0.0108 (0.0724)
Fin. Edu. and ETF-Voucher (T3)	-0.0344 (0.0800)
Age	0.000878 (0.00778)
Female (0/1)	-0.0372 (0.0659)
Math grade (1-6)	0.0466* (0.0266)
Economics grade (1-6)	-0.0132 (0.0438)
Parent working in fin. services (0/1)	0.00928 (0.0524)
Risk attitude (0-10)	-0.0762 (0.0801)
No. of books scale (1-6)	-0.00615 (0.0148)
Reading comprehension (1-6)	0.00607 (0.0177)
In state student (0/1)	-0.0160 (0.0562)
Constant	0.0639 (0.290)
Observations	186
R-squared	0.034

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table S3: Psychometric properties of the financial knowledge test items

	Question	% Correct		Coefficient	SE
basic (van Rooij et al. 2011)	1) Numeracy (Big 3)	78.57	Discrimination	1.462	0.538
			Difficulty	-1.445	0.354
	2) Compound interest	29.71	Discrimination	1.217	0.410
			Difficulty	-0.643	0.217
	3) Inflation (Big 3)	83.43	Discrimination	1.250	0.422
			Difficulty	-1.717	0.428
	4) Time value of money	20.86	Discrimination	0.288	0.209
			Difficulty	0.660	0.726
	5) Money illusion	34.57	Discrimination	0.345	0.244
			Difficulty	-3.295	2.282
advanced (van Rooij et al. (2011)	6) Stock market	34.57	Discrimination	0.672	0.287
			Difficulty	-1.805	0.711
	7) Stocks	36.86	Discrimination	1.017	0.349
			Difficulty	-1.638	0.461
	8) Mutual funds	28.00	Discrimination	1.171	0.349
			Difficulty	-0.487	0.196
	9) Bonds 1	22.86	Discrimination	0.440	0.220
			Difficulty	0.028	0.375
	10) Returns	25.71	Discrimination	1.213	0.359
			Difficulty	-0.261	0.174
	11) Fluctuations	38.57	Discrimination	0.466	0.301
			Difficulty	-3.688	2.245
	12) Diversification 1	37.43	Discrimination	1.095	0.376
			Difficulty	-1.642	0.446
	13) Bonds 2s [EXCLUDED in aggregate scale]	8.00	Discrimination	0.030	0.269
			Difficulty	52.783	480.539
	14) Risk	28.00	Discrimination	0.400	0.234
			Difficulty	-1.149	0.751
	15) Diversification 2 (Big 3)	73.71	Discrimination	1.092	0.383
			Difficulty	-1.107	0.327
	16) Bonds	8.29	Discrimination	0.591	0.282
			Difficulty	2.744	1.205
	17) ETFs	15.14 %	Discrimination	0.780	0.264
			Difficulty	1.029	0.370
Cronbach's α					0.9001

Financial knowledge test items (van Rooij et al. 2011)

1. Numeracy: Suppose you had 100 € in a savings account and the interest rate was 2 % per year. After 5 years, how much do you think you would have in the account if you left the money to grow? (i) More than 102 €; (ii) Exactly 102 €; (iii) Less than 102 €; (iv) Do not know; (v) Refusal.
2. Interest compounding: Suppose you had 100 € in a savings account and the interest rate is 20 % per year and you never withdraw money or interest payments. After 5 years, how much would you have on this account in total? (i) More than 200 €; (ii) Exactly 200 €; (iii) Less than 200 €; (iv) Do not know; (v) Refusal.
3. Inflation: Imagine that the interest rate on your savings account was 1 % per year and inflation was 2 % per year. After 1 year, how much would you be able to buy with the money in this account? (i) More than today; (ii) Exactly the same; (iii) Less than today; (iv) Do not know; (v) Refusal.
4. Time value of money: Assume a friend inherits 10,000 € today and his sibling inherits 10,000 € 3 years from now. Who is richer because of the inheritance? (i) My friend; (ii) His sibling; (iii) They are equally rich; (iv) Do not know; (v) Refusal.
5. Money illusion: Suppose that in the year 2026, your income has doubled and prices of all goods have doubled too. In 2026, how much will you be able to buy with your income? (i) More than today; (ii) The same; (iii) Less than today; (iv) Do not know; (v) Refusal.
6. Stock market: Which of the following statements describes the main function of the stock market? (i) The stock market helps to predict stock earnings; (ii) The stock market results in an increase in the prices of stocks; (iii) The stock market brings people who want to buy stocks together with those who want to sell stocks; (iv) None of the above; (v) Do not know; (vi) Refusal.
7. Which of the following statements is correct? If somebody buys the stock of firm B in the stock market: (i) He owns a part of firm B; (ii) He has lent money to firm B; (iii) He is liable for firm B's debts; (iv) None of the above; (v) Do not know; (vi) Refusal.
8. Which of the following statements is correct? (i) Once one invests in a mutual fund, one cannot withdraw the money in the first year; (ii) Mutual funds can invest in several assets, for example invest in both stocks and bonds; (iii) Mutual funds pay a guaranteed rate of return which depends on their past performance; (iv) None of the above; (v) Do not know; (vi) Refusal.
9. Which of the following statements is correct? If somebody buys a bond of firm B: (i) He owns a part of firm B; (ii) He has lent money to firm B; (iii) He is liable for firm B's debts; (iv) None of the above; (v) Do not know; (vi) Refusal.
10. Considering a long time period (for example 10 or 20 years), which asset normally gives the highest return? (i) Savings accounts; (ii) Bonds; (iii) Stocks; (iv) Do not know; (vi) Refusal.
11. Normally, which asset displays the highest fluctuations over time? (i) Savings accounts; (ii) Bonds; (iii) Stocks; (iv) Do not know; (v) Refusal.
12. When an investor spreads his money among different assets, does the risk of losing money: (i) Increase; (ii) Decrease; (iii) Stay the same; (iv) Do not know; (v) Refusal.
13. *If you buy a 10-year bond, it means you cannot sell it after 5 years without incurring a major penalty. True or false? (i) True; (ii) False; (iii) Do not know; (iv) Refusal. [EXCLUDED due to low discrimination]*
14. Stocks are normally riskier than bonds. True or false? (i) True; (ii) False; (iii) Do not know; (iv) Refusal.
15. Buying a company stock usually provides a safer return than a stock mutual fund. True or false? (i) True; (ii) False; (iii) Do not know; (iv) Refusal.
16. If the interest rate falls, what should happen to bond prices? (i) Rise; (ii) Fall; (iii) Stay the same; (iv) None of the above; (v) Do not know; (vi) Refusal.

Additional question:

17. What is an "ETF"? (i) A financial product which tracks the performance of, for example, a specific stock index as cost-effectively as possible; (ii) A financial product for which fund managers actively seek out lucrative investment opportunities and make the corresponding investments; (iii) A financial product that guarantees investors a fixed payout after 10 years if they pay a monthly savings contribution; (iv) Do not know; (v) Refusal.