

The impact of an online game-based financial education course

Multi-country experimental evidence

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DOI

[10.1016/j.jce.2024.08.001](https://doi.org/10.1016/j.jce.2024.08.001)

Publication date

2024

Document Version

Final published version

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Citation for published version (APA):

Cannistrà, M., De Beckker, K., Agasisti, T., Amagir, A., Pöder, K., Vartiak, L., & De Witte, K. (2024). The impact of an online game-based financial education course: Multi-country experimental evidence. *Journal of Comparative Economics*, 52(4), 825-847. <https://doi.org/10.1016/j.jce.2024.08.001>

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Contents lists available at ScienceDirect

Journal of Comparative Economics

journal homepage: www.elsevier.com/locate/jce

The impact of an online game-based financial education course: Multi-country experimental evidence

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ARTICLE INFO

JEL-codes:

I21

G53

Keywords:

Financial Education

RCT

Game-based approach

Cross-country analysis

ABSTRACT

This paper evaluates the impact of an online game-based financial education tool on students' financial literacy levels. By conducting a Randomized Controlled Trial (RCT) involving 2,220 students across four countries in a multi-country experimental setting, we demonstrate that the intervention significantly enhances students' financial literacy levels by 0.313 SD. This study contributes to the emerging academic literature concerning the evaluation of financial education interventions that incorporate learning-by-playing. The participation of students from four countries adds relevance by facilitating cross-comparison of outcomes and stimulating discussions about country-specific factors and peculiarities influencing youth financial literacy.

1. Introduction

Financial literacy, recognized as a valuable skill (Remund, 2010), offers numerous benefits, including improved debt management (Lusardi & Tufano, 2015), increased likelihood of retirement planning (Lusardi & Michell, 2017), and enhanced resilience during crises such as the Covid-19 pandemic (Lusardi, Hasler, & Yakoboski, 2021). Despite its importance, many individuals worldwide have low levels of financial literacy (De Beckker et al., 2019). This issue is particularly prevalent among young people, as evidenced by evaluations of 15-year-olds in the PISA assessments, revealing that their financial literacy levels fall below basic thresholds in many countries (OECD, 2014, 2017, 2020).

A natural response to low financial literacy levels is financial education. Some countries have already incorporated financial education into their mandatory school curriculum, while others are considering its inclusion (OECD, 2022). While organizing activities and engaging students are essential, it is crucial to understand whether and how these initiatives have the desired positive impacts on participants' skills (Kaiser & Menkhoff, 2017; Kaiser & Menkhoff, 2020; Kaiser et al., 2022). By understanding the learning

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<https://doi.org/10.1016/j.jce.2024.08.001>

Received 30 August 2023; Received in revised form 22 May 2024; Accepted 3 August 2024

Available online 17 August 2024

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mechanisms and successful features of interventions, financial education can become a useful tool to improve financial literacy (Collins & Odders-White, 2015).

When designing interventions in the financial education domain, recent trends in teaching and evaluation merit consideration. There is a growing emphasis on gamification, which assumes that incorporating learning-by-playing aspects enhances interest and motivation among students (Dicheva et al., 2015). In an educational context, a game-based approach involves implementing real-world activities (Kiili, 2007). Given its practical applicability, the adoption of innovative learning-by-playing initiatives in financial education appears to be an effective strategy for conveying financial concepts (Batty et al., 2020). However, the evidence regarding its effectiveness remains limited (Angel, 2018; French et al., 2020; Kalmi & Rahko, 2022; Rodriguez-Raga & Martinez-Camelo, 2022; Sconti, 2022).

To bridge this research gap, our study investigates the effectiveness of a game-based activity, specifically a Financial Escape Room, in enhancing the financial literacy levels of secondary school students. The treatment involves a straightforward and concise online game covering financial literacy topics such as interest and changes calculation, bank account management, and savings. In the game, players take on the role of a robber tasked with overcoming a series of challenges to unlock a bank vault.

By conducting a Randomized Controlled Trial (RCT) involving 2,220 students, we causally evaluate the effectiveness of the Financial Escape Room. Randomization occurred at the school level, with all participating students assigned to either the control or treatment condition. An innovative and unique aspect of this evaluation is the inclusion of students from four countries: Belgium, Estonia, Italy, and Slovakia. Previous research has demonstrated that variations in effectiveness may exist, as cultural influences extend beyond individual socio-economic characteristics in determining financial literacy outcomes (De Beckker et al., 2020). This cross-country evaluation offers the opportunity to test the external validity of the results, enabling comparisons across diverse contexts and contributing to discussions on the intervention's overall effectiveness.

To preview the main findings, the impact of the treatment (online game) on students' financial literacy amounts to 0.313 standard deviations. However, the effect varies significantly among the different countries in our study, ranging from only 0.182 standard deviations in Estonia, to 0.242 in Italy, 0.334 in Slovakia, and 0.618 in Belgium. The substantial impact in Belgium may be attributed to the low initial level of financial literacy, which was notably lower than in the other countries where baseline financial literacy levels were more aligned. Further analysis also reveals heterogeneity in the impact depending on certain socio-economic characteristics, indicating that male students (0.408 SD), native speakers (0.321 SD), those enrolled in an academic school track (0.342 SD), and those with older and younger siblings (0.368 SD) are among those who benefit the most from the treatment. Having a lower socio-economic status, as proxied by not traveling abroad during the last year, yields a below-average impact, yet still relatively substantial (0.264 SD). In certain countries, some of these heterogeneity effects are even more pronounced. Concerning gender, we observe a higher effect of the treatment for boys in Belgium (0.520 SD) and Slovakia (0.455 SD). Being a native speaker is particularly significant for the uptake in Belgium (0.560 SD), while the impact of treatment on students with lower socio-economic status is even larger than average in countries such as Italy (0.364 SD) and Slovakia (0.357 SD).

The substantial and statistically significant effect of the online game on students' financial literacy levels represents a valuable outcome of this research for practitioners and decision-makers. Due to its brevity, ease of implementation, low costs, and independence from teacher mediation, this type of activity can serve as an effective solution for enhancing students' financial literacy at scale with minimal investments. Similar game-based interventions can support and complement ongoing efforts to systematically incorporate financial education into school curricula and/or extracurricular activities.

The remainder of this paper is organized as follows. Section 2 reviews the literature on randomized controlled trial evaluations of financial education in secondary schools and explores the role of gamification in this context. Section 3 presents background information on the financial literacy levels of youth in the participating countries (Belgium, Estonia, Italy and Slovakia). Section 4 outlines the empirical methods employed, while section 5 discusses the results. Finally, section 6 concludes and presents policy implications derived from the study.

2. Literature

2.1. Evaluation of financial education activities for students

Overall, studies evaluating financial education activities in secondary education remain limited (Kaiser & Menkhoff, 2017), with less than half employing rigorous RCTs to assess effectiveness. Some studies report positive effects, but with variations. Bruhn et al. (2016) find significant improvements in financial proficiency and graduation outcomes, yet mixed evidence for financial behavior. Bover et al. (2018) study the impact of a 10-hour financial education course on 3,000 9th-grade students, noting the greatest improvements among those from disadvantaged socio-economic backgrounds. Frisnacho (2020) conduct a national evaluation of a financial education program for high-school students in Peru, revealing learning gains in the treatment group that helped reduce initial inequalities. Isterbeke et al. (2020) investigate whether differentiated instruction enhances the impact of a program on 2,407 students

from the 8th and 9th-grade students. To examine the impact, schools were randomly assigned to four different conditions: one control condition and three experimental conditions testing different forms of instructional types. All experimental conditions made use of a computerized serious game consisting of four lectures of 50 minutes on the topic ‘means of payment’¹.

Their findings indicate that while differentiated treatments do not influence financial knowledge for the entire sample, non-native students benefited significantly when they are matched to a peer with similar ability, conditional on receiving differentiated instructions. Maldonado et al. (2022) examine how parental involvement enhances the impact of a similar program as Iterbeke et al. (2020) on 2,779 students from the 8th and 9th grades. They observe that the intervention that stimulates parental involvement matters the most for students of a low socio-economic status.

Other evaluations of traditional teaching methods also indicate positive impacts of interventions, though often not statistically significant (e.g., Berry et al., 2018; Shephard et al., 2017; Lührmann et al., 2018). In summary, the available evidence suggests that educational programs enhance students’ financial literacy, with a particularly significant positive effect on those from socioeconomically disadvantaged backgrounds.

The present study contributes to the academic discussion surrounding the evaluation of *online* financial education interventions. In this domain, Angel (2018) tested three fully digital tools aimed at enhancing young students’ financial literacy and appeal. The study finds mostly insignificant impacts of the treatments on financial literacy. The author suggests that the lower marginal cost of implementing ICT-based solutions, compared to a traditional training course, may result in lower knowledge gains. Batty et al. (2020) evaluate the impact of a simulation-based activity on engaging elementary school students in making daily financial decisions. The evaluation demonstrates significant and robust improvements in financial knowledge, comparable to those achieved through traditional frontal lectures on the same topics. Agasisti et al. (2022) conduct an RCT to evaluate the effect of a financial education course on secondary school students. Due to the Covid-19 emergency and school closures, the intervention was delivered online. The initiative shows positive and significant improvements in the financial knowledge of the treatment group. Rodríguez-Raga and Martínez-Camelo (2022) conducted an RCT to test the effectiveness of three learning tools (game, guide, and website) for students aged 6 to 18 years. While no significant differential effects are observed among treatments, there is an overall improvement in financial literacy levels.

Considering the characteristics of the interventions evaluated thus far, the present study is innovative for two reasons. Firstly, most experiments in this domain involve teachers as mediators of knowledge transmission, leading to two consequences: (i) the need for teacher training on financial topics, resulting in an upfront and substantial investment cost, and (ii) variations in the quality of teachers, which could potentially affect the intervention’s effectiveness. This research investigates the treatment effects of a fully digital initiative where no teacher intermediation is required. Secondly, while existing studies typically focus on initiatives conducted within a single country, the present research is in a multi-country setting, involving students from four European countries. This allows for the exploration of heterogeneity effects across different educational systems.

2.2. Game-based approach to financial education

In the field of financial education, there has been a notable exploration of various strategies to introduce inventive learning methodologies, with gamification standing out as a particularly promising approach. By integrating gameplay, students engage in skill-building activities that foster not only intellectual but also social and emotional development (Dicheva et al., 2015). One compelling feature of gamified learning lies in its incorporation of challenging problems coupled with scaffolding techniques, which effectively guide players toward discovering solutions (Deater-Deckard et al., 2013; Sweetser and Wyeth, 2005).

Digital games have emerged as prominent and effective tools for teaching and learning across various educational settings (Klopfer et al., 2009; Steinkuehler et al., 2012; De Grove et al., 2012; Deater-Deckard et al., 2013). Considering that financial literacy instruction prioritizes problem-solving within real-life scenarios, the utilization of digital games presents a logical avenue for developing these essential skills in students (Koh, 2016).

Scholars have extensively examined various financial education game experiences. For example, the Financial Literacy Hub for Teachers in Singapore has crafted *mShopper*, a game fostering collaborative learning among students. This platform instructs them on budget management, prudent consumer decision-making, and discerning common marketing ploys (Woodcock and Johnson, 2018). *KASHING*, a mobile learning application, integrates financial education through gamification and micro-lectures (Samonte et al., 2017). Similarly, *Inspire! Build your Business*, a game developed by the Department of Innovation Management and Entrepreneurship at the University of Klagenfurt, creatively blends theoretical concepts with practical exercises, specifically targeting university students to enhance their comprehension of business model development (Krajger et al., 2018).

In summary, while numerous games aimed at imparting essential financial concepts already exist, only a handful of studies have scrutinized their impact on students’ financial acumen. Within the literature, only two studies stand out for their comparison between traditional financial education lectures and learning-by-playing activities (e.g., Kalmi and Rahko, 2022; Sconti, 2022). Interestingly, both studies find no significant disparities when assessing the effectiveness of game-based versus traditional teaching methods, indicating that game-based instruction can be just as efficacious as the conventional approach in terms of enhancing financial

¹ In our study, we borrowed the *Financial Escape Room* developed for one of the lectures in the experiment by Iterbeke et al. (2020) in Flanders to test it as a standalone online initiative in a multicountry context. While in the experiment of Iterbeke et al. (2020), the focus is on how differentiated instructions contribute to an increased uptake of material, we provided only one version with the inclusion of all instructions and focused only on one aspect of the course, namely the *Financial Education Room*. The data sample and time period of our experiment are different from those of the experiment conducted by Iterbeke et al. (2020).

knowledge. These findings underscore the potential value of games and simulation activities in augmenting the financial literacy of young learners. However, it's worth noting that, to date, no rigorous evaluations—particularly those employing a pure control group without any treatment—of game-based activities have been conducted within the realm of financial education. Consequently, the aim of this study is to fill this critical research gap by evaluating a novel online game tailored to bolster the financial knowledge of high school students.

3. Financial literacy in Belgium, Estonia, Italy and Slovakia: Insights from PISA

When evaluating the present state of financial literacy among young students across various countries, a reliable source of information is the Programme for International Student Assessment (PISA), conducted every three years by the OECD among 15 year old students. Although PISA commonly reveals low levels of financial literacy, it is essential to recognize nuanced differences. Specifically, this section delves into the financial literacy performance of youth in Belgium, Estonia, Italy, and Slovakia—countries where our intervention occurred. Table 1 provides an overview of the PISA financial literacy results. Panel A displays the performance in financial literacy, including the ranking and mean score for each country, as well as the percentage of low achievers and top performers. Panel B presents the sources of heterogeneity, focusing on gender, home language, and socio-economic status. These sources of heterogeneity are calculated as follows: gender by the difference in mean scores between boys and girls; home language by the difference in mean scores between students who speak the language of the assessment at home and those who speak another language; and socio-economic status by the percentage of variance in financial literacy performance explained by socio-economic status (SES).

Students in Belgium² exhibited relatively strong performance in PISA financial literacy, securing the second and first positions in 2012 and 2015, respectively. In both years, the mean score for students in Belgium was significantly above the OECD average. However, approximately 8.7% and 12% of young Belgians failed to reach the basic level of financial literacy in 2012 and 2015, respectively, while only 19.7% and 24% were classified as top performers. This indicates a growing gap between low and top performers. A noteworthy observation is the significant difference in mean scores between those who speak the language of the country at home and those who do not, with native speakers scoring 49 and 93 points higher than non-native speakers in 2012 and 2015, respectively. Furthermore, significant heterogeneity based on socio-economic status was observed, with 16% of the variance in financial literacy scores explained by socio-economic status in 2015.

Estonian 15-year-old students demonstrated remarkable progress, ranking third in 2012 and claiming the top position in 2018, marking a significant positive advancement over the six-year period. In both years, the share of low achievers remained relatively low at around 5.3%, while the share of high performers increased from 11.3% in 2012 to 19.0% in 2018. Regarding the sources of heterogeneity, it is noteworthy that the variance in financial literacy scores explained by socio-economic status is relatively low: 6.7% in 2012 and 6.1% in 2015. This is significantly lower than the OECD average, indicating that socio-economic status plays a lesser role in Estonia compared to other OECD countries. Additionally, although native speakers score better than non-native speakers, the differences are smaller than in other countries.

Italian 15-year-old students demonstrate notably lower levels of financial literacy compared to other OECD members, ranking 17th in 2012, 9th in 2015, and 13th in 2018, with an average score significantly below the OECD average. Gender disparities are evident, with Italian male students consistently achieving significantly higher scores than females in all three years. The language spoken at home also plays a significant role, with native speakers scoring significantly higher than non-native speakers. Notably, there are no significant differences in scores based on socio-economic status, with only 5.5% (2012) to 7.9% (2018) of the variance in financial literacy performance explained by socio-economic differences.

Slovak students also yielded disappointing results in financial literacy, placing in the lower range of the PISA assessment. Many 15-year-old Slovak students encountered challenges in grasping financial concepts, evidenced by a significant decline of 25 points in average performance between PISA 2012 and PISA 2015, coupled with an increase in the proportion of students scoring in the lower percentile of the distribution. However, a promising improvement in average scores was observed in PISA 2018. Notably, there were large differences between native and non-native speakers in 2012, with a gap of 111 points—among the largest differences in the four countries studied. This difference declined to 41 points in 2018. In terms of gender differences, a significant disparity was observed only in 2015, with boys scoring on average 25 points less than girls. The variance in financial literacy due to socio-economic status fluctuated significantly over the three years, with a notable 6.5% in 2015 and 15.2% in 2018.

In summary, among the four countries in our sample, 15-year-old students in Italy and Slovakia exhibit relatively low financial literacy performance, while students in Belgium and Estonia show relatively high performance. Additionally, we observe a significant gender effect only in Italy, whereas the impact of being a native speaker is evident in all four countries. The largest variance in scores due to socio-economic status is found in Belgium and Slovakia. The primary objective of this paper is to examine and analyze the effectiveness of our *Financial Escape Room* in facilitating knowledge acquisition within these diverse contexts. In our heterogeneity analysis, we will pay particular attention to the sources of heterogeneity identified by PISA.

² It is important to note that when we refer to students in Belgium, we specifically mean students in Flanders. For our experiment, as well as for the PISA data, only students from Flanders, the northern region of Belgium, are included.

Table 1
PISA financial literacy results.

Panel A: Performance in financial literacy				
	Wave	Ranking Mean score	Share of low achievers (Level 1 or below)	Share of top performers (Level 5 or above)
Belgium	2012	2 nd place 541 pts. (> OECD average)	8.7% (< OECD average)	19.7% (> OECD average)
	2015	1 st place 541 pts. (> OECD average)	12.0% (< OECD average)	24.0% (> OECD average)
	2018	Not participating in this wave		
Estonia	2012	3 rd place 529 pts. (> OECD average)	5.3% (< OECD average)	11.3% (> OECD average)
	2015	Not participating in this wave		
	2018	1 st place 547 pts. (> OECD average)	5.3% (< OECD average)	19.0% (> OECD average)
Italy	2012	17 th place 466 pts. (< OECD average)	21.7% (> OECD average)	2.1% (< OECD average)
	2015	9 th place 483 pts. (< OECD average)	20.0% (< OECD average)	6.0% (< OECD average)
	2018	13 th place 476 pts. (< OECD average)	20.9% (> OECD average)	4.5% (< OECD average)
Slovakia	2012	16 th place 470 pts. (< OECD average)	22.8% (> OECD average)	5.7% (< OECD average)
	2015	12 th place 445 pts. (< OECD average)	35.0% (> OECD average)	6.0% (< OECD average)
	2018	12 th place 481 pts. (< OECD average)	21.2% (> OECD average)	7.2% (< OECD average)
Panel B: Sources of heterogeneity				
	Wave	Gender	Home language	Socio-economic status
Belgium	2012	Males obtain 11 pts. more than females	Native speakers obtain 49 pts. more than non-natives	11.3% (< OECD average)
	2015	Males and females obtain comparable scores	Native speakers obtain 93 pts. more than non-natives	16.0% (> OECD average)
Estonia	2018	Not participating in this wave		
	2012	Males obtain 3 pts. less than females	Native speakers obtain 46 pts. more than non-natives	6.7% (< OECD average)
	2015	Not participating in this wave		
Italy	2018	Males obtain 3pts more than females	Native speakers obtain 7 pts. more than non-natives	6.1% (< OECD average)
	2012	Males obtain 8pts more than females	Native speakers obtain 40 pts. more than non-natives	7.5% (< OECD average)
	2015	Males obtain 11pts more than females	Natives obtain 35 pts. more than non-natives	5.5% (< OECD average)
Slovakia	2018	Males obtain 15 pts more than females	Natives obtain 49 pts. more than non-natives	7.9 % (< OECD average)
	2012	Males obtain 3 pts. less than females	Native speakers obtain 111 pts. more than non-natives	18.2% (> OECD average)
	2015	Males obtain 25 pts. less than females	Native speakers obtain 78 pts. more than non-natives	6.5% (< OECD average)
	2018	Males obtain 1 pt. more than females	Native speakers obtain 41 pts. more than non-natives	15.2% (> OECD average)

Note: Data are obtained from OECD reports on financial literacy from PISA2012 (OECD, 2014), PISA2015 (OECD, 2017), and PISA2018 (OECD, 2020). Panel A reports the ranking of each country with its mean PISA score, along with the share of low achievers and the share of top performers. Panel B reports the sources of heterogeneity. These sources of heterogeneity are calculated as follows: Gender by the difference in mean scores between boys and girls. Home language by the difference in mean scores between students who speak the language of assessment at home and students who speak another language. Socio-economic status by the percentage of variance in financial literacy performance explained by socio-economic status (SES).

4. Design, treatment and method

4.1. Experimental design

The impact of the Financial Escape Room game-based activity on students' financial literacy scores is assessed through a Randomized Control Trial (RCT). This trial is conducted in secondary schools across four countries: Belgium, Estonia, Italy and Slovakia.³ School recruitment entails an open call within each country's network of participating universities, with one university serving as the representative for each country. Once a school agrees to participate, its students are randomly assigned to either a control or treatment group. Randomization at the school level offers the advantage of minimizing interference for schools with multiple participating classes. Both groups undergo pre- and post-tests during the school day. Between these assessments, the treatment group participates in the Financial Escape Room, while the control group gains access to the activity only after completing the post-test. The experiment's timeline is illustrated in Fig. 1 and typically spans two to three weeks. The experiment was conducted between November 2020 and January 2021, a period marked by the closure of most European schools due to the COVID-19 pandemic, necessitating the transition of all didactical activities online.

Table 2 presents the list of variables utilized in the empirical analysis, which have been collected through pre- and post-questionnaires. The pre-test comprises various inquiries regarding students' background information, encompassing demographics, academic details, and financial literacy-related questions. In contrast, the post-test solely assesses students' financial literacy to facilitate a pre-post assessment. Financial literacy is assessed through four questions encompassing subjects⁴ explored in the *Financial Escape Room*, namely three financial knowledge questions: (Q1) inflation, (Q2) compounded interest, (Q3) change calculation, and one financial behaviour question: (Q4) responsible card handling.

A detailed overview of these financial literacy questions can be found in Appendices A1 and A2. The variable *Pre-test financial literacy score* is determined by computing the percentage of correctly answered questions on financial literacy in the pre-test, while the *Post-test financial literacy score* is similarly calculated based on responses from the financial literacy test administered in the post-test.⁵

Table 3 reports the distribution of the answers to the four financial literacy questions in both the pre-test and the post-test. The number of correct answers is lowest for the compounded interest rate question (Q2) in both the pre-test and post-test, with 50.59% and 55.59% of students answering this question correctly, respectively. The same applies to the best-answered question, which involves students calculating the amount of change they should receive (Q3). This question is answered correctly by 66.17% and 78.38% of the students in the pre-test and post-test, respectively. Between the pre-test and post-test, we observe a steady improvement in all aspects of financial knowledge (Q1 – Q3), as well as financial behaviour (Q4).

4.2. The Financial Escape Room

The *Financial Escape Room* is an interactive online game-based learning activity, developed in the framework of a European project about financial education. Students could access the game by means of an online link that was sent to them by their teachers, who received it after they subscribed to the experiment⁶. The game was played on an individual basis with no restrictions on the number of students who could play the game simultaneously. The game presents students with a series of challenges that they must overcome to access a bank vault. The game is divided into three parts⁷. In the first part, students need to answer 18 questions correctly, covering topics such as means of payment, bank accounts, interest rates, change calculation, and understanding of VAT or inflation, in order to obtain a Morse code which grants them entry to the bank. Once inside, students must search for the only employee who knows the location of the vault. This is achieved through a 'Who is it?' game, where students are presented with 10 questions about interest rates or money change calculations. Each correct calculation earns them a hint that helps them to find the employee with the vault location knowledge. In the final level, students encounter 10 multiple-choice questions about means of payment. Throughout the game, students have the option to consult information sheets if they do not know the correct answer, allowing them to progress while learning. This feature of the *Financial Escape Room* serves as primary educational component, as it provides ready-to-use information to support functional learning and serves as an extrinsic incentive.

³ Secondary school teachers and academics from these countries partnered within a Project funded by the European Commission, named EUFin ("Innovative integrated tools for financial literacy education across Europe"), in the framework of European KA2 Strategic Partnerships for Higher Education.

⁴ The subjects covered in our intervention, the Financial Escape Room, align with the topics included in the PISA assessments organized by the OECD every three years for 15-year-old students. Although the specific questions from the PISA financial literacy assessment are not publicly available, we consulted the teachers on our research team to develop targeted questions that test the various topics. Some of the questions, such as Q1 and Q2, are inspired by the Big Three Questions of Lusardi & Mitchell (2014).

⁵ The literacy scores were standardized with a mean of zero and a standard deviation of one prior to their inclusion in the regression analysis. This standardization was undertaken to ensure comparability and to facilitate the assessment of treatment effects.

⁶ Depending on whether the students' school was assigned to the control or the treatment group, the link to the *Financial Escape Room* was sent after completing the pre- or the post-test. For students in the control group, the *Financial Escape Room* was only accessible after the experiment finished, so after they completed both the pre-test and the post-test. For students in the treatment group, the *Financial Escape Room*, was already accessible after they completed the pre-test. Students of this group only received the post-test after completing the *Financial Escape Room*.

⁷ More details of the questions asked in the game are provided in Appendix B. One can access the game by clicking on the following link: https://toll-net.be/moodle/xertetoolkits/play.php?template_id=40885#page1

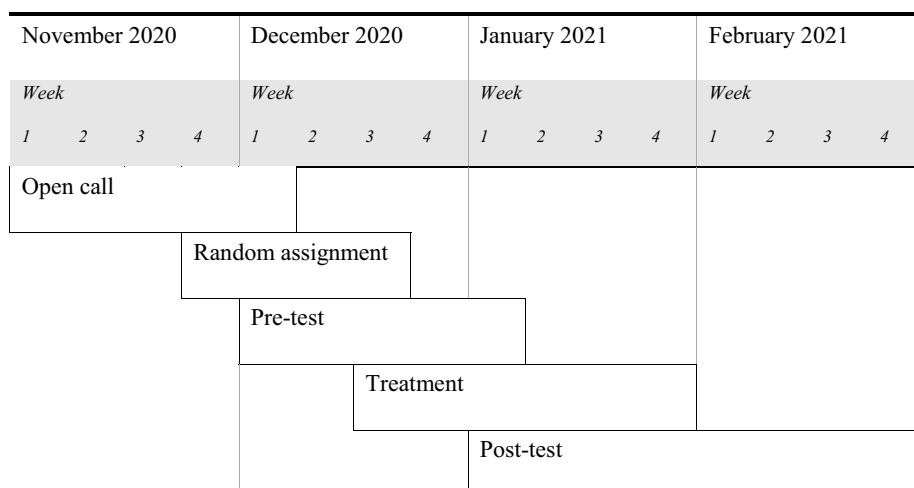


Fig. 1. RCT timeline. Note: The fact that phases are overlapping is due to the imperfect synchronization among the different countries. Given that students in different countries were not in contact, this does not cause spillover effects.

Table 2

Description of variables.

Variable name	Description	Type	Possible values
Gender	Whether the student is male	Binary	{0; 1}
Age	Students' age	Numerical (integer)	[11- 17]
Home language	Whether the student's home language is one of the national languages	Binary	{0; 1}
Family	Number and age of student's siblings (if any)	Categorical	{only child; older siblings; younger siblings; older and younger siblings}
No Holidays abroad	Whether the student did not travel abroad with their family during the previous year.	Binary	{0; 1}
Math grade	Grade obtained in math in the previous year: from 0, the lowest level, to 4, the highest one	Numerical (integer)	{0; 1; 2; 3; 4}
Literature grade	Grade obtained in literature in the previous year: from 1, the lowest level, to 4, the highest one	Numerical (integer)	{0; 1; 2; 3; 4}
Academic school track	If the student is enrolled in an academic school track	Binary	{0; 1}
Country	The school's country	Categorical	{Estonia; Belgium; Italy; Slovakia}
Pre-test financial literacy	Total correct answers from the pre- test	Numerical (Continuous)	[0, 4]
Post-test financial literacy	Total correct answers from the post-test	Numerical (Continuous)	[0, 4]

Note: This table reports the dependent and independent variables used in the empirical investigation. For the empirical analysis, pre- and post-test financial literacy scores are standardized with a mean of 0 and a standard deviation of 1.

The storytelling aspect of the *Financial Escape Room* is a key characteristic, as it aims to engage students in successfully completing all levels. Typically, students take around 90 minutes to complete the activity, but there are no time constraints, so they can remain connected as long as they wish.

Table 3

Distribution answers financial literacy question.

Panel A: Financial knowledge					
Question		Pre-test		Post-test	
		Correct (%)	Incorrect (%)	Correct (%)	Incorrect (%)
Q1	Inflation	61.13	38.87	70.99	29.01
Q2	Compounded interest	50.59	49.41	55.59	44.41
Q3	Change calculation	66.17	33.83	78.38	21.62
Panel B: Financial behaviour					
Question		Pre-test		Post-test	
		Correct (%)	Incorrect (%)	Correct (%)	Incorrect (%)
Q4	Careful card handling	53.11	46.89	65.95	34.05

Note: This table reports the fraction of correct and incorrect answers to the four financial literacy questions. We distinguish between four financial knowledge questions and two financial behaviour questions.

Table 4

Descriptive statistics.

Variable	Control group (N = 929)	Treatment group (N = 1,291)	Total (N = 2,220)	p-value
Gender (Male)	376 (40.47%)	509 (39.43)	885 (39.86)	0.619
Age (Year)	15.72 (1.50)	14.56 (2.06)	15.05 (1.94)	0.000
Home language (Native)	872 (93.86%)	1,196 (92.64%)	2,068 (93.15%)	0.261
Family				
1 - Only child	165 (17.76%)	206 (15.96%)	371 (16.71%)	0.036
2 - Older siblings	306 (32.94%)	423 (32.77%)	729 (32.84%)	
3 - Younger siblings	355 (38.21%)	460 (35.63%)	815 (36.71%)	
4 - Older and younger siblings	103 (11.09%)	202 (15.65%)	305 (13.74%)	
No holidays abroad (Yes)	313 (33.69%)	302 (23.39%)	615 (27.70%)	0.000
Math grade (4)	2.78 (0.89)	2.92 (0.93)	2.87 (0.91)	0.002
Literature grade (4)	2.90 (0.73)	3.01 (0.79)	2.97 (0.76)	0.001
Academic school track (Yes)	726 (78.15%)	1,079 (83.58%)	1,805 (81.31%)	0.001
Country				0.000
Belgium	128 (13.78%)	516 (39.97%)	644 (29.01%)	0.000
Estonia	164 (17.65%)	185 (14.33%)	349 (15.72%)	
Italy	531 (57.16%)	490 (37.96%)	1,021 (45.99%)	
Slovakia	106 (11.41%)	100 (7.75%)	206 (9.28%)	
Pre-test financial knowledge (3)	1.92 (0.93)	1.67 (0.99)	1.78 (0.97)	0.000
Pre-test financial behaviour (1)	0.57 (0.50)	0.50 (0.50)	0.53 (0.50)	0.003
Pre-test financial literacy (4)	2.49 (1.12)	2.18 (1.21)	2.31 (1.18)	0.000
Post-test financial knowledge (3)	2.03 (0.88)	2.06 (0.91)	2.05 (0.89)	0.518
Post-test financial behaviour (1)	0.64 (0.48)	0.67 (0.47)	0.66 (0.47)	0.131
Post-test financial literacy (4)	2.68 (1.08)	2.73 (1.11)	2.71 (1.10)	0.230

Note: Standard errors are reported in parentheses, with the exception of gender, home language, family, and country, where percentages are given. Gender represents the relative share of boys in our sample. Age represents the average age of the participating students. Home language is a dummy indicating whether a student speaks the local language at home. Family is a categorical variable indicating whether someone has older or younger siblings. No holidays abroad is a dummy indicating whether the student has not travelled abroad, serving as a proxy for the socio-economic status of the student. Math and literature grades refer to the results of the previous year. These are self-reported and range from 0 to 4. Each category represents a certain range of results: 0 "Less than 50%"; 1 "50% or more, but less than 60%"; 2 "60% or more, but less than 70%"; 3 "70% or more, but less than 80%"; 4 "More than 80%". Academic track is a dummy indicating whether a student belongs to an academic school track. Country is a categorical variable indicating to which country a student belongs. The pre- and post-test financial knowledge scores are based on a set of three financial knowledge questions measuring knowledge of the concepts of inflation, compound interest, and change calculation, while the pre- and post-test financial behaviour scores measure careful card handling behaviour. The pre- and post-test financial literacy scores are based on the sum of the pre-test financial knowledge and behaviour scores. The p-value refers to an OLS regression where the characteristic is regressed on a treatment indicator with standard errors clustered at the school level.

***p<0.01; **p<0.05; *p<0.1

4.3. Data

Table 4 presents a summary of descriptive statistics for the combined sample from the four countries. The pooled sample includes a total of 2,220 students. On average, 39.86% of the pooled sample are male students. The average age of participants is 15.05 years, with most speaking the local language (93.15%) and having either one older (32.84%) or one younger sibling (36.71%). To gauge socioeconomic status (SES), students were asked about the number of days spent on holidays abroad; 27.70% reported not having any holidays abroad in the year prior to the survey. Several student-level covariates⁸ are included, such as average self-reported grades in two main subjects, mathematics and literature, as well as the type of school track attended⁹. On average, students perform quite high on both math (2.87 out of 4) and literature (2.97 out of 4), while a large majority (81.31%) belongs to the academic track. The sample consists of students from Belgium (29.01%), Estonia (15.72%), Italy (45.99%) and Slovakia (9.28%). Descriptive statistics for each country are presented in Table C1 in Appendix C.

To test for differences between control and treatment groups, we present the *p*-values of the OLS regression of socioeconomic characteristic on the treatment indicator. Overall, the sample demonstrates some imbalance between the treatment and control groups, showing statistically significant differences in certain aspects. Notably, students in the control group are slightly older (15.72 years) compared to those in the treatment group (14.56 years). Additionally, students in the control group tend to have a somewhat lower socioeconomic status, as evidenced by the higher percentage of students who report not having traveled abroad in the year prior (33.69% for the control group versus 23.39% for the treatment group). Considering math and literature grades, we observe that students in the treatment group score significantly higher than those in the control group. Moreover, there is an imbalance concerning the school track. The proportion of students in the academic track is somewhat higher in the treatment group (83.58%) compared to the control group (78.15%).

One potential threat to the validity of our study lies in the disparity between the characteristics of our sample and those of the underlying population in the selected countries. Although we do not implement a specific strategy to address this possibility, we evaluate the representativeness of the selected sample. Table C2 in Appendix C facilitates a comparison between the distribution of students in the sample and the population based on gender and across different school tracks. It is notable that all participating countries exhibit an overrepresentation of students from academic tracks. Furthermore, countries generally demonstrate a lower representation of males in the sample compared to their official statistics, with the exception of Estonia.

4.4. Empirical strategy

The study incorporates two primary components into its empirical strategy within the framework of evaluating the intervention through a Randomized Controlled Trial (RCT): Inverse Probability Treatment Weighting (IPTW) and a multi-country approach. The first component tackles the issue of imbalanced data, as evidenced in Table 4, where the treatment and control groups exhibit differences in observable characteristics. To mitigate this disparity, IPTW is employed to assess the treatment effect. The second component involves conducting the experiment in four distinct countries, each with its own unique characteristics, as elaborated in Section 3. This section outlines how the methodological approach accommodates these two components.

The first methodological aspect addresses the imbalances between treatment and control groups concerning observable characteristics. To mitigate the impact of unbalanced variables on the post-tests' score, they are included as controls in the intent-to-treat (ITT) OLS regressions. However, controlling for observables alone may not suffice to obtain an unbiased treatment estimation (Shen et al., 2014). Inverse Probability of Treatment Weighting (IPTW) is proposed to enhance the power of the Randomized Controlled Trial (RCT). IPTW involves two main steps (Chesnaye et al., 2022). Firstly, a propensity score is calculated, defined as the conditional probability of being exposed to a particular treatment given the values of measured covariates:

$$p(\mathbf{X}) = P(T=1|\mathbf{X})$$

Where $p(\mathbf{X})$ represents the probability of being treated, given a set of baseline covariates $\mathbf{X}=(X_1, \dots, X_p)$. Secondly, weights are calculated as the inverse of the propensity score:

$$IPTW = w(\mathbf{X}) = \frac{1}{1 - p(\mathbf{X})}$$

Calculated in this way, these weights are applied to the sample to create a pseudo-sample in which covariates are equally distributed across control and treated groups.

The second methodological aspect to address is the estimation of the treatment's effect in a multi-countries context. Following the guidelines provided by Feaster et al. (2011), this research explores different statistical approaches to account for country effects: (1) no

⁸ This set of student-level covariates is utilized based on previous studies that have identified a positive correlation between academic performance and financial literacy (e.g., Frisancho 2020; Lührmann et al. 2015).

⁹ Due to differences in upper secondary school tracks across participating countries, this variable has been dichotomized: 1 for students enrolled in an academic track, and 0 otherwise. The academic track aligns with the general track as defined by the ISCED 2011 classification. Specifically, this typology describes the general track as "education programmes designed to develop learners' general knowledge, skills, and competencies, as well as literacy and numeracy skills, often to prepare participants for more advanced education programmes at the same or a higher ISCED level and to lay the foundation for lifelong learning" (UNESCO Institute for Statistics, 2012).

country effects, (2) fixed country effects, (3) random country effects, and (4) interaction effects.

The first strategy aims to assess the treatment effect while disregarding any country-specific influence. This measure serves primarily as a baseline result. Second, fixed effects for each country are incorporated to accommodate within-country analysis of treatment effects. The inclusion of country-specific dummy variables causes each predictor to deviate from its country-specific mean. The model is specified as follows:

$$y_{ij} = \alpha + \beta_{ij} \text{Treatment}_{ij} + \gamma_{ij} x_{ij} + \delta_j d_j + \varepsilon_{ij}, \sum_{i=1}^S \delta_j = 0, \varepsilon_{ij} \sim N(0, \sigma_e^2)$$

where y_{ij} denotes the standardized value of the post-test financial literacy score of student i in country j ; Treatment_{ij} takes the value 1 if student i in country j received the financial education treatment; x_{ij} represents a number of student characteristics (gender, age, home language, family situation, holidays abroad, math and literature grades, academic school track and pre-test score) and d_j is a dummy which accounts for country-specific fixed effects.

The third strategy for addressing the multi-country experimental design is the random effects model, which decomposes the variance of the model. The rationale behind this approach is to accommodate the variability in the outcome attributed to differences across countries. The model specification is as follows:

$$y_{ij} = \alpha + \beta_{ij} \text{Treatment}_{ij} + \gamma_{ij} x_{ij} + s_j + \varepsilon_{ij}, s_j \sim N(0, \sigma_s^2), \varepsilon_{ij} \sim N(0, \sigma_e^2)$$

where s_j represents the random effect of country j , which follows a normal distribution and is independent from the error term ε_{ij} . In both cases, the coefficient of interest, expressing the treatment effect, is β_{ij} . It is important to note that, due to variations in sample sizes of participants in the treatment condition across countries, the treatment estimate in the random effects case will be a weighted average of the within-country and between-country components of treatment differences.

Finally, the country-by-treatment interaction via the fixed-effect approach aims to control for both the main effect of country and the interaction between country and treatment, without explicitly modeling the variability in these terms arising from country differences. The model is expressed as follows:

$$y_{ij} = \alpha + \gamma_{ij} x_{ij} + \delta_j d_j + \rho_i d_j \text{Treatment}_{ij} + \varepsilon_{ij},$$

$$\sum_{j=1}^S \delta_j = 0, \sum_{j=1}^S \rho_j = 0, \varepsilon_{ij} \sim N(0, \sigma_e^2),$$

In this model, ρ_i represents the country-by treatment interaction. With no a priori preference for a specific model and considering the varying informative content conveyed by each, this paper utilizes and compares all of them.

4.5. Sample selection, randomization and attrition

The experiment started in November 2020 across the four participating countries with a simultaneous open call to secondary schools. After each country recruited participants for the initiative, randomization occurred at the school level, assigning students to either control or treatment groups. From December 2020 to February 2021, the intervention unfolded according to the previously outlined steps: pre-test, Financial Escape Room activity, and post-test. The pre-test serves as the initial data collection moment for participating students. One month later, students assigned to the treatment group participated in the Financial Escape Room activity during regular school hours. Upon completion of the activity, they were asked to fill out the final questionnaire. The control group gained access to the digital activity only after completing the post-test.

Due to this structure, no information is available on attrition between enrollment and the pre-test. However, attrition between the pre- and the post-test is documented. Specifically, 62.77% of students who completed the pre-test also completed the post-test. These students are referred to as compliers. To gain further insight into the characteristics of non-compliers who only participated in the pre-test, descriptive statistics associated with compliers and non-compliers are provided in [Table D1](#) in Appendix D. It can be observed that the rate of male students is somewhat lower among compliers (39.86%) compared to non-compliers (44.72%). Regarding age, compliers appear to be somewhat older (15.05 years old) than non-compliers (14.47 years old). Moreover, students in the complier group are more likely to speak the local language at home. On average, 93.15% of compliers are native speakers, while only 81.85% of non-compliers speak the local language at home. In terms of family situation, compliers are more likely to belong to smaller families. Additionally, both math and literature grades are higher for compliers, and they are more often enrolled in an academic school track.

To test whether some of the socio-economic characteristics play a significant role in determining whether someone is a complier or non-complier, we conduct a test for selective attrition. Here, we regress the socio-economic characteristics against the attrition dummy. The results of this analysis are depicted in [Tables D2 and D3](#) in Appendix D. Findings confirm the intuition derived from the descriptive statistics. If a student is a non-native speaker, has low achievement in terms of math or literature, or does not follow an academic school track, they are more likely to be a non-complier.

Table 5
Intent-to-treat analysis.

	Post-test financial literacy			
	No country effects (1)	Fixed effects (2)	Random effects (3)	Interaction effects (4)
Treatment	0.339*** (0.043)	0.313*** (0.042)	0.317*** (0.042)	
Pre-test financial literacy	0.285*** (0.023)	0.260*** (0.020)	0.263*** (0.020)	0.263*** (0.020)
Treatment [1] x country [Belgium]				0.618*** (0.097)
Treatment [1] x country [Estonia]				0.182* (0.099)
Treatment [1] x country [Italy]				0.242*** (0.058)
Treatment [1] x country [Slovakia]				0.334** (0.130)
Controls for students characteristics	Yes	Yes	Yes	Yes
Observations	2,220	2,220	2,220	2,220

Note: Financial literacy scores are standardized with a mean of zero and a standard deviation of one. Estimates are the result of an intent-to-treat (ITT) regression of the post-test financial literacy score on a treatment dummy, the pre-test financial literacy score, and a set of controls for student characteristics (gender, age, home language, family, no holidays abroad, math grade, literature grade, and academic school track). Standard errors shown in parentheses.

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

5. Results

5.1. Treatment effect

The effectiveness of the Financial Escape Room is assessed by measuring financial literacy in the post-test. Table 5 presents the results of the intent-to-treat estimation for financial literacy¹⁰. The four models utilized in this study assess the impact of the Financial Escape Room while considering different factors. As described in Section 4.4, Model 1 examines the treatment effect without accounting for any country-specific effects. Model 2 incorporates country fixed effects, while Model 3 incorporates country random effects. Finally, Model 4 explores the country-by-treatment interaction effects.

The pure treatment effects are reported as 0.339 SD in Model 1, 0.313 SD in Model 2, and 0.317 SD in Model 3. It's important to highlight the role of the multi-country factor in the fixed and random effects models, as they reveal similar treatment effects. The fixed effects model considers within-country effects, while the random effects model incorporates additional information by considering both within-country and between-country effects. Consequently, the slightly higher treatment impact observed in the third model is anticipated, given its ability to capture a broader range of effects. To further investigate the varying effects observed among different countries, the fourth model examines the country-specific treatment interaction effects, which yielded results of 0.618 SD for Belgium, 0.182 SD for Estonia, 0.242 SD for Italy, and 0.334 SD for Slovakia. It is worth noting that all models control for baseline financial literacy by including pre-test scores among the control variables.

5.2. Heterogeneity analysis

In the previous section, we discussed the average effects of the *Financial Escape Room* across the entire student population. However, it is important to recognize the potential for significant heterogeneity within the population. To further investigate the impact of the treatment on different subgroups, we examine the interaction effect between the treatment dummy and various student characteristics. This analytical approach enables us to assess the treatment effect on participants while focusing on specific features such as gender, age, and other relevant factors. Table 6 presents the results of this heterogeneity analysis.

Notably, all the interaction coefficients are statistically significant, indicating that they differ from zero. This suggests that the impact of the *Financial Escape Room* is heterogeneous. It is worth exploring the magnitude of these effects, particularly when they exceed the average treatment effect observed in the fixed effects model (0.313 SD). Coefficients surpassing this threshold are associated with gender (0.408 SD), language spoken at home (0.321 SD), enrollment in an academic school track (0.342 SD), and family situation

¹⁰ It's crucial to emphasize that all regressions employ standardized coefficients, with a mean of 0 and a standard deviation of 1. This standardization facilitates straightforward comparisons of treatment effects. Additionally, inverse weighting is employed to address the balancing of treated and control groups in terms of observables.

Table 6
Heterogeneity analysis.

	Post-test financial literacy							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment [1] x Gender [Male]	0.408*** (0.065)							
Treatment [1] x Age		0.019*** (0.0027)						
Treatment [1] x Home Language [Native]			0.321*** (0.044)					
Treatment [1] x [Only one child]				0.172* (0.098)				
Treatment [1] x [Older siblings]				0.353*** (0.072)				
Treatment [1] x [Younger siblings]				0.324*** (0.067)				
Treatment [1] x [Older and younger siblings]				0.368*** (0.114)				
Treatment [1] x No holidays abroad [Yes]					0.264*** (0.076)			
Treatment [1] x Math grade						0.099*** (0.014)		
Treatment [1] x Literature grade							0.101*** (0.014)	
Treatment [1] x Academic school track [Yes]								0.342*** (0.048)
Controls for student characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for pre-test financial literacy score	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,220	2,220	2,220	2,220	2,220	2,220	2,220	2,220

Note: Financial literacy scores are standardized with a mean of zero and a standard deviation of one. Estimates result from an intent-to-treat (ITT) regression of the post-test financial literacy score on the interaction of a treatment dummy with each student characteristic. All student characteristics are also included separately as control variables. We also control for the pre-test financial literacy score. We use the fixed effects model for estimation. Standard errors are shown in parentheses.

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

(younger siblings: 0.324 SD; older siblings: 0.353 SD; both older and younger siblings: 0.368 SD). The intervention tends to have a greater effect on male students, native speakers, and those enrolled in an academic school track. Additionally, having siblings also plays an enhancing role, which may be explained by financial socialization at home. Regarding the other interactions, it is worth noting that even students from lower socio-economic backgrounds (as proxied by having no holidays abroad in the previous year) show a relatively substantial improvement in their scores (0.264 SD).

The intervention's effectiveness may not be fully explained by the analysis presented so far due to further variations across countries. Table 7 explores the differences in the treatment's effectiveness across countries by considering three factors: gender, language spoken at home (proxy for immigrant status), and whether a student has traveled abroad in the past year (proxy for socio-economic status)¹¹. Column 1 presents the results of the interaction effect between gender and treatment, along with country dummies. The results indicate that the effect of gender is predominantly driven by men in Belgium (0.520 SD) and Slovakia (0.455 SD). In both countries, men benefit significantly more from the treatment's effects compared to men in other countries. Column 2 reports the results of the interaction between immigrant status, approximated by the variable "Home Language," with treatment and country effects. The results reveal a particularly strong effect for students in Belgium (0.560 SD). In Belgium, native speakers benefit significantly more from the treatment than non-native speakers. Column 3 reports the effect of socio-economic status, approximated by the variable "No Holidays Abroad," among treated students. The results indicate that the effect is primarily driven by students in Italy (0.364 SD) and Slovakia (0.357 SD).

¹¹ These factors have been shown in PISA results to be important in explaining variations in scores within countries (see also Section 3).

Table 7
Heterogeneity analysis by country.

	Post-test financial literacy		
	(1)	(2)	(3)
Treatment [1] x country [Belgium] x Gender [Male]	0.520*** (0.092)		
Treatment [1] x country [Estonia] x Gender [Male]	0.375*** (0.124)		
Treatment [1] x country [Italy] x Gender [Male]	0.321*** (0.087)		
Treatment [1] x country [Slovakia] x Gender [Male]	0.455** (0.185)		
Treatment [1] x country [Belgium] x Home Language [Native]		0.560*** (0.091)	
Treatment [1] x country [Estonia] x Home Language [Native]		0.290*** (0.101)	
Treatment [1] x country [Italy] x Home Language [Native]		0.241*** (0.059)	
Treatment [1] x country [Slovakia] x Home Language [Native]		0.315** (0.130)	
Treatment [1] x country [Belgium] x No holidays abroad [Yes]			0.050 (0.126)
Treatment [1] x country [Estonia] x No holidays abroad [Yes]			0.027 (0.219)
Treatment [1] x country [Italy] x No holidays abroad [Yes]			0.364*** (0.091)
Treatment [1] x country [Slovakia] x No holidays abroad [Yes]			0.357* (0.193)
Controls for students characteristics	Yes	Yes	Yes
Control for pre-test financial literacy score	Yes	Yes	Yes
Observations	2,220	2,220	2,220

Note: Financial literacy scores are standardized with a mean of zero and a standard deviation of one. Estimates result from an intent-to-treat (ITT) regression of the post-test financial literacy score on the interaction of a treatment dummy with each country and a selection of three student characteristics (gender, home language, and no holidays abroad). All student characteristics are also included separately as control variables. We also control for the pre-test financial literacy score. We use the fixed effects model for estimation. Standard errors are shown in parentheses.

***p<0.01; **p<0.05; *p<0.1

6. Concluding remarks

This paper examined the impact of an online game-based learning activity on students' levels of financial literacy. By conducting a Randomized Control Trial (RCT), the study found that adopting a digital and gamified approach to financial education results in an average improvement of 0.313 SD in students' financial literacy scores. This effect size aligns with the outcomes observed in previous traditional approaches, indicating that game-based initiatives are just as effective as traditional methods¹². Additionally, the findings demonstrate the effectiveness of the intervention across four countries, suggesting the potential for cross-border scalability.

The findings of this study hold significant policy implications for financial education initiatives. One key implication is the cost-effectiveness of online game-based approaches. While the initial development of gamified financial education tools, such as our *Financial Escape Room*, involves significant upfront costs compared to traditional approaches, the implementation costs are relatively low once developed. Traditional financial education methods, such as classroom instruction, require continuous investment in teacher training, curriculum development, and physical materials. Each new cohort of students necessitates repeated expenses. In terms of scalability, digital tools like the one evaluated in this paper can be scaled easily and efficiently. Once the initial investment is made, the marginal costs of providing the tool to additional users are low. This contrasts with traditional methods, where scaling involves proportionally increasing costs: more teachers need to be trained, more classrooms are required, and more materials must be produced and distributed. Another element that contributes to its cost-effectiveness is the ease of distribution and access. Students can access gamified learning tools, such as our *Financial Escape Room*, from anywhere with an internet connection. This reduces the need for physical infrastructure and allows for greater flexibility in learning schedules. In contrast, traditional approaches require physical presence in classrooms, which involves costs related to facilities, utilities, and geographical constraints that can limit access for some students. Finally, digital initiatives excel in long-term sustainability compared to traditional methods. Once digital tools are created, they remain highly sustainable. Periodic updates can keep the content relevant and engaging at a relatively low cost. In contrast, maintaining the quality and relevance of traditional courses requires continuous investment in teacher training and curriculum updates. Additionally, physical materials degrade over time and need to be replaced, adding to long-term costs.

¹² For an overview of effect sizes found in previous studies, see the meta-analyses by Kaiser and Menkhoff (2017), Kaiser and Menkhoff (2020), and Kaiser, Lusardi, Menkhoff, and Urban (2022).

However, while implementing online programs such as the *Financial Escape Room* holds promise for expanding financial education, it comes with its own set of limitations that might be addressed in the future. First, the program is short, which might be tackled by expanding the content to cover a wider range of financial topics in more depth. This could involve incorporating, in addition to modules on payment methods and basic financial knowledge, modules on saving, investing, credit management, and retirement planning. Additionally, it would be useful to develop a game that takes players into a virtual world in which they progress to the next level once they have completed one. This would increase the likelihood that students will be engaged with the game for a longer timespan. Second, since the outcome of the *Financial Escape Room* is not connected to their grades, the stakes for students are also quite low. To increase student engagement and motivation, teachers can consider offering incentives such as certificates of completion, badges, or rewards for achieving certain milestones within the program. Creating a sense of competition through leaderboards or challenges can also encourage participants and foster a collaborative learning environment. Another way of raising the stakes for students and increasing the relevance of the program is by exploring opportunities to integrate online financial education modules into existing curricula. By tying the program to students' grades, teachers can incentivize participation and ensure that students take the material seriously.

Future research could explore whether games also influence financial behaviors or attitudes. Additionally, while this game adopts a storytelling approach as a motivational element to enhance students' learning, future game-based initiatives might focus on a role-playing approach. Role-playing is crucial for triggering behavioral changes (Carlin & Robinson, 2012). Another area for further investigation is the long-term impact of digital game-based activities on financial literacy topics and any potential differences compared to traditional approaches. While the current experiment may not directly investigate long-term outcomes, existing literature suggests that financial education can have enduring positive impacts. For instance, Frisanchi (2023) examines the impact of a large-scale RCT implemented in 300 public high schools in Peru and finds that three years after the intervention, those with outstanding loans in the treatment group reduced arrears by 20%. Similarly, Billari et al. (2023) study an internet-based financial literacy intervention with the largest employer-based pension fund in Italy. Their findings indicate that participants exposed to the program were more likely to seek additional information on financial planning and to change investment lines within the pension fund. A follow-up survey conducted nine months after the initial questionnaire reveals that the nudging towards more active investment behavior persists among those who completed the online seminar. Additionally, a pilot field experiment among undergraduates in Germany by Oberrauch and Kaiser (2024) reveals that three months after a video treatment, financial literacy scores increased by 50 percent of a standard deviation. These findings suggest that digital financial education initiatives, such as video games covering relevant and engaging topics, can significantly improve financial education. However, the three-month follow-up period is relatively short to fully capture the long-term effects.

CRedit authorship contribution statement

Marta Cannistrà: Data curation, Formal analysis, Project administration, Validation, Writing – original draft. **Kenneth De Becker:** Data curation, Formal analysis, Methodology, Writing – review & editing. **Tommaso Agasisti:** Conceptualization, Project administration, Resources. **Aisa Amagir:** Project administration. **Kaire Pöder:** Project administration. **Lukáš Vartiak:** Project administration. **Kristof De Witte:** Conceptualization, Funding acquisition, Project administration, Resources, Supervision.

Acknowledgement

The authors acknowledge support from the European Commission through the Erasmus+ project Eufin (2018-1-BE02-KA203-046843). Kristof De Witte acknowledges financial support from the Flemish Science Organisation through the grant S000617N. This paper has benefitted from the comments of participants at the European Economic Association (EEA) Conference (2023), Bank of Finland Financial Literacy Conference (2023), National Bank of Slovakia Research Seminar (2023), Open Universiteit Accounting and Finance Seminar, Mannheim Institute for Financial Education (MIFE) Early Career Workshop (2022) and Lisbon Economics and Statistics of Education (LESE) Conference (2022).

Appendix

Appendix A: Questionnaires

Appendix A1: Pre-test questionnaire

Information about students

- School name:
- Class:
- Gender:
 - Female
 - Male
- First letter of your mother's name
- First letter of your father's name
- Civic number of your address:

- Year of birth: []
- Month of birth
 - January
 - February
 - March
 - April
 - May
 - June
 - July
 - August
 - September
 - October
 - November
 - December

Studies and economic situation

- Your school's track:
 - Humanities
 - Scientific
 - Linguistics
 - Human Sciences
 - Economic
 - Vocational
- Math grade obtained at the end of previous school year:
 - Less than 50%
 - 50% or more, but less than 60%
 - 60% or more, but less than 70%
 - 70% or more, but less than 80%
 - More than 80%
- Literature grade obtained at the end of previous school year
 - Less than 50%
 - 50% or more, but less than 60%
 - 60% or more, but less than 70%
 - 70% or more, but less than 80%
 - More than 80%
- Which language do you usually speak at home?

[Different options depending on the most spoken languages in the participating countries]

- Description of your domestic situation. If your domestic situation changes sometimes, for instance, because your parents are divorced, select the answer that best fits your domestic situation over the past year:
 - I am an only child
 - I only have older brothers or sisters
 - I only have younger brothers or sisters
 - I have both younger and older brothers and sisters
- How many times have you travelled abroad in the past year for at least two consecutive days?
 - Never
 - 1 time
 - 2 times
 - More than 2 times

Financial literacy questions

1. With a €100 banknote, in five years you will be able to buy:

- More than today
- Less than today
- As today
- I don't know

2. You open a savings account today and deposit €100 on it. The interest on your savings account is about 2% per year. How much money will be in your savings account after 5 years if you don't deposit nor withdraw anything:

- More than €110
- Exactly €110
- Less than €110
- I don't know

3. Joost buys a DVD for €19.00. He receives a discount of 10% on the selling price. He pays with a banknote of €20. How much change does the cashier have to give him back?

- €1.90
- €2.00
- €2.90
- €1.00
- I don't know

4. Select everything that means "handle credit card with care".

- Fill in the data of your credit card only on a secure website of a known and reliable seller
- Write your PIN code on the back of the debit card
- Confirm preferably the payment for your online purchases with a code that you have to fill in on your card reader
- Put your credit card along with the PIN code in your wallet
- I don't know

Appendix A2: Post-test questionnaire

Information about students

- School name: []
- Class: []
- Gender:
 - Female
 - Male
- First letter of your mother's name []
- First letter of your father's name []
- Civic number of your address: []
- Year of birth: []
- Month of birth
 - January
 - February
 - March
 - April
 - May
 - June
 - July
 - August
 - September
 - October
 - November
 - December

Financial literacy questions

1. With a banknote of €50, in 3 years you can presumably buy:

- Less than today
- As today
- More than today

- I don't know

2. Today you open a savings account and deposit €200 on it. The interest on your savings account is 2% per year. How much money will you have in your savings account after 5 years if you will not deposit nor withdraw anything?

- Exactly €204
- More than €204 but less than €220
- Exactly €220
- More than €220
- I don't know

3. Ann buys a book that costs €18. She receives a discount of 10% on the selling price. She pays with a banknote of €20. How much change does the employee have to give her back at the cashier?

- €3.80
- €1.80
- €16.20
- €2.00
- I don't know

4. Indicate which of the following people take care of valuables in their possession.

- Mia can easily give her debit card and the PIN code to her friends.
- Paul put his credit card, with which he can make contactless payments, in a metal case
- Elias immediately calls Card Stop if he loses his debit card
- Helena does not disconnect when she makes a payment with her smartphone because the app closes immediately.
- I don't know

Appendix B: The Financial Escape Room

The game presents students with a series of challenges that they must overcome to access a bank vault. The game is divided into three parts. In this appendix we provide an overview of the questions asked in each part of the game.

Part 1 – Entering the bank

In the first step students need to answer 18 questions correctly covering topics such as means of payment, bank accounts, interest rates, change calculation, and understanding of VAT or inflation. Each answer is linked to a *Morse* code representing a specific letter. Together, all 18 answers form the key that provides students access to the bank. Below, we provide an overview of the 18 questions that needed to be answered with true or false.

1. A Portuguese euro coin looks exactly the same as a Belgian euro coin.
2. If I buy a car of €10,000, I can pay with banknotes of €10 because cash money is a legal paying method.
3. A current account is not the same as a saving account.
4. With a debit card (like Maestro) and with a credit card (like Visa or Mastercard) you can almost always pay in a shop or online.
5. With a prepaid card you can always pay in another country.
6. If you pay with your smartphone, you can pay €100 at a time without using your pin.
7. If someone steals my bank card, he can try all number combinations to crack my pin code.
8. When I transfer money to a person in another country, I need the IBAN-code of that person to avoid high costs.
9. In the EU you can pay with a bank card in most shops.
10. A bitcoin is a metal coin I can pay with.
11. If you receive €100 today, then you will be able to buy less with it next year.
12. The website www.compare.com provides trustworthy information.
13. If you want to know how much money you've got on your account, then you'll find it on number 3 of the bank statement. [A picture of a bank statement is shown with number 3, referring to "Former saldo EUR"]
14. An IBAN-number always begins with a code for the country.
15. From the age of 12, you can take money from your savings account to buy a new bike.
16. Is it a good idea to answer this mail as soon as possible? [A picture of a phishing mail is shown to the students]
17. A cash receipt must mention the rate of VAT.
18. On an invoice, the name of the seller must always be mentioned.

Part 2 – Finding the employee with knowledge of the location of the vault

In the second step, students need to solve 10 calculations. For every correct calculation, they receive a hint to find the employee who knows the location of the vault. Below, we provide an overview of the 10 calculation questions.

1. You move abroad for a year to study. Your parents give you a prepaid card. The card costs €15 a year. Monthly your parents transfer an amount (free of charge). Every month you collect this amount, at a cost of €4 per collect. Every month you check your account and you pay €0.50 per message. How much will your prepaid card have cost after 1 year?
2. I bought a sandwich and it costed €3.50 but as a regular customer I got a 10% discount. How much change will I get on my €20 bill?
3. The rent for my sister's students home is €350 per month. She pays 5% additional costs a year for electricity and internet. How much does she pay a year?
4. A bottle of 1.5 liter of water at €1.20 of 3 small bottles of 0.5 liter at €0.35 per bottle. Which option is correct? Calculate the price per liter!
 - a. Bottle 1.5 liter costs €1.80/l and is most expensive
 - b. Bottle 1.5 liter costs €0.80/l and is cheapest
 - c. Bottle 0.5 liter costs €0.70/l and is cheapest
 - d. Bottle 0.5 liter costs €1.05/l and is most expensive
5. In a shop I want to pay food for €54.50. I have 5 meal vouchers of €8.00 each. How much extra will I have to pay?
6. A whole year, except in July and August, you visit your grandmother every month per train.
 - A go and return ticket costs €9.20.
 - A Go-pass costs €52.00 for 10 single tickets.
 - A youth subscription for a whole year costs €192.00.
7. How much does the cheapest option costs a year?
8. If I want to pay a car of €9000, then I can pay 10% in cash, with a maximum of €3000. How much I am allowed to pay in cash?
9. You can choose between two options for your smartphone (see table below)

	Formula Puma	Formula Panda
Fee per month (€)	€ 15	No monthly fee
National message (€)	Included	€ 0.07
International message (€)	€ 0.11	€ 0.15
1 Mb mobile internet (€)	Included till 50 Mb Above that: €0.05 per Mb	€ 0.10

- Every month you send 100 national messages.
- Every month you send 10 international messages.
- You use 60 Megabyte (Mb) for mobile internet.

How much will the cheapest formula costs per month?

10. Without VAT, my breakfast for two costs €18.93 at 12% VAT and the two coffees €4.63 at 21% VAT. How much do I have to pay VAT included?
11. You found some cool sun glasses on an American web shop. The glasses cost €69.99. The web shop charges extra costs: you pay €5 if you pay it with your bank card and shipping costs are 15% of the purchasing price. You can also buy the glasses in a local shop for €84.99. How much is the total price in the web shop?

Part 3

In the third step, students have to answer 10 multiple choice questions about means of payment. Each answer is linked to a flag representing a specific letter. Together, all 10 answers form the code that enable students to open the bank vault. Below we provide an overview of the 10 multiple-choice questions.

1. At 18, you would like to study abroad with an exchange program. Which of these options is the safest way for your parents to provide the necessary money?
 - a. Cash money
 - b. A prepaid card
 - c. A credit card
 - d. A check
2. You buy a sandwich in the local shop. How will you pay? The local shop has NFC?
 - a. A €20 banknote
 - b. A credit card
 - c. Wireless with your smartphone
 - d. A bank transfer
3. Your elderly sister rents a home. What is for your parents the most practical way to pay the monthly rent of €350?
 - a. A bank transfer
 - b. A standing order
 - c. A credit card
 - d. A prepaid card

4. You buy food and drinks in a supermarket for a total amount of €79.80. How will you pay? The shop has a pay terminal with NFC.
 - a. A check
 - b. Wireless without pincode
 - c. With your debit card in a payment terminal
 - d. With bitcoins
5. How can I pay for food in a shop?
 - a. A check
 - b. A service check
 - c. Eco check
 - d. Dinner check
6. I buy a train ticket on the website of the national railway company. How can I pay this in a save way?
 - a. Payment app on my smartphone
 - b. Debit card and card reader
 - c. Credit card and card reader
 - d. All three options are possible and safe
7. You are 18 and you just got your driving licence. Tomorrow you will collect your first car that you bought with your savings. How will you pay the €9000 to the car dealer?
 - a. Cash money
 - b. A prepaid card
 - c. A bank check on the car dealer's name
 - d. A direct debit
8. Monthly your phone company sends an invoice to pay your fee and consumption. Choose the most practical way to do the payment.
 - a. A bank transfer
 - b. Online transfer without card reader
 - c. Direct debit
 - d. Credit card
9. You have a breakfast with a friend. The restaurant doesn't accept cards. You're the only one who has cash but you both have the banking app. You pay the total amount. How can your friend pay the amount of €26.80 as soon as possible?
 - a. You pass the ATM, he withdraws the money and pays you back in cash
 - b. With a credit card
 - c. With the payment app on your smartphone
 - d. You send a message with the code of a bitcoin
10. You ordered new sunglasses at an American web store for €69.99. What is the best way to pay this?
 - a. An online money transfer with bank card and card reader
 - b. You send money in an envelope
 - c. You phone your bank and and ask them to make the payment
 - d. You buy a prepaid card to pay the amount by an online transfer.

Appendix C: Descriptive statistics per country

Table. C1, Table. C2

Table C1

Descriptive statistics by country

	Belgium	Estonia	Italy	Slovakia
Variable	(N = 644)	(N = 349)	(N = 1,021)	(N = 206)
Gender (Male)	274 (42.55%)	170 (48.71%)	379 (37.12%)	62 (30.10%)
Age (Year)	12.77 (1.00)	14.21 (1.01)	16.59 (0.99)	15.95 (0.76)
Home language (Native)	579 (89.91%)	320 (91.69%)	966 (94.61%)	203 (98.54%)
Family				
1 - Only child	82 (12.73%)	45 (12.89%)	221 (21.65%)	23 (11.17%)
2 - Older siblings	224 (34.78%)	111 (31.81%)	330 (32.32%)	64 (31.07%)
3 - Younger siblings	240 (37.27%)	110 (31.52%)	386 (37.81%)	79 (38.35%)
4 - Older and younger siblings	98 (15.22%)	83 (23.78%)	84 (8.23%)	40 (19.42%)
No holidays abroad (Yes)	112 (17.39%)	43 (12.32%)	384 (37.61%)	76 (36.89%)
Math grade (4)	2.98 (0.99)	3.29 (0.69)	2.87 (0.78)	1.81 (0.77)
Literature grade (4)	3.11 (0.81)	3.44 (0.59)	2.91 (0.58)	1.97 (0.73)
Academic school track (Yes)	576 (89.44%)	349 (100%)	752 (73.65%)	128 (62.14%)
Pre-test financial knowledge (3)	1.19 (0.88)	1.62 (0.91)	2.11 (0.89)	2.25 (0.77)
Pre-test financial behaviour (1)	0.36 (0.48)	0.71 (0.45)	0.56 (0.50)	0.59 (0.49)

(continued on next page)

Table C1 (continued)

	Belgium	Estonia	Italy	Slovakia
Pre-test financial literacy (4)	1.55 (1.07)	2.34 (1.10)	2.67 (1.08)	2.84 (0.97)
Post-test financial knowledge (3)	1.71 (1.02)	1.72 (0.69)	2.32 (0.77)	2.34 (0.76)
Post-test financial behaviour (1)	0.45 (0.50)	0.55 (0.50)	0.83 (0.38)	0.65 (0.48)
Post-test financial literacy (4)	2.16 (1.21)	2.26 (0.88)	3.15 (0.89)	2.99 (0.94)

Note: Standard errors are reported in parentheses, with the exception of gender, home language, family, and country, where percentages are given. Gender represents the relative share of boys in our sample. Age represents the average age of the participating students. Home language is a dummy indicating whether a student speaks the local language at home. Family is a categorical variable indicating whether someone has older or younger siblings. No holidays abroad is a dummy indicating whether the student has not travelled abroad, serving as a proxy for the socio-economic status of the student. Math and literature grades refer to the results of the previous year. These are self-reported and range from 0 to 4. Each category represents a certain range of results: 0 "Less than 50%"; 1 "50% or more, but less than 60%"; 2 "60% or more, but less than 70%"; 3 "70% or more, but less than 80%"; 4 "More than 80%". Academic track is a dummy indicating whether a student belongs to an academic school track. The pre- and post-test financial knowledge scores are based on a set of three financial knowledge questions measuring knowledge of the concepts of inflation, compound interest, and change calculation, while the pre- and post-test financial behaviour scores measure careful card handling behaviour. The pre- and post-test financial literacy scores are based on the sum of the pre-test financial knowledge and behaviour scores

Table C2

Comparison of the sample and population by academic school track and gender

		Gender		Academic school track	
		Male	Female	Yes	No
Belgium	Real	48.99%	51.01%	47.31%	52.69%
	Experiment	42.55%	57.45%	89.44%	10.56%
Estonia	Real	47.19%	52.81%	54.53%	45.47%
	Experiment	48.71%	51.29%	100%	0.00%
Italy	Real	47.00%	53.00%	54.77%	45.22%
	Experiment	37.12%	62.88%	73.65%	26.35%
Slovakia	Real	50.06%	49.94%	35.97%	64.03%
	Experiment	30.10%	69.90%	62.14%	37.86%

Note: The Table presents a comparison between the distribution of students among the three (macro) school tracks and by gender in experiment's sample and in the referred population.

Appendix D: Attrition

Table. D1, Table. D2, Table. D3

Table D1

Descriptive statistics by compliers and non-compliers

	Compliers	Non-compliers
Gender (Male)	885 (39.86%)	589 (44.72%)
Age (Year)	15.05 (0.04)	14.47 (0.05)
Home language (Native)	2,068 (93.15%)	1,078 (81.85%)
Family		
1 - Only child	371 (16.71%)	176 (13.36%)
2 - Older siblings	729 (32.84%)	426 (32.35%)
3 - Younger siblings	815 (36.71%)	444 (33.71%)
4 - Older and younger siblings	305 (13.74%)	271 (20.58%)
No holidays abroad (Yes)	615 (27.70%)	323 (24.53%)
Math grade (4)	2.87 (0.91)	2.61 (1.02)
Literature grade (4)	2.97 (0.76)	2.76 (0.89)
Academic school track (Yes)	1,805 (81.31%)	962 (73.04%)
Country		
Belgium	644 (50.51%)	631 (49.49%)
Estonia	349 (58.17%)	251 (41.83%)
Italy	1,021 (75.91%)	324 (24.09%)
Slovakia	206 (64.98%)	111 (35.02%)
Observations	2,220	1,317

Note: This table reports the compliers and non-compliers. Compliers are those students who participated in both the pre-test and the post-test. Non-compliers are those who participated only in the pre-test. Standard errors are reported in parentheses, with the exception of gender, home language, family, and country, where percentages are given. Gender represents the relative share of boys in our sample. Age represents the average age of the participating students. Home language is a dummy indicating whether a student speaks the local language at home. Family is a categorical variable indicating whether someone has older or younger siblings. No holidays abroad is a dummy indicating whether the student has not travelled abroad, serving as a proxy for the socio-economic status of the student. Math and literature grades refer to the results of the

previous year. These are self-reported and range from 0 to 4. Each category represents a certain range of results: 0 "Less than 50%"; 1 "50% or more, but less than 60%"; 2 "60% or more, but less than 70%"; 3 "70% or more, but less than 80%"; 4 "More than 80%". Academic track is a dummy indicating whether a student belongs to an academic school track.

Table D2

Selective attrition for the pooled sample.

Dependent variable	Attrition
Gender	0.0283 (0.0217)
Age	0.0030 (0.0197)
Home language	-0.1532*** (0.0314)
Family (ref. 1 – Only child)	
2 - Older siblings	0.0064 (0.0349)
3 - Younger siblings	-0.0002 (0.0250)
4 - Older and younger siblings	0.0358 (0.0323)
No holidays abroad	-0.0176 (0.0216)
Math grade	-0.0408*** (0.0108)
Literature grade	-0.0456***
Academic school track	-0.1043** (0.0446)
Country Estonia (ref.: Belgium)	-0.0112 (0.1344)
Country Italy (ref.: Belgium)	-0.2406**
Country Slovakia (ref.: Belgium)	-0.2129**
Constant	0.8877***
Observations	3,537
R ²	0.4592

This table reports the estimates of an OLS regression of an attrition indicator (a dummy variable indicating whether there are missing observations between the pre-test and post-test) on the socio-economic variables (gender, age, home language, family, math grade, literature grade, academic school track) and country dummies. Standard errors are in parentheses and are clustered at the school level.

***p<0.01; **p<0.05; *p<0.1.

Table D3

Selective attrition for the cross-countries sample.

Dependent variable	Attrition			
	Belgium	Estonia	Italy	Slovakia
Gender	-0.0001 (0.0352)	-0.0063 (0.0647)	0.0411 (0.0297)	0.0962 (0.0786)
Age	0.0220 (0.0362)	0.0084 (0.0522)	-0.0265 (0.0194)	-0.0692** (0.0210)
Home language	-0.1672*** (0.0513)	-0.1410 (0.0837)	-0.0712 (0.0416)	-0.1020 (0.2007)
Family (ref. 1 – Only child)				
2 - Older siblings	0.0542 (0.0462)	0.0605 (0.0524)	-0.0163 (0.0581)	-0.1150 (0.1119)
3 - Younger siblings	0.0124 (0.0392)	0.1329** (0.0516)	-0.0184 (0.0260)	-0.1521 (0.1222)
4 - Older and younger siblings	0.1040** (0.0489)	0.0854 (0.0734)	-0.0074 (0.0563)	-0.1938 (0.1389)
No holidays abroad	0.0107 (0.0489)	0.0732 (0.0453)	-0.0510** (0.0184)	-0.1044** (0.0268)
Math grade	-0.0313* (0.0175)	-0.0499 (0.0480)	-0.0358** (0.0122)	0.0443 (0.0223)
Literature grade	-0.0358 (0.0269)	-0.1008** (0.0417)	-0.0370 (0.0205)	0.0430* (0.0175)

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Table D3 (continued)

Dependent variable	Attrition			
	Belgium	Estonia	Italy	Slovakia
Academic school track	-0.1982* (0.1047)		-0.0809** (0.0326)	0.0135 (0.0517)
Constant	0.6434 (0.5148)	0.8285 (0.7103)	1.0285** (0.3721)	1.5032 (0.3119)
Observations	1,275	600	1,345	317
R ²	0.1248	0.0558	0.0247	0.0566

This table reports the estimates of an OLS regression at the country level of an attrition indicator (a dummy variable indicating whether there are missing observations between the pre-test and post-test) on the socio-economic variables (gender, age, home language, family, math grade, literature grade, academic school track). Standard errors are in parentheses and are clustered at the school level.

***p<0.01; **p<0.05; *p<0.1.

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