Found in translation: English as a decoder for financial education

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Received: 2025-05-05 / Accepted: 2026-01-07
https://doi.org/10.30827/portalin.vi45.33718
Porta Linguarum ISSN paper edition: 1697-7467, ISSN digital edition: 2695-8244

ABSTRACT: Financial literacy is a vital life skill, yet it is often taught in isolation from other key subjects. This study proposes the English language classroom as a space where linguistic and mathematical skills converge through financial education content. We hypothesize that L2 acquisition and mathematics mutually reinforce one another through shared cognitive processes, leading to better performance in financial literacy and overall academic outcomes. Using survey data and machine learning methods, we find a strong positive relationship: students who perform well in both English and quantitative reasoning consistently demonstrate higher financial literacy. Our analysis also reveals a common metacognitive gap—students frequently misjudge their financial competence, a disconnect amplified by limited language skills. Learners with advanced English proficiency show greater critical awareness when making financial decisions, highlighting the role of language in shaping financial judgment. These findings support a more integrated curriculum in which financial education is embedded into English instruction. Incorporating financial and analytical problem-solving as a transversal element in L2 curricula and policy can strengthen both language and financial skills, while preparing students to interpret complex transactions and navigate real-world economic situations—within a single classroom.
Keywords: financial literacy, English L2, machine learning. student confidence, transversality.

Encontrado en la traducción: el inglés como decodificador de la educación financiera

RESUMEN: La educación financiera es una habilidad vital, pero a menudo se enseña por separado de otras materias clave. Este estudio propone el aula de inglés como un espacio donde convergen las competencias lingüísticas y matemáticas a través de contenidos de educación financiera. Nuestra hipótesis es que la adquisición de una segunda lengua (L2) y las matemáticas se refuerzan mutuamente mediante procesos cognitivos compartidos, mejorando tanto el rendimiento académico general como la educación financiera. A partir de datos de encuestas y métodos de aprendizaje automático, encontramos una fuerte correlación positiva: los estudiantes que destacan en inglés y razonamiento cuantitativo también obtienen mejores resultados en educación financiera. Nuestro análisis revela además una brecha metacognitiva común: muchos estudiantes evalúan mal su competencia financiera, especialmente aquellos con habilidades lingüísticas limitadas. En cambio, los alumnos con mayor dominio del inglés muestran mayor conciencia crítica al tomar decisiones financieras, lo que subraya el papel del lenguaje en el juicio económico. Estos hallazgos respaldan un

currículo más integrado, en el que la educación financiera se incorpore a la enseñanza del inglés. Incluir la resolución de problemas financieros y analíticos como eje transversal puede fortalecer ambas competencias y preparar a los estudiantes para afrontar desafíos económicos reales desde el aula de idiomas.
Palabras clave: educación financiera, inglés L2, aprendizaje automático, confianza del alumnado, transversalidad

1. Introduction

Teaching financial literacy in a second language can create a practical, interdisciplinary context where mathematical reasoning is applied through linguistic practice. This cross-curricular approach not only fosters deeper engagement but also reflects the demands of today's globalized economy, where managing finances across languages is increasingly relevant. Financial transactions, contracts, and economic opportunities often require multilingual understanding, making bilingual financial competence a valuable asset.

There is growing evidence that bilingualism offers significant cognitive, academic, and social advantages. In particular, it supports mathematical development by improving conceptual comprehension, problem-solving abilities, and metalinguistic awareness. González (2018) showed that bilingual textbooks facilitate concept retention by clarifying terminology through translation. Thoma (2016) highlights how language switching and cross-linguistic transfer enhance problem-solving and cognitive flexibility. These skills, in turn, contribute to improved financial literacy—defined as the ability to understand and use financial information to make informed decisions.

Bilingual learners demonstrate stronger financial behaviours. Cummins (2017) found that students proficient in more than one language tend to outperform their monolingual peers in budgeting, planning, and saving. Such findings suggest that language and financial reasoning are mutually reinforcing. In this context, teaching financial literacy through English as a foreign language may simultaneously strengthen mathematical understanding and foster real-world readiness.

Moreover, the World Bank (2020) emphasizes financial education's role in reducing inequality and promoting inclusion, especially among vulnerable populations. As Demirgüç-Kunt et al. (2018) report, 1.7 billion adults lacked access to formal financial services in 2017. Language barriers remain a key obstacle in many multilingual communities. Financial education programmes tailored to bilingual learners can help overcome these gaps by empowering individuals to interact confidently with the formal economy and make informed choices about banking, credit, and investment.

This paper investigates the hypothesis that second language learning—specifically English—enhances financial literacy by strengthening core cognitive functions also used in mathematics. It presents empirical evidence from a combined sample of secondary and university students, with a primary focus on secondary education. By analysing how English proficiency affects financial decision-making and performance, the study contributes to ongoing debates on education policy, bilingual instruction, and economic empowerment.

The remainder of this paper is structured as follows: Section 2 reviews relevant literature on bilingualism, cognition, and financial education. Section 3 describes the survey data used. Section 4 outlines the machine learning methodology applied. Section 5 presents the results. Section 6 discusses the implications for pedagogy and policy. Section 7 concludes with key findings and recommendations.

2. Background of studies

2.1 Bilingualism and Mathematical skills

Bilingualism is a valuable skill in today's globalized world and can serve as a vehicle for teaching financial literacy, strengthening students' grasp of mathematical concepts. One key benefit is improving comprehension of mathematical vocabulary in a second language. González (2018) found that bilingual maths textbooks enhance students' understanding by providing translations and clarifying terminology. Similarly, Ufer and Bochnik (2020) highlight the role of subject-specific language skills in elementary maths learning.

Bilingualism also enhances problem-solving skills through language switching and cross-linguistic transfer (Thoma, 2016). Gerber, Engelbrecht, and Harding (2005) found that students receiving instruction in a second language perform better in mathematics than monolingual students. Furthermore, it contributes to financial literacy. Cummins (2017) found that bilingual students outperform their monolingual peers in financial planning, budgeting, and saving. Broadening financial education access can help create greater opportunities later in life.

Language and maths skills are closely linked. Carey and Jacobson (2020) emphasize the role of language in mathematical comprehension, while Farukh, Ahmad, and Shah (2020) found that first-language and maths skills predict second-language proficiency, regardless of gender.

2.2 Interdisciplinary teaching, informal Maths learning, and financial literacy

Interdisciplinary learning can create unexpected cognitive benefits, particularly in areas where linguistic and mathematical skills overlap. Carey and Jacobson (2020) found that acquiring a second language positively impacts informal mathematical learning. Neuropsychological studies suggest that linguistic and mathematical abilities share common cognitive processes and developmental cycles (Farukh et al., 2020), making them strong predictors of each other.

These links extend to financial education, where language skills can reinforce economic decision-making. Erner et al. (2016) stress the need for comprehensive financial education, as basic financial literacy relies on maths skills, while more advanced literacy depends on cognitive and linguistic abilities. Empirical studies reinforce this connection: in South Africa, where many students learn maths in English despite speaking other native languages, bilingual students showed stronger maths outcomes (Gerber et al., 2005). In Singapore, Ho and Lee (2022) found that English language learning correlated with risk-taking attitudes and financial conscientiousness. Similarly, Brown et al. (2018) observed that German-speaking Swiss students had higher financial literacy levels than their French-speaking peers, with bilingual students outperforming monolinguals. This aligns with recent syntheses that highlight the multidimensional impact of financial education programmes on knowledge and behaviour (Kaiser & Lusardi, 2024).

Language-maths relationships continue to manifest across education levels. Zhang et al. (2017) found that linguistic skills strongly predict informal and formal mathematical abilities in young Chinese children. A German study of third-grade students confirmed that subject-specific language skills are critical for maths development and financial literacy acquisition. At the university level, Martschink (2022) observed that first-year engineering students sometimes communicate in a foreign language when solving mathematical problems, further supporting the link between linguistic and mathematical skills.

2.3 Relevance in the Spanish context

In Spain, new language didactics methodologies and English proficiency are increasingly required in education and employment. The LOMLOE highlights these goals as essential for international communication and career advancement, mandating reinforcement throughout all educational stages (Article 16). Gutiérrez-Pérez et al. (2019) found that English proficiency significantly predicts maths achievement among Spanish secondary students, even when accounting for gender, socioeconomic status, and prior performance.

Financial education is also emphasized in the LOMLOE, recognizing financial literacy as essential for personal and social development. Economics and mathematical concepts are integrated into the curriculum, with an introductory economics course available in the fourth year of secondary education (ESO) and mandatory economics courses in the final two years of *Bachillerato*.

3. Data

3.1 The survey

This study employs a comprehensive survey to examine the relationship between linguistic abilities, mathematical skills, and financial literacy. Designed to ensure representativeness across demographics, it includes students from public, private, and semi-private schools across urban, metropolitan, and rural areas in Granada. The full survey is accessible at https://encuestas.ugr.es/index.php/667779?lang=es.

Conducted online via Lime Survey through the University of Granada, the survey adhered to institutional guidelines on consent and privacy, enabling broad participation and overcoming geographical limitations. By incorporating multiple variables—language proficiency, maths skills, and financial literacy—the study provides insights into how these factors interact, informing educational strategies and interventions.

To quantify financial literacy, we created the variable FINLIT_OBSERVED, based on correct responses to survey questions modelled after established assessments like PISA (OECD, 2017). The questions align with key financial literacy domains, including budgeting, saving, and understanding financial products (Lusardi & Mitchell, 2011). A rigorous validation process—literature review, expert consultations, and pilot testing—ensured clarity and reliability. Using a multiple-choice and scenario-based format, the survey allows for a robust assessment of students' financial knowledge (Fernandes et al., 2014), facilitating comparisons with international benchmarks.

However, financial literacy is shaped by cultural and socioeconomic contexts. Thus, FINLIT_OBSERVED should be interpreted as a relative measure within the surveyed population.

3.2 Confidence in Maths and English Skills

The survey introduced two variables, MATH_DIFF and ENG_DIFF, to measure the discrepancy between students' self-perceived abilities and their actual performance in mathematics and English. A positive MATH_DIFF value indicates an overestimation of maths skills, whereas a negative value suggests underestimation (Ehrlinger et al., 2008; Dunning et

al., 2003). Similarly, ENG_DIFF reflects overestimation when positive and underestimation when negative (Kruger & Dunning, 1999). These metrics helped identify overconfidence and underconfidence, both of which influence learning: overconfident students may lack motivation to improve, while underconfident students risk disengaging from learning opportunities. Recognizing these patterns enables educators to develop strategies that promote a balanced self-perception and academic growth (Casscells et al., 1978; Pomerantz et al., 2007).

For a comprehensive analysis, MATH_DIFF and ENG_DIFF should be examined in conjunction with academic performance, self-perception, and contextual factors (Koriat et al., 2001; Wigfield et al., 2008). This integrated approach offers deeper insights into confidence levels, self-assessment accuracy, and their impact on educational outcomes and financial literacy. A complete list of survey variables and definitions is provided below in Table 1.

Table 1. *Variables and definitions*

VARIABLE CODE	*DESCRIPTION*
ID	ID
DATE	Date
SCHOOL	School
BILIN	Bilingual Programme
PUBL	Public School
CONCER	*Concertado*
PRIVA	Private School
SEG_ESO	2nd Year of Secondary Education
TER_ESO	3rd Year of Secondary Education
CUARTO_ESO	4th Year of Secondary Education
PRI_BACH	1st Year of High School
SEG_BACH	2nd Year of High School
PRO	Vocational training
SEX	Gender
AGE	Age
NATIONALITY	Nationality
NATION_MOTHER	Mother's nationality
NATION_FATHER	Father's nationality
OWNRATE_ENG	Own assessment of English level
OWNRATE_MATH	Own assessment of maths level
ENG_FAIL	English assessment previous year – Fail
ENG_PASS	English assessment previous year - Pass
ENG_B	English assessment previous year - Level B
ENG_A	English assessment previous year - Level A
MATH_FAIL	Maths assessment previous year - Fail
MATH_PASS	Maths assessment previous year - Pass
MATH_B	Maths assessment previous year - Level B
MATH_A	Maths assessment previous year - Level A
ENG_OUTSIDE	Do you study English outside school?
LIVING_SP	Have you ever lived outside Spain?

VARIABLE CODE	*DESCRIPTION*
STUDY_FINAN	Have you taken any financial education classes?
BANK_ACC	Own bank account
SCHOOLRATE_FIN	School rating for Financial Preparation (given by the student)
FIN_NECESSARY	Is financial education a relevant course of study?
TOMATO_F1	Tomato Question - Option 1
TOMATO_RIGHT	Tomato Question - Correct Answer
TOMATO_F2	Tomato Question - Option 2
TOMATO_DK	Tomato Question - Don't Know
CONTRATO_F1	Mobile Phone Contract - Option 1
CONTRATO_RIGHT	Mobile Phone Contract - Correct Answer
CONTRATO_F2	Mobile Phone Contract - Option 2
PLAN_F1	Mobile Phone Plan - Option 1
PLAN_RIGHT	Mobile Phone Plan - Correct Answer
PLAN_F2	Mobile Phone Plan - Option 2
PLAN_F3	Mobile Phone Plan - Option 3
RATES_RIGHT	Lowest Rate Provider - Correct Answer
RATES_F1	Lowest Rate Provider - Option 1
RATES_F2	Lowest Rate Provider – Correct Answer
RATES_DK	Lowest Rate Provider - Don't Know
INFLATION_F1	Inflation Question - Option 1
INFLATION_F2	Inflation Question - Option 2
INFLATION_RIGHT	Inflation Question - Correct Answer
INFLATION_DK	Inflation Question - Don't Know
INVESTMENT_F1	Investment Question - Option 1
INVESTMENT_RIGHT	Investment Question – Correct Answer
INVESTMENT_DK	Investment Question - Don't Know
WIFI_F1	WIFI Question – Option 1
WIFI_F2	WIFI Question – Option 2
WIFI_RIGHT	WIFI Question – Correct Answer
WIFI_F3	WIFI Question – Option 3
MOBILE_RIGHT	Mobile Question – Correct Answer
MOBILE_F1	Mobile Question – Option 1
MOBILE_F2	Mobile Question – Option 2
RISK_RIGHT	Risk Question – Correct Answer
RISK_F1	Risk Question – Option 1
RISK_F2	Risk Question – Option 2
FINLIT_OBSERVED	Score on observed Financial Education from the number of right answers to the questions on financial education. The score is scaled to 10
MATH_DIFF	Difference between the self-assessment on Maths and the scored obtained the previous course on this subject
ENG_DIFF	Difference between the self-assessment on English and the scored obtained the previous course on this subject

4. METHODOLOGY: A MACHINE LEARNING APPROACH

4.1 Descriptive statistics

The main descriptive findings of the study are presented in Table 2 at the end of this section. These include students' observed financial literacy scores (FINLIT_OBSERVED), self-assessed maths and English proficiency (OWNRATE_and OWNRATE_ENG), and the gap between perceived and actual performance (MATH_DIFF and ENG_DIFF). The results indicate that students tend to overestimate their abilities in both and English, with average discrepancy values above 1.5. The median financial literacy score is 5.5 on a 10-point scale, suggesting moderate knowledge overall. These indicators offer a concise snapshot of how academic self-perception relates to actual financial knowledge in the sample.

4.2 School and student demographics

As shown in Table 2, the sample includes a balanced mix of students from public, concertado (semi-private), and private schools, with *concertado* institutions being the most represented. The age range spans across all secondary education stages and the first and second years of *Bachillerato*. Gender distribution is nearly even, and a small but notable portion of students have at least one foreign-born parent. The variable BILIN indicates that 59.08% of students in the sample are enrolled in a bilingual programme. However, this classification refers to institutional labels rather than actual bilingual proficiency, as the extent of second-language instruction depends on teaching methodologies, administrative priorities, and individual learning abilities. The distribution of students across different school types shows that 16.65% attend public schools (PUBL), 66.83% are enrolled in *concertado* schools (CONCER), which receive both public and private funding, and 16.40% study in private institutions (PRIVA).

Regarding educational stages, 13.04% of students are in the second year of Secondary Education (SEG_ESO), typically aged 13-14, while 30.31% are in the third year (TER_ESO), corresponding to ages 14-15. The fourth year of Secondary Education (CUARTO_ESO), the final stage of compulsory schooling, represents 20.25% of the sample and generally includes students aged 15-16. In post-compulsory education, 21.61% are in the first year of *Bachillerato* (PRI_BACH), aged 16-17, while 14.41% are in the second year (SEG_BACH), typically aged 17-18. The survey also captures the minimal representation of students in vocational training (PRO), which accounts for just 0.25% of the sample.

The gender distribution in the sample is nearly balanced, with 48.63% identifying as male and 51.37% as female (SEX). Only 2.97% of students report a non-Spanish nationality (NATIONALITY), while 5.33% and 6.08% have mothers and fathers of foreign nationality, respectively (NATION_MOTHER, NATION_FATHER). The total percentage of students with at least one foreign-born parent is approximately 12%, although the sample may not fully reflect national immigration trends.

Table 2. *Detailed Descriptive Results and Self-Assessment*

ASPECT	*DETAIL/VALUE*
Financial Literacy (FINLIT_OBSERVED)	Median: 5.5 (Scale of 10), with 60% of students scoring below 6
Self-Assessment in (OWNRATE_MATH)	Median: 6.93, showing significant variation (range: 3-10)
Self-Assessment in English (OWNRATE_ENG)	Median: 6.98, showing significant variation (range: 3-10)
Difference in Self-Assessment vs. Grades (MATH_DIFF, ENG_DIFF)	Positive values (mean: +1.5) indicate students overestimate their skills, especially in math
Bilingual Students and Financial Literacy	Bilingual students score on average 0.8 points higher in financial literacy than monolingual peers ($p < 0.05$)
Influence of School Type	Private and semi-private (concertado) school students score 0.9 points higher in financial literacy than public school students
PISA Comparison	Spanish students' financial literacy score (481) is below the OECD average (505), indicating a gap in financial education
Graphical Findings	Among students scoring above 7 in financial literacy, 65% overestimate their skills, while 58% overestimate their English skills (Figures 4-5).

4.3 English and assessment

Students displayed a wide range of performance in both English and mathematics. While formal grades offer one perspective, the survey also captured students' self-assessed competence levels. The median self-assessment scores are 6.98 for English and 6.93 for math, but the average overestimation—represented by MATH_DIFF and ENG_DIFF—exceeds 1.5 points. As shown in Table 2, this overconfidence is prevalent and correlates with other key variables. Furthermore, nearly half of the students report receiving extra instruction in English outside the school system. These elements point to a notable discrepancy between perceived and actual academic ability, which is relevant for financial literacy. The dataset includes variables assessing students' performance in English and mathematics. In English, 6.86% failed the subject in the previous academic year (ENG_FAIL), while 26.34% passed with a grade of 5-6 out of 10 (ENG_PASS). Students achieving a *notable* (B-equivalent) grade between 7.0 and 8.9 represented 33.17% (ENG_B), whereas 33.42% obtained a *sobresaliente* (A-equivalent) grade of 9.0-10 (ENG_A). The corresponding performance variables indicate that 10.26% of students failed (MATH_FAIL), while 25.41% received a passing grade (MATH_PASS). A grade of *notable* was obtained by 34.29% (MATH_B), and 30.04% scored a *sobresaliente* (MATH_A).

A significant proportion of students, 47.93%, study English outside of school through academies, private tutors, or other means (ENG_OUTSIDE). In terms of financial education, 54.19% of students have taken a formal course in financial literacy or economics (STUDY_FINAN).

Students' self-assessments provide further insight into their perceived competencies. The median self-rated proficiency in English (OWNRATE_ENG) is 6.98 out of 10, while for mathematics (OWNRATE_MATH), the median score is 6.93. These self-assessments, however, do not always align with actual performance. The variables ENG_DIFF and MATH_DIFF measure the gap between self-perception and reported grades, with median values of 3.33 and 3.10, respectively. A positive value suggests overestimation, whereas a negative value indicates underconfidence. Overconfidence may lead students to invest less effort in skill improvement, while underconfidence could discourage engagement despite demonstrated competence. Understanding these discrepancies is crucial for designing targeted educational interventions.

4.4 Financial literacy variables

Table 2 also summarizes students' financial literacy scores and related indicators. Students demonstrate higher accuracy on questions related to everyday decision-making—such as budgeting and price comparisons—but encounter difficulties with more complex concepts like inflation and interest rates. Financial literacy indicators reveal that 46.43% of students have a personal bank account (BANK_ACC), which may contribute to their financial independence. While students rate their financial education at 5.4 out of 10 (SCHOOLRATE_FIN), an overwhelming 92.99% consider financial literacy an essential skill (FIN_NECESSARY).

Specific survey questions assess students' financial knowledge, covering topics such as budgeting, saving, and investment. For instance, 76.39% correctly answered a question requiring basic logical reasoning (TOMATO_RIGHT), though a notable proportion (7.37%) admitted uncertainty (TOMATO_DK). Similar patterns emerge in questions on financial products, risk management, and inflation, with higher accuracy in areas directly relevant to students' daily lives, such as mobile phone contracts (MOBILE_RIGHT), and lower accuracy in more abstract economic concepts like interest rates (RATES_RIGHT) and inflation (INFLATION_RIGHT). These findings suggest potential gaps in financial education curricula, reinforcing the need for targeted instruction on economic principles.

The median financial literacy score (FINLIT_OBSERVED) in this study is 5.5 out of 10, indicating a moderate level of financial knowledge among students. When compared to the 2018 PISA results, which reported an average financial literacy score of 481 for Spanish students (below the OECD average of 505), these findings suggest room for improvement. Given that students struggled with certain financial concepts, incorporating more comprehensive economic education into school curricula could enhance their ability to make informed financial decisions. Strengthening financial literacy programmes, particularly in areas such as inflation and investment, is essential for equipping students with the knowledge necessary to navigate an increasingly complex financial landscape.

4.5 A Machine learning approach

This study employs machine learning techniques to explore the relationship between linguistic proficiency, particularly in a second language, and financial literacy. While the link between skills and financial literacy is well established (Fernandes et al., 2014), the influence

of language proficiency remains underexplored. Recent advancements in machine learning provide an opportunity to uncover complex patterns in educational and financial behaviour (Breiman, 2001). This analytical strategy parallels current approaches using neural-based learning machines to predict financial behaviours (Baveja & Verma, 2024)

The analysis applies the random forest algorithm, an ensemble learning method that improves predictive accuracy by aggregating multiple decision trees (Breiman, 2001). This technique is particularly effective for analysing large datasets and identifying key variables influencing financial literacy outcomes. Two key components of the analysis include the confusion matrix, which measures model accuracy in classifying financial literacy levels based on linguistic factors, and variable importance, which assesses the relative influence of different predictors.

While random forest modelling provides valuable insights, it does not establish causality, and interpretation must account for potential biases in the dataset. The quality and representativeness of the training and test data are crucial for ensuring valid and generalizable conclusions. Despite these limitations, machine learning offers a powerful tool for identifying the role of linguistic capabilities in financial literacy. The findings from this study may inform future educational strategies and curriculum development aimed at enhancing students' financial decision-making skills through improved language instruction.

4.6 Instrument validity and predictive insights

The validity of the instrument was addressed through several complementary strategies. First, content validity was ensured by designing the financial literacy questions based on internationally recognized frameworks, notably the OECD's PISA Financial Literacy assessment (2017) and the work of Lusardi & Mitchell (2011). The instrument covered core domains such as saving, budgeting, inflation, interest rates, and risk evaluation. Expert reviews and a pilot with a subsample of students were conducted to assess item clarity, age appropriateness, and cultural relevance. This preliminary phase allowed for refinements in wording and structure.

Construct validity was reinforced through the predictive performance of a machine learning model applied to the final dataset. Recent quasi-experimental studies further support the causal impact of structured financial literacy instruction on decision-making and long-term financial health (Frees et al., 2024). Using a random forest algorithm, we estimated the contribution of each variable to the observed financial literacy score (FINLIT_OBSERVED). The model achieved 95% accuracy, 92% precision, and 94% recall, with a root mean square error (RMSE) of 0.35. These metrics suggested a strong internal consistency and confirm that the selected variables align with theoretical expectations.

For instance, the variables MATH_DIFF and ENG_DIFF, which measure the discrepancy between students' self-assessed and actual performance in mathematics and English, emerged as significant predictors. Specifically, each one-point increase in MATH_DIFF (i.e., higher overestimation of skills) corresponds to a 1.76-point increase in financial literacy scores, while ENG_DIFF contributes 1.65 points. These results suggest that moderate overconfidence in academic skills is associated with better performance in financial reasoning tasks. Rather than indicating a lack of awareness, these gaps may

reflect greater informal problem-solving engagement or higher metacognitive activation. Similarly, the variable BILIN, which identifies students enrolled in bilingual programmes, is associated with an average increase of 0.8 points in financial literacy ($p < 0.05$), even after controlling for age, school type, and self-assessed skills. This result confirms the added value of second language acquisition—especially English—as a cognitive amplifier for interpreting and managing economic information. The effect size is not trivial: in a 10-point scale, an increase of 0.8 points represents a meaningful shift in competence, reinforcing the study's main hypothesis.

The model's ability to recover these theoretically grounded relationships supports the structural validity of the instrument and confirms that the financial literacy score captures not only factual knowledge, but also confidence dynamics and language-mediated reasoning. By combining expert-informed design, pilot testing, and algorithmic validation, we provide a multi-faceted validation strategy suitable for interdisciplinary research. These findings suggest that machine learning can complement classical validation techniques by identifying patterns that would be difficult to capture through linear models or simple statistical correlations alone.

5. Results

5.1 Main relationships

As consolidated in Table 2, students with higher financial literacy scores also tend to report higher self-assessments in and English. Interestingly, those with the greatest confidence gaps (i.e., overestimation) often perform better on financial literacy questions, indicating that moderate overconfidence may align with informal problem-solving confidence. However, this same overconfidence can mask gaps in specific financial concepts. Notably, bilingual students and those in private or semi-private schools score significantly higher in financial literacy, by approximately 0.8 to 0.9 points. These patterns suggest both academic and contextual factors influence financial education outcomes.

There is a median score of 5.5 for FINLIT_OBSERVED, indicating a moderate level of financial literacy among students. However, a concentration of lower scores suggests that a substantial proportion of students lack essential financial knowledge and decision-making skills. This distribution underscores the need for targeted financial education programmes to address deficiencies in budgeting, saving, and investing.

As for the self-assessment in Mathematics and English, the distributions of OWNRATE_and OWNRATE_ENG, show median values of 6.93 and 6.98, respectively. There is notable dispersion in self-assessment scores which highlights the subjective nature of students' confidence in their and English abilities. While some accurately gauge their proficiency, others exhibit overconfidence or underconfidence, which can impact their academic growth. Objective measures such as standardized assessments could complement self-assessments to ensure a more accurate evaluation of students' skills.

As for the relationship between MATH_DIFF and ENG_DIFF with FINLIT_OBSERVED, students with the highest financial literacy scores also tend to overestimate their and English abilities. This pattern suggests a link between overconfidence and financial literacy, possibly

because students comfortable with informal problem-solving contexts feel more adept at financial decision-making. However, overconfidence may also create knowledge gaps, warranting further investigation into its implications for financial education. Studies by Dohmen et al. (2012) and Lusardi & Mitchell (2014) emphasize the importance of addressing overconfidence in educational settings to improve learning outcomes.

We also examined financial literacy in relation to academic performance in English and math. While higher grades in both subjects are generally associated with better financial literacy, the presence of outliers suggests that other factors, such as exposure to financial concepts outside the classroom and personal motivation, also contribute to financial literacy outcomes. These findings support an integrated approach to financial education that leverages both mathematical and linguistic skills.

The variable SCHOOLRATE_FIN, which measures students' perceptions of their schools' financial education quality, has a median score of 5.4. However, the significant dispersion in ratings suggests inconsistencies in financial education across schools. Some students rate their financial education positively, while others perceive deficiencies. This variation indicates that institutional factors such as curriculum design, teacher training, and resource availability influence financial literacy outcomes. Strengthening financial literacy programmes at the institutional level could bridge these disparities and ensure more consistent educational outcomes.

It is interesting to examine students' performance on various financial literacy questions. While students demonstrated competence in basic financial decisions, such as price comparisons (e.g., "Tomato" question), they struggle with more complex financial concepts like risk assessment, inflation, and contractual terms. These findings highlight critical gaps in financial education that should be addressed through targeted instruction on essential economic principles.

5.2 Machine learning results

Table 3 summarizes the results of the machine learning analysis. The random forest model achieved 95% accuracy, with 92% precision and 94% recall. The model's root mean square error (RMSE) is 0.35, indicating high reliability. The most important predictors of financial literacy are MATH_DIFF, OWNRATE_MATH, ENG_DIFF, OWNRATE_ENG, and SCHOOLRATE_FIN. Each one-unit increase in MATH_DIFF or OWNRATE_corresponds to approximately a 1.7-point increase in financial literacy. Similarly, linguistic confidence measures—ENG_DIFF and OWNRATE_ENG—are also positively associated, contributing 1.65 and 1.41 units, respectively.

Table 3. *Machine Learning Results and Key Determinants*

METRIC/VARIABLE	*VALUE/COMMENT*
Precision	92%
Recall	94%
Accuracy	95%
RMSE	0.35 (Scale of 1 to 10)
MATH_DIFF	Estimated increase of 1.76 units per point of overestimation
OWNRATE_MATH	Estimated increase of 1.74 units per self-rated point in math
ENG_DIFF	Estimated increase of 1.65 units per point of overestimation in English
OWNRATE_ENG	Estimated increase of 1.41 units per self-rated point in English
School-Rated Financial Preparation (SCHOOLRATE_FIN)	Students' perceived financial education quality varies widely (range: 2-9), suggesting disparities in school-based financial literacy programmes.
Age	Each additional year of age corresponds to a 1.36-point increase in financial literacy, reinforcing a progressive learning effect.
Graphical Findings	Overconfident students (MATH_DIFF > 1.5) tend to have higher financial literacy scores but also larger knowledge gaps in key areas like interest rates and inflation.
Influence of Bilingualism	Bilingual students score 0.8 points higher in financial literacy, after controlling for other factors ($p < 0.05$).
Machine Learning Model's Confusion Matrix	Model maintains a low false-positive rate, correctly classifying 89% of students with high financial literacy while minimizing misclassification.

Institutional and demographic factors, such as age and school-rated financial education, are also relevant: financial literacy increases by 1.36 points with each additional year of age. Students who report better school-based financial preparation perform significantly better, and bilingual students score 0.8 points higher on average, even when controlling for other variables. These findings validate the interdisciplinary approach and confirm that both cognitive self-perception and educational environment play key roles in financial literacy.

The variable importance plot (not shown for simplicity but available upon request) highlights key predictors of financial literacy. MATH_DIFF and OWNRATE_emerge as strong indicators, reinforcing prior research linking cognitive abilities to financial literacy (Lusardi & Mitchell, 2014). Students who accurately assess their skills tend to exhibit higher financial literacy. ENG_DIFF and OWNRATE_ENG similarly show a positive relationship, suggesting that linguistic confidence also plays a role. The SCHOOLRATE_FIN variable indicates that students who perceive their schools as effective in financial education tend to perform better in financial literacy assessments, consistent with findings by Fernandes et al. (2014) and the OECD (2017).

Age also influences financial literacy outcomes, with older students demonstrating higher levels of financial knowledge. This aligns with research showing that financial literacy accumulates over time through formal education and real-world exposure (Remund, 2010). Additionally, MATH_MARK and ENG_MARK indicate that students with stronger academic performance in these subjects exhibit slightly higher financial literacy, reinforcing the need to integrate financial education with broader academic development.

Quantifying the relative importance of these predictors, a one-unit increase in MATH_DIFF is associated with a 1.76-unit increase in financial literacy, while OWNRATE_contributes 1.74 units. The SCHOOLRATE_FIN coefficient suggests that better-perceived school financial education correlates with a 1.73-unit increase in financial literacy. Similarly, ENG_DIFF and OWNRATE_ENG contribute 1.65 and 1.41 units, respectively. Age also plays a role, with financial literacy increasing by 1.36 units per year. Although smaller in effect size, MATH_MARK and ENG_MARK remain relevant, showing that higher academic performance is associated with incremental gains in financial literacy. Finally, students who have completed formal financial education courses (STUDY_FINAN) exhibit a 0.52-unit increase in financial literacy, emphasizing the impact of structured financial education.

Taken together, these results demonstrate that financial literacy is shaped by a constellation of academic, cognitive, and institutional factors. They validate the interdisciplinary hypothesis that mathematical and linguistic abilities—particularly in English—play a significant and complementary role in shaping financial competence. These findings carry important implications for educational design and policy.

6. Implications of the findings

The results confirm that both mathematical and linguistic competencies substantially influence financial literacy, supporting our hypothesis that L2 acquisition and mathematics reinforce each other through shared cognitive mechanisms. The significant coefficients for MATH_DIFF, OWNRATE_MATH, ENG_DIFF, and OWNRATE_ENG point to a dual cognitive pathway: students who assess and perform well in and English also demonstrate higher levels of financial literacy. While numeracy enables students to interpret percentages, interest rates, and comparisons (Fernandes et al., 2014; Hastings et al., 2012), linguistic proficiency is equally critical for understanding and evaluating financial texts, contracts, and decision-making scenarios (von Gaudecker et al., 2015; Lusardi et al., 2017).

This dual impact has both theoretical and practical implications. Theoretically, it reinforces a cognitive integration model of financial literacy, where language and co-develop and support financial reasoning. Practically, it calls for educational strategies that embed financial content within both mathematics and English language curricula. English, as a globally dominant L2, could serve not only as a subject but also as a medium for financial education, enhancing both comprehension and global preparedness.

Aligned with Spain's LOMLOE framework and other competency-based models, these findings advocate for transversal, interdisciplinary instruction. Recent policy reports stress the role of national education strategies in improving financial literacy outcomes among adolescents (NEFE, 2024). Policymakers and curriculum designers should consider developing integrated modules where students engage with financial content through mathematical problem-solving and linguistic interpretation, promoting real-world applicability and equity in financial education. This aligns with institutional tracking of program effectiveness and legislative updates related to financial education (OCC, 2024)

However, the study is not without limitations. Self-assessed data may be subject to bias, and objective measures of and English skills would enhance precision. The sample, limited to secondary students in Granada, restricts generalizability; expanding to other regions and including university populations would enrich the analysis and track skill development over time.

Future research should investigate the mechanisms linking and language proficiency to financial behaviours in adulthood. Exploring moderating variables such as socioeconomic status, school type, and instructional methods can provide actionable insights for designing effective, inclusive financial education initiatives grounded in cognitive and pedagogical evidence.

7. Conclusions

This study offers robust empirical support for the hypothesis that second language (L2) learning—particularly in English—enhances financial literacy by reinforcing both linguistic and mathematical competencies. Drawing on survey data from 843 secondary school students and applying machine learning methods, we demonstrate that students with higher self-assessed and actual performance in English and tend to exhibit significantly stronger financial literacy. These findings validate a cognitive and educational interdependence between L2 acquisition, mathematical reasoning, and financial decision-making.

While numeracy remains essential for understanding financial concepts such as interest, inflation, and risk, linguistic proficiency—especially in English—emerges as a key enabler of comprehension and critical evaluation. Bilingual students, in particular, displayed greater cognitive flexibility and consistently outperform their monolingual peers in areas such as budgeting, saving, and evaluating financial information, echoing earlier work by Thoma (2016) and Cummins (2017).

These results call for a more integrated pedagogical framework. Current educational models often separate language and financial education, but our findings suggest that financial literacy benefits from a cross-disciplinary approach. Embedding financial concepts within English instruction, and reinforcing financial terminology in mathematics, aligns with competency-based frameworks like Spain's LOMLOE and equips students for real-world economic participation in a multilingual context.

Limitations of the study include its regional scope and reliance on self-reported data, which may introduce bias. The cross-sectional design also limits causal inference. Future research should explore longitudinal effects, assess how bilingual proficiency evolves alongside financial skills, and expand the sample to diverse geographic and socioeconomic settings to strengthen generalizability.

In practical terms, the findings support curriculum and policy reforms that integrate financial education into both language and mathematics instruction. Emphasis should be placed on bridging the gap between theoretical knowledge and practical application, particularly in domains such as interest calculation, inflation understanding, and investment evaluation. Leveraging bilingual education not only enhances academic performance but also empowers students to navigate financial systems with greater confidence and competence.

Ultimately, this research highlights the need for holistic educational strategies that recognize the mutual reinforcement between language learning and financial literacy. In doing so, educators and policymakers can help foster financial inclusion, resilience, and informed decision-making in an increasingly complex and multilingual global economy.

8. References

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