Promoting Financial Numeracy Through Mathematics Education

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This study explores how financial numeracy can be effectively promoted within mathematics education for third and fourth graders. Using a Design-Based Research approach, it identifies challenges in students' financial decision-making and implications for the design of educational interventions. The findings underscore the need for thoughtfully designed reflective tasks to enhance students' dispositions and critical orientation towards purposefully applying mathematics in financial contexts.

Introduction and Problem Statement

Financial education has gained significant attention in recent years, as financial literacy is viewed as essential in an increasingly complex society. Unlike previous generations, children today are exposed to a changing financial landscape, including greater exposure to cashless transactions, such as tap-and-go payments and in-app purchases. Simultaneously, shrinking social benefits, aging populations, and more complex financial services mean that future generations will likely face greater financial responsibilities at an earlier age (OECD, 2020). Despite this, the definition of financial literacy and its integration into education remain subjects of debate. Narrower views focus mostly on financial knowledge acquisition and retention, while broader definitions also include required attitudes/motivations and skills/behaviour (Amagir et al., 2018). Furthermore, while a strong correlation between numeracy and financial literacy has been recognised (OECD, 2020), the role of numeracy is frequently reduced to performing basic arithmetic procedures, neglecting the broader numeracy perspective adopted in mathematics education. This study aims to address this gap by exploring how financial numeracy can be fostered within mathematics education. By acknowledging that financial numeracy extends beyond knowledge to include behavioural and attitudinal dimensions, this research seeks to identify challenges in students' financial decision-making and behaviour and thus determine the likely conditions necessary for a successful educational intervention.

Theoretical Background: Financial Literacy in Mathematics Education

Research identifies two effective approaches for embedding financial literacy within mathematics education: experiential learning and a focus on numeracy.

Experiential Learning

Experiential learning has been identified as particularly effective in meta-studies examining the most successful design elements for financial education (see e.g., Amagir et al., 2018). Practical experiences with money can not only enhance financial and economic understanding (Claar, 1996) but also improve mathematical skills (Grassmann, 2008) and engagement with mathematics (Attard, 2018). A practical example of experiential learning in primary schools is the simulated classroom economy described by Batty et al. (2020), where students manage their own money in a classroom setting. The study found significant improvements in financial knowledge, attitudes, and behaviours. However, the exclusive use of quantitative measures leaves unanswered questions about why these improvements occurred. Additionally, students participating in the program showed a significant increase—about 10 percentage points—in meeting state mathematics standards compared to those not in the program. While this improvement demonstrates the effectiveness of the experiential learning approach, the broad nature of the measures used (e.g., standardised test scores) does not provide insight into specific

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gains related to applying mathematics in financial contexts or how mathematics education can be purposefully integrated with financial literacy.

Numeracy as a Bridge Between Mathematics and Real-World Contexts

Numeracy is often narrowly defined, particularly in terms of its significance for financial literacy, where it is frequently reduced to basic calculations. Lusardi (2008), for instance, differentiates financial numeracy, which involves basic knowledge, from financial literacy, which encompasses advanced understanding. In contrast, mathematics education takes a much broader view, recognising numeracy as a critical connection between mathematics and real-world contexts. Steen (1998), for example, emphasises that numeracy is distinct yet complementary to mathematics: while mathematics focuses on abstraction, numeracy grounds learning in real data and diverse situations. In the last years, the study of numeracy practices—how people actually use mathematics in their daily lives—has gained increasing attention. Surveys like the Programme for the International Assessment of Adult Competencies collect data on how frequently adults use mathematics in everyday life, such as calculating prices or budgets. Besides analysing the frequency of numeracy practices, there are also studies investigating how mathematics is used, such as the one by Northcote and Marshall (2016), which highlights how mathematics in practice often relies less on exact written calculations and more on estimation and mental strategies. Numeracy is increasingly understood as embedded in cultural, societal, and power dynamics; a perspective referred to as Numeracy as Social Practice (Yasukawa et al., 2018). Social and contextual influences significantly shape how mathematics is applied in everyday contexts, adding another layer of complexity to its study and teaching. Teaching numeracy in schools poses challenges because classroom mathematics practices often fail to align with real-world practices. In terms of the context of money/finance, there have been several studies addressing the gap between school and everyday mathematics, for instance, Nunes et al. (1993) observed that children working as street vendors, could effectively solve money-related problems using their informal strategies outside of school but struggled when these tasks were reframed within school procedures. Similarly, Brenner (1998) highlights that children's understanding of money in their daily lives often diverges from how financial problems are presented in classrooms.

Bridging this gap requires educational strategies that foster numeracy. The Critical Numeracy Framework developed by Goos et al. (2014) for classroom-use, provides a comprehensive approach to this by conceptualising numeracy through five inter-connected dimensions: Mathematical Knowledge (concepts, problem-solving, estimation); Contexts (real-world application); Dispositions (confidence and adaptability); Tools (physical, digital, and representational aids); and Critical Orientation (using mathematics to make decisions, build arguments, and evaluate positions). In recent years, there have also been studies specifically focused on the teaching and learning of financial numeracy in financial contexts. Research by Sawatzki and Sullivan (2017) and Blue et al. (2018) emphasises the importance of a critical orientation in financial decision-making. This involves navigating choices while fostering key capabilities such as accepting challenges, comparing options, and integrating mathematical and social reasoning. Furthermore, when considering context, it is recommended to avoid overly simplistic "border contexts" that merely disguise mathematical problems in superficial financial settings. Instead, emphasis should be placed on tasks that engage seriously with financial contexts (Burkhardt et al., 2024). As there are only limited insights into how financial educational interventions for younger students (aged 8 – 10) should be designed, especially in terms of fostering financial numeracy, the overall study addresses the following research question:

- How can financial numeracy be promoted in mathematics lessons in third/fourth grade?

To answer this question, the aims of this paper were to:

- Examine challenges to financial numeracy practices in students' financial behaviour and decision-making (for hypothetical financial decisions and experiential learning).
- Infer success conditions for experiential learning approaches and implications for financial numeracy task design.

Methods

To answer the research questions, a Design-Based Research (DBR) methodology was employed to iteratively develop and refine an educational intervention aimed at promoting financial literacy through mathematics education. DBR was chosen as it can provide researchers with detailed insights into students' thinking processes, enabling the identification of learning progressions and challenges necessary for refining the intervention (Prediger et al., 2012). The DBR process in this research involved two iterative cycles:

- Cycle 1 (2023): Implemented with 16 students (9 third-graders, 7 fourth-graders), identifying barriers to financial and mathematical reasoning.
- Cycle 2 (2024): Refined intervention implemented with 14 students (9 third-graders, 5 fourth-graders), focusing on improved task design and structured reflection.

Participating students were selected from two rural schools in Baden-Württemberg, Germany, chosen due to previous partnerships in financial literacy initiatives. The students can best be described as predominantly middle-class, though they came from diverse cultural backgrounds and, based on their mathematics grades, exhibited varying levels of mathematical achievement. Unlike countries such as Australia, where financial literacy is explicitly embedded in the curriculum, Germany has not yet taken this step. However, money is included in the measurement strand of the mathematics curriculum. Moreover, their financial experiences are likely to differ as well. For instance, in Sweden, cashless transactions are the norm, whereas in Germany, over half of all payments in 2023 were still made in cash (Ego et al., 2024). Participation in the lessons was voluntary and part of an after-school programme. Pre-and Post-Interviews and Classroom Observations were used to provide a holistic view of changes in financial numeracy and influencing factors. Data was analysed using qualitative content analysis (Mayring, 2010).

- Semi-Structured Pre-Intervention Interviews: The interviews were used to explore students' baseline attitudes, knowledge, financial decision-making, and numeracy practices through self-reports and hypothetical scenarios. The shopping scenario required students to decide on, and justify, the best course of action when funds were insufficient, involving cost estimation, contextual interpretation, and product exchanges based on price comparisons and proportional reasoning.
- Classroom Observations: The researcher observed students' decision-making and reasoning during the simulated classroom-economy. In this simulation, students earned and managed money (income and expenses) to reach a savings goal. Furthermore, they could spend part of their money at a classroom store. Participation in spending at the classroom store was not guided by specific mathematical procedures or shopping scripts. Each group of students had six opportunities to participate in shopping activities; however, as the activity was voluntary, not every child engaged in each session. Data was collected through recordings of the lessons and field notes. Since pre-interviews revealed that most children had only handled cash payments, the classroom store was designed around cash transactions while also exploring behaviours that could present challenges in cashless interactions.
- Semi-Structured Post-Intervention Interviews: As per the initial interviews, the same questions were asked, and similar scenarios were used to evaluate the effectiveness of

the intervention by analysing changes in attitudes, knowledge, and financial decision-making and numeracy practices.

This paper examines students' decision-making in shopping contexts during Cycle 1, focusing on their responses during the pre-intervention interviews to the shopping scenario and their behaviours whilst shopping at the classroom store. Instead of quantitatively counting strategies or problems encountered, this analysis qualitatively describes typical approaches and problematic behaviours used by multiple students. These observations were complemented by insights from the interviews regarding students' self-reported financial experiences and numeracy practices.

Findings

Financial Experiences and Socialisation

Students' financial experiences and socialisation varied significantly, influenced by parental involvement and societal norms. Some parents actively involved their children in budgeting and financial decision-making, while others excluded them, often citing beliefs that money-related topics were private or inappropriate for children. Parental values, such as thriftiness, shaped students' financial attitudes. Thus, the degree of autonomy in money management varied widely among students. Student interview responses indicated that some lacked access to their own funds and relied entirely on their parents for financial decisions, with parents frequently vetoing purchases they deemed unnecessary. Others managed their money more independently, with parents offering guidance rather than control. These students could more often reflect on a purchase they regretted and why, for example differentiating between price and value and weighing price against personal value or utility considerations.

Attitudes Toward Mathematics and Numeracy Practices

Even though students were explicitly asked about the use of mathematics in their everyday lives, they frequently mentioned school-related applications. For example, instead of recounting instances where they needed to estimate ingredients for baking or prices, students perceived mathematics as necessary primarily for completing homework and preparing for tests. Furthermore, the need for mathematics was more often associated with their future aspirations, such as achieving dream jobs, rather than immediate practical applications. Regarding numeracy practices with money, students reported applying mathematics in certain financial contexts, such as counting the money in their piggy banks. In fact, money was the most mentioned link between mathematics and daily life and the primary context in which students reported using mathematics outside of school. However, while many students regularly accompanied their parents when shopping, this did not consistently lead to numerate behaviours, such as comparing prices or calculating total costs. Instead, their engagement was often limited to asking their parents whether specific products could be purchased.

Challenges for Financial Numeracy

The challenges for Financial Numeracy are listed in Table 1. Observed challenges were first coded inductively and then categorised within the dimensions of the Critical Numeracy Framework (Goos et al., 2014). For example, students who consistently relied on the same calculation strategy, ignoring contextual efficiency, were assigned the inductive code "rigid/inflexible strategies." This code was subsequently mapped to the deductive category "disposition" in the Critical Numeracy Framework, as "rigid/inflexible strategies" would be the opposite of a flexible disposition. Since the dimensions of the framework are interconnected, assigning each observed challenge to a single category was not always straightforward.

However, this categorisation was chosen to highlight how financially numerate behaviour relies on more than just basic calculation skills and to illustrate the aspects involved.

Table 1

Observed Challenges for Financial Numeracy

Numeracy dimension	Specific challenge	Observed behaviours	Excerpts from this study
Dispositions	Rigid, inflexible problem-solving approaches	Overreliance on one approach without considering efficiency, such as exact calculations using place value partitioning or the written algorithm.	To check how much two items for 1,99 € each cost together, child calculates 1 € + 1 € = 2 €, 90 ct + 90 ct = 180 cts, 9 ct + 9 ct = 18 ct and afterwards adds these amounts. (E.L. and P.I.)
	Compensation strategies to minimise/avoid mathematical effort	Substituted mental effort with physical effort by going through several iterations of shopping script	Child buys item for 5,99 €, received 4,01 € change, then buys another item for 3,99 €, and receives two cents change. (E. L.)
		Taking all desired items without checking sufficiency of money beforehand	Child buys items totalling at 6,98 € and only notices at checkout that he can't pay for everything. (E.L.)
	Financial values impeding numeracy practices (Value of Money)	Change was not checked for small amounts, as it was perceived as insignificant.	Child buys items totalling 8,91 €, pays with 9 €, and does not check if the three cents change are correct, stating 'It is only a few cents, it is not worth much'. (E.L.)
Financial context	Simplistic interpretation of solutions in context	Applied rounding rules without considering contextual implications, leading to incorrect assessments of sufficiency.	Child estimates total costs by rounding individual prices according to the rounding rules to the nearest euro, interpreting 5 € as sufficient for items costing 1,29 €, 2,39 €, 1,49 €, and 1,19 €. (P.I.)
Critical Orientation	Simplistic Validation of mathematical solutions	Validated decisions based on ease or simplicity rather than feasibility or contextual appropriateness.	Relating to the last example: The estimation is deemed appropriate as it was easy to calculate and meant that money sufficed. (P.I.)
	Only social, no mathematical reasoning.	Relied solely on social reasoning instead of mathematical reasoning/problem-solving.	Instead of checking receipts or substituting a product for a cheaper one, child suggest asking for more money from parents/teacher. (P.I. and E.L.)

Note. For each challenge it is noted in the excerpt whether this observation was made during the hypothetical scenario in the pre-intervention interview (P.I) or during the experiential learning environment (E.L.).

Discussion

Influence of Prior Socialisation and the Role of Financial Experiences

Personal financial experiences can serve as valuable learning tools for children, allowing them to reflect on past decisions, identify mistakes, and differentiate between the price and value of products. However, financial socialisation and prior experiences of students varied greatly, and this diversity must be carefully considered when designing educational interventions or learning experiences. Experiential learning through simulations, such as a classroom store, can create a more level playing field for students to engage in financial

decision-making and to develop foundational skills in a supportive, low-risk environment. Nevertheless, simply providing opportunities for shopping experiences may not be enough to foster numerate behaviours. This was evident from students' self-reports, where, despite recognising the importance of mathematics in managing money, students still engaged infrequently in financial numeracy practices, such as checking change or comparing prices. This finding aligns with the work of Grassmann (2008) who observed that children in Germany have limited opportunities for independent financial decision-making. Even in supportive contexts such as the shopping store, these behaviours do not automatically emerge—particularly when children only accompany their parents rather than shopping independently. Some students in the simulation resorted to strategies that bypassed mathematical reasoning. This tendency was enabled by the realistic environment, which, while engaging, also highlighted further challenges in effectively promoting numeracy through experiential learning. For instance, some avoided mental calculations by making multiple store trips until their money ran out, while others handed all their money to the "cashier" without verifying if it was sufficient. These behaviours echo Brenner's (1998) findings, where children substituted mental effort with physical actions in real shopping contexts. However, unlike Brenner's preschool participants, who likely lacked the necessary mathematical knowledge, the students in this study avoided/did not see any value in applying their existing mathematical knowledge. Such avoidance is particularly concerning in the context of increasing cashless transactions. Without the disposition/inclination to estimate costs or track expenses, children may overspend or accrue debt without realising it, as they cannot rely on immediate cues like running out of physical cash. This highlights a critical limitation of experiential learning: while it encourages engagement, it may not inherently promote robust numeracy practices or a productive disposition towards mathematics.

Challenges in Bridging School Mathematics and Real-World Applications

When students were encouraged to apply mathematics in shopping contexts, several challenges emerged. Certain dispositions, such as inflexible problem-solving approaches, impeded effective financial decision-making in both hypothetical scenarios and experiential learning settings. For example, students often relied on the same strategy for all problems, such as using written algorithms or place value partitioning, without considering number relationships or the context to find more efficient strategies – for example, using an algorithm when calculating 1,99 € + 1,99 € where an efficient strategy would be 2 € +2 € – 2 ct. Financial dispositions also played a significant role in decision-making. For instance, some students dismissed small amounts of money as insignificant and did not check their change, reflecting how their perception of monetary value influenced whether numeracy practices were enacted. Social reasoning often replaced mathematical reasoning. Students frequently relied on parental support or negotiated for more money instead of verifying their calculations. Sawatzki and Sullivan (2017) emphasise that integrating social and mathematical reasoning is essential for fostering balanced financial decision-making, as decisions based on beliefs rather than calculations leave individuals vulnerable. A further challenge was students' tendency to view mathematics as a set of fixed procedures rather than as a reflective and adaptive tool for problem-solving. For example, students applied rounding rules mechanically without interpreting or validating the mathematical solutions in context. Such a procedural focus does not align with the skills needed in contemporary everyday life, including the changing financial landscape, where mental calculation, strategic estimation, and reflective reasoning are far more important (Northcote & Marshall, 2016).

Implications for Design and Conclusion

The findings suggest that while experiential learning engages students, having the experience on its own might not be sufficient in fostering financial numeracy. Thus, in this intervention, experiences were accompanied by reflective tasks, addressing common challenges observed before and during the intervention. These should foster a productive disposition toward mathematics by emphasising its practical value in financial contexts and empower students to approach financial decisions with greater confidence and agency, not only relying on social reasoning. Furthermore, the findings suggest that students should adopt a more critical orientation to how mathematics is applied purposefully in context. Some exemplary tasks can be seen in Figure 1. Unlike lower-order tasks that focus on following predefined procedures (e.g., calculating sum of products using written algorithm), tasks in the intervention were designed to encourage students to share their reasoning and engage in discussions to find and evaluate different approaches or judge the reasonableness of mathematical solutions in context.

Figure 1

Examples of Designed Tasks

Pre- and post-interviews were compared to identify chances and limitations of this design-approach. Key markers of improvements and remaining challenges include:

- Enhanced flexibility: Many students began to demonstrate a more flexible use of mathematics. For example, when calculating prices, they recognised when estimates would suffice instead of always resorting to exact calculations.
- Improved interpretation and validation: More students tried to interpret and validate mathematical solutions in context, though understanding compensation in estimations (e.g., how repeated rounding up affects accuracy) remained challenging.
- Experiential learning and numeracy practices: Students appreciated the hands-on experiences, and some linked them to improved self-efficacy in managing money. Some students reported an increase of personal numeracy practices, such as checking receipts, but for many, engagement was limited by the lack of opportunities provided by parents.

This study underscores findings from the literature that financial numeracy is not automatically improved by merely exposing students to financial experiences. Meaningful integration requires well-designed tasks combining experiential learning with structured reflection to develop flexibility and a critical orientation about mathematics in context. Financial numeracy, in a broader sense, (see Savard & Cavalcante, 2021), involves understanding financial concepts through mathematical investigations and examining their connections to the economic system and other systems (e.g., politics, ethics), encouraging consideration of the social and ethical implications of financial decisions (Blue et al., 2018). Future research will include more pre-intervention interview questions to explore students' understanding of prices and price formation, addressing misconceptions, such as seeing prices as objective measures. Tasks will require critical analysis of price formation, including factors like production costs and profit margins. Post-interviews will assess whether students have developed a better understanding of the subjective nature of pricing and its social implications, laying the groundwork for a critical evaluation of market practices, such as dynamic pricing.

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