Understanding Chinese students’ success in the PISA financial literacy: A praxeological analysis of financial numeracy

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Abstract
The goal of this article was to investigate how Chinese mathematics curriculum policies and textbook tasks could help explain the results obtained by Chinese students in the 2012 and 2015 Programme for International Student Assessment (PISA) financial literacy exams. Inspired by the Anthropological Theory of the Didactic, we conducted a praxeological analysis of financial numeracy tasks from middle school textbooks and the PISA. We conceptualized the term financial numeracy as the use, production, and communication of mathematical information in financial situations. The analysis permitted us to contrast the solution to PISA tasks with that of financial tasks from middle school mathematics textbooks. Our results show that, despite the lack of attention to mathematics in the curriculum policies for financial literacy, the mathematics textbooks seem to support the performance of students in the PISA by (a) incorporating more mathematically complex content, (b) tackling equivalent financial concepts, (c) providing students with enough time to consolidate their understanding throughout middle school, and (d) designing pedagogy that revisits these concepts over the years. The implications of this study inform mathematics education research and practice. If we are to incorporate financial literacy in mathematics curricula, this process should be done with intentionality and in connection to multiple mathematical concepts and processes.

Keywords
financial numeracy, financial literacy, PISA, China, middle school mathematics, curriculum policies, mathematical tasks

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1. Introduction
With increasing efforts to reform mathematics curricula worldwide, financial literacy has become a source of attention for policy makers and educators. A variety of definitions of financial literacy exists depending

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on the epistemological beliefs of scholars and institutions. Overall, these definitions include some variation of the “knowledge and understanding of financial concepts, [...] and the skills, motivation, and confidence to apply such knowledge and understanding in order to [...] improve the financial well-being of individuals and society, and to enable participation in economic life” (OECD, 2020, p. 43). In other words, financial literacy goes beyond formal knowledge of financial concepts; it involves the ability to use such knowledge to understand the world and actively participate in it.

The international movement of financial literacy has led many institutions to implement initiatives that include international assessments of youth and adults. These assessments often lead to policies to tackle the lack of basic knowledge of financial concepts and products. Reforming mathematics curriculum is one of such policies which, despite the consensus of its importance, generates vastly different approaches to financial literacy in mathematics: a standalone course, an interdisciplinary topic, a sub-strand of mathematics, a sub-topic of arithmetic, etc. (Savard & Cavalcante, 2021a). These approaches are often inconsistent and portray distinct understandings of financial concepts. These inconsistencies reveal a lack of consensus about the role of mathematics in developing financial literacy.

Although there is consensus that mathematics plays an important role to develop students’ financial literacy (Bansilal, 2016; Manuel & Morony, 2011; Sole, 2014), its specific role is still under-theorized. Some researchers believe financial literacy merely involves basic arithmetic skills (Joo & Chatterjee, 2012; Lusardi, 2012). Others suggest that financial literacy involves broader mathematical literacy, or numeracy (Cavalcante, 2020). We speak of practices that involve the production, use, and communication of mathematical information: counting, comparing, estimating, representing, predicting, modeling, etc. It is within this perspective of numeracy as a social practice (Yasukawa et al., 2018) that we conceptualize the term financial numeracy as the use, production, and communication of mathematical information in financial situations (Savard & Cavalcante, 2021b). Financial numeracy is a more-precise term to refer to the intersection between mathematical and financial literacies. It involves a subset of both fields and can help us understand how financial concepts can fit within mathematics curricula.

This article explores the financial numeracy present in Chinese middle school mathematics education. China has been recognized for its achievements in international assessments in all subjects, including financial literacy. Specifically, the goal of the article is to analyze how Chinese mathematics education might help explain the results obtained by the country in the Programme for International Student Assessment (PISA) financial literacy assessments. To do so, we first introduce such an assessment and China’s performance. We then present our theoretical framework of financial numeracy and the methods used to collect and analyze data. Our findings are presented in three parts: curriculum response to financial literacy, overview of financial numeracy tasks, and examples of financial numeracy tasks from arithmetic, algebra, and data. Finally, we discuss the results by reflecting on the ways in which mathematics education helps us explain the PISA results.

2. Financial literacy in the PISA: What about mathematics?

The PISA was created in 2000 by the Organisation for Economic Co-operation and Development (OECD) to assess 15-year-old students’ scholastic performance around the world in some subjects (e.g., reading, mathematics, and science). In 2012, the OECD decided to start assessing financial literacy along with the traditional subjects. This incorporation reflects international trends to raise awareness for financial literacy among students with the goal of empowering them to make sound financial decisions. As, part of these international trends, many countries have developed strategies to incorporate financial concepts into school curricula (Garcia et al., 2013; Messy & Monticone, 2016; OECD, 2015, 2016a). Financial concepts have then been integrated into a wide variety of ways: a cross-disciplinary area, a stand-alone course, a strand of a subject such as mathematics, or even a sub-strand within a traditional course (Savard & Cavalcante, 2021a). According to Cordero
et al. (2022), the most common approach is that of a cross-disciplinary area that links financial concepts to multiple subjects in the curriculum. Although this approach can be efficient to prevent overloading the curriculum, it also presents the risk of being too broad that teachers do not feel prepared to effectively incorporate financial concepts in their classrooms. Furthermore, flexibility can turn into inconsistency in the way financial concepts are portrayed, and differences among schools within the same curriculum jurisdictions can lead to inequalities in financial education opportunities (Atkinson & Messy, 2013; Grifoni & Messy, 2012).

Despite these curriculum and international assessment trends, not all PISA participating countries have chosen to take the financial literacy exam since its creation. Furthermore, in some countries (e.g., Canada) only a subset of students from certain provinces have participated. Chinese students from only four jurisdictions participated in the 2012 and 2015 PISA exams: Beijing, Shanghai, Jiangsu, and Guangdong (BSJG). These are some of the most economically prosperous regions of China, so any comparison with other countries must be taken with caution. However, as the OECD argues (2020), altogether these regions represent a population of around 180 million, bigger than almost all participating countries. Furthermore, the average income per capita in these regions is below average for OECD countries.

Both in 2012 and 2015, Chinese students ranked first in the exam (OECD, 2017b). Among the students, only 9% are unable to recognize financial products and make simple financial decisions (whereas the average worldwide was 22%). Furthermore, 33% of students scored the highest level of financial literacy in the exam, indicating their ability to deal with complex financial information and solve nontrivial financial problems (the global average was only 12%). Their scores were strongly correlated with mathematics performance: around 69% of the financial literacy score reflects skills measured in the mathematics and/or reading assessments, while 31% of the score reflects factors uniquely captured by the financial literacy assessment. Given this strong correlation, it begs the question of whether the Chinese mathematics education context supports the students’ performance in the PISA exam.

Scholarly literature has investigated a range of factors to explain differences in scores of students around the world. An analysis of PISA results conducted by Cordero et al. (2022) showed that financial education contributes to students’ financial literacy regardless of how financial concepts are taught. However, this contribution seems to be limited when compared to the major role played by other factors. Among these factors, we identify individual and institutional characteristics of students (Arellano et al., 2014), sociocultural factors (Bottazzi & Lusardi, 2016, 2021), and the role of families (Moreno-Herrero et al., 2018).

Among the many factors that can explain students’ performance in the exam, the role of mathematics education has been studied to a limited extent. Savard (2018) explored the epistemology of sample items from the PISA mathematical literacy with the aim of investigating whether they could foster financial concepts through mathematics. The author concluded that many opportunities exist within these tasks to develop students’ understanding of money, transactions, and risk through probability. Similarly, Ozkale and Ozdemir Erdogan (2020a) used the PISA exams to explore the interactions between mathematical and financial literacies. However, instead of looking at sample tasks, the authors compared and contrasted the frameworks of mathematical and financial literacies in terms of content, processes, and contexts. Their results led to the proposal of a theoretical model (Ozkale & Ozdemir Erdogan, 2020b) in which mathematics contributes to financial literacy. These results are consistent with the conceptual dimension of financial numeracy we have found in previous work (Cavalcante, 2020; Savard & Cavalcante, 2021b). In other words, both studies indicated that mathematics improves the conditions for students to develop financial literacy. Hence, they argue that financial literacy should be incorporated into mathematics education. In this paper, we propose an empirical study to reflect on such an argument. Our goal is to understand if mathematics education can be considered a factor to explain student performance in the PISA financial literacy.
We aim to shed light on the Chinese mathematics education context and how it might explain the results obtained by China in 2012 and 2015.

3. A framework of praxeologies of financial numeracy

To analyze how Chinese mathematics education can provide insights into Chinese students’ performance in the 2012 and 2015 PISA exams, we used the Anthropological Theory of the Didactic (ATD) to guide our analysis. The theory is rooted in the study of the didactic transposition (Bosch & Gascón, 2006, 2014), that is, the process of mobilizing and reframing knowledge produced in one institutional setting to another. Institutions, according to ATD, are social structures (physical or not) in which knowledge circulates in one of three ways: it is created, it is used, or it is taught (Chevallard, 2019). For the purposes of this article, we consider the PISA exam and Chinese mathematics textbooks to be two distinct institutions with distinct conditions for the circulation of knowledge. An ATD-rooted analysis would then pay attention to how financial and mathematical concepts are used for the purposes of assessing students’ financial literacy (PISA) or teaching mathematics (textbooks).

This theoretical framework is particularly helpful to understand financial numeracy education for it acknowledges different ways of engaging with mathematical and financial concepts. Financial situations require a great deal of mathematical processes that are not always recognized in mathematics education communities. Incorporating financial concepts in mathematics classrooms requires us to displace our epistemology from disciplinary (a mere reproduction of scholarly mathematics) to one that reflects how mathematical processes emerge in those situations. In other words, a numeracy epistemology is necessary to make sense of contemporary changes in curriculum.

ATD helps us defy the often-naturalized conception of disciplines as independent bodies of knowledge that schools must teach. An ATD perspective supports the numeracy aspect of financial numeracy since it recognizes the role of financial contexts in the creation, use, and teaching of mathematical processes. To question these naturalized perceptions, ATD uses the construct of praxeology as its most basic unit of analysis. A praxeology is any intentional human activity. Chevallard (2006) states that “no human action can exist without being, at least partially, ‘explained’, made ‘intelligible’, ‘justified’, ‘accounted for’, in whatever style of ‘reasoning’ such an explanation or justification may be cast. Praxis thus entails logos, which, in turn, backs up praxis” (p. 23). A praxeology can be then analyzed as a set of four elements consisting of a type of task, a technique, a technology, and a theory. While the first two elements form the practice block of a praxeology, the latter two forms the theoretical, or justification block. Figure 1 summarizes the main aspects of ATD to analyze a didactical situation within financial numeracy (the PISA financial literacy and the Chinese textbooks).

A type of task is the goal that an action is carried out to achieve. In formal education, financial numeracy tasks pose a variety of goals for students to achieve which require them to use different techniques.

A technique is the steps necessary to carry out the task. Each technique entails different actions to select and use information (mathematical and financial processes) to achieve the goal. In a financial numeracy task, students engage in mathematical and financial processes. The OECD (2016b) created frameworks that identify both financial and mathematical literacy processes. The institution’s framework includes four financial literacy processes: identify financial information, analyze information in financial context, evaluate financial issues, and apply financial knowledge. The institution also identifies mathematical literacy processes which are embedded in seven capabilities: communicating, mathematizing, representing, reasoning, solving problems, using language and operations, using mathematical tools. For the purposes of our framework, we consider these capabilities as a reflection of mathematical literacy processes. In each capability, students can formulate situations mathematically, employ mathematical concepts and procedures, and interpret mathematical outcomes. A
detailed description of these processes has been published in the PISA 2015 Assessment and Analytical Framework (OECD, 2016b).

A technology is the justification behind each technique. Justifications exist in the form of explanations, reasoning, and other forms of discourse. Financial literacy processes find their justifications in financial concepts that explain the world of finance (e.g., time value of money, interest, and profit/loss). Mathematical literacy processes find their justifications in mathematical concepts (e.g., numbers, ratios, percentages, functions, measures of central tendency, and graphs). These concepts (both financial and mathematical) are created within specific institutions and used or taught in others (such as an international assessment or a textbook).

A theory is the ensemble of technologies that exists in a coherent body of knowledge. While many theories are rooted in traditional academic disciplines, a social group can develop a coherent set of technologies to justify their everyday practices without them. In this article, since we are interested in financial numeracy tasks in formal education, the theories behind the justifications of any task can be found within the academic disciplines of finance and mathematics.

A praxeological analysis of the PISA and the Chinese textbooks must be understood and characterized by the conditions and constraints of knowledge used by each institution (Artigue & Winsløw, 2010). A contrast between these two institutions reveals three main differences associated with their: educational goal, use of financial concepts, and use of mathematical concepts. The PISA aims to assess students, focuses on financial concepts, and uses mathematical concepts when it serves its focus. The textbooks aim to teach students, focus on mathematical concepts, and use financial concepts when it serves their focus. Each of these institutions is therefore created under distinct epistemologies and is informed by distinct theories (e.g., financial, mathematical, and pedagogical).

Given these institutional differences and the theories that inform them, in this article we are mainly concerned with the practice block of the praxeologies. Our aim is to analyze whether the tasks and techniques presented in mathematics support the tasks and techniques assessed in the PISA exam. In
other words, we seek to investigate the ways in which Chinese mathematics education can help explain the performance of Chinese students in the PISA financial literacy.

4. Context and methods

The goal of this article is to investigate whether Chinese mathematics education can shed light on the performance of Chinese students in the 2012 and 2015 PISA financial literacy assessments. In China, mandatory education includes nine grades of elementary and middle school. After that, students can either further their academic education or join vocational schools to gain employment immediately after. Approximately half of the Chinese students attend high school (academic) while the other half move to vocational studies. Students writing the PISA exam have just graduated from ninth grade (the last grade of mandatory education). We then chose to focus this study on the grades immediately before the writing of PISA for (a) it includes the years of mandatory education and (b) it provides strong evidence as to why mathematics education supports the students’ performance in the exam.

To reach our goal, we focused on two institutional mandates that reflect the epistemology of mathematics education in the country: curriculum policies and mathematics textbooks. According to Pepin et al. (2013), “mathematics textbooks [and curriculum] are widely used as the main resource for teaching, and they are perceived to reflect the views expressed in curricular documents” (p. 686). Specifically, we aim to answer the following research questions:

1. How has the Chinese curriculum responded to the international movement of financial literacy in education?
2. How is financial numeracy depicted in Chinese middle school mathematics textbooks?
3. Are the textbooks’ depiction of financial numeracy consistent with the PISA financial literacy?

In the following subsections, we describe the methods used for data collection and analysis to answer our research questions.

4.1 Curriculum policies

In China, national curriculum policies are debated through a continuous dialogue between the legislative and executive powers. The process of creating these policies starts from letters written by parliamentary representatives (deputies to the National People’s Congress). These letters address educational issues of importance to the country. Whenever the Ministry of Education (MOE) has designed a curriculum policy that addresses one or more of these letters, it publishes a response to such letters highlighting how curriculum changes reflect the issues brought by in the letters. To identify curriculum policies associated with financial numeracy education, we looked for the policies related to financial education and financial literacy on the MOE’s website (http://www.moe.gov.cn). In addition to the responses to parliamentary letters, we also collected reports and statistics related to financial education published by the institution.

4.2 Mathematics textbooks

In the four provinces which participated in the PISA exam (BSJG), a wide variety of mathematics textbooks have been approved by the MOE. According to the institution, eight different publishers have mathematics collections recommended for use in middle school. This diversity exists because in China, only the subjects of Chinese, history, and politics are unified and taught through the MOE’s own materials. For all other subjects, provinces can choose the materials that best meet their needs.
Since we were interested in analyzing financial numeracy tasks from all mathematical domains, we chose to select one collection for analysis in its entirety. To choose the textbook collection, we created an online survey for BSJG teachers. A total of 60 public school teachers replied to the survey, half of which use the collection from the People’s Education Press. The collection is comprised of two textbooks in each grade, for a total of six books from seventh to ninth grades. Additionally, the teachers also reported using the textbooks along with materials developed internally in their schools. Based on these answers, we validated our assumption that, despite their variety in use, textbooks are still the best representation of the curriculum’s vision for mathematics education in China. They represent a common ground among different provinces and schools.

4.3 Data analysis

Our analytical strategy used a triangulation design (Tashakkori et al., 2020) to answer the research questions and reach the goals of the study. To answer research question 1, we organized the curriculum policy documents chronologically and extracted the justifications for fostering financial education in the Chinese curriculum. Our goal was to highlight the intentionality presented in the responses to parliamentary letters. Upon selecting those justifications, we then filtered the content according to the disciplines involved in the MOE propositions. As such, we ended up with justifications in two content areas: Mathematics, Moral and the Rule of Law. Our findings are presented according to these two disciplines.

To answer research question 2, we reviewed each textbook entirely and selected every task depicting a financial situation (i.e., involving money). These tasks became our unit of analysis which we then coded. Our coding scheme was informed by our theoretical framework and included the textbook grade, mathematical content (according to the Chinese curriculum), financial content (according to the OECD framework), and mathematical and financial literacy processes. Table 1 presents a summary of coding scheme, including individual codes used.

Since our coding scheme was created based on existing frameworks of mathematical and financial literacies, its reliability was ensured by having both authors individually code the tasks and then compare and contrast their results. The extension of our data set and the qualitative nature of this study allowed us to then a consensus-building approach to ensure the coding scheme was used consistently. Codes under the categories grade, mathematical content, financial content, and financial literacy process did not require further discussions after the first round of independent coding. As for codes under mathematical literacy processes, we first solved each task individually, then contrasted both solutions. Although our answers matched in all cases, the approach to solving them differed in some cases. As we will present in the next section, we kept these different solutions and coded the associated mathematical literacy processes accordingly. For example, some financial numeracy tasks could be solved numerically or algebraically. In this case, we kept both solutions in our analysis, but coded both as mathematizing since they “Identify the underlying mathematical variables and structures in the real-world problem and make assumptions so that they can be used” (OECD, 2016b, p. 71). Finally, we validated our solutions and codes by having them be reviewed by a mathematics education researcher not involved in the project.

Finally, to answer research question 3, we contrasted the results of our data analysis with sample tasks published by the OECD from the PISA financial literacy exams of 2012 and 2015. We examined if financial numeracy tasks in Chinese middle school mathematics promote similar or different mathematical processes as the PISA. Consequently, the curriculum policy analysis provided insight as to whether financial numeracy tasks were intentionally incorporated into the textbooks, and the textbook tasks analysis provided a glimpse at the mathematical processes implemented in Chinese middle schools. Together, both data strands helped us understand if mathematics education in China promotes skills that contribute to student success in the PISA.
5. Findings

5.1 Financial literacy curriculum policies in China

Understanding of financial and economic life has long been part of the Chinese curriculum. More recently, in 2011, the MOE revised the national compulsory education documents and incorporated financial literacy more explicitly. They did so by identifying relevant subject areas for its development. Mathematics and “Moral and the rule of law” were the two subjects selected for fostering financial literacy. In mathematics, the MOE encouraged learning of disciplinary content in combination with the reality of family economic life. Although this expectation might seem to be intuitive, it did not specify which financial concepts were related to family economic life, leaving it up to teachers to interpret how to implement mathematics in meaningful ways.

“Moral and rule of law” was more explicit in content learning expectations. The course focuses on students’ understanding of private property, family investment, and related financial knowledge. These concepts, although still broad and general, provided a better sense of the vision of financial literacy promoted by the MOE. In fourth grade, for example, students were expected to learn about responsible consumption, and investment savings. In eighth grade, students were taught to distinguish financial fraud, be vigilant and prevent being scams. Overall, the expectations of this course seemed to emphasize awareness of the financial system and how to participate in it.

Particularly in wealthier jurisdictions such as Shanghai and Guangzhou, financial literacy was incorporated into local primary and secondary schools through informal initiatives of materials and books. A series of reading books was prepared and distributed to schools and the Zhejiang Department of Education collaborated with the Securities Regulatory Bureau to incorporate financial concepts into a publication titled “Man, Nature and Society” to be provided to schools. Similarly, the Sichuan Securities Regulatory Bureau and the Southwest University of Finance and Economics

| Table 1. Coding scheme used for data analysis. |
|-----------------------------------------------|
| Categories                                | Codes                                                  |
| Grade                                     | Seventh grade                                          |
|                                            | Eighth grade                                           |
|                                            | Ninth grade                                            |
| Mathematical content                      | Arithmetic                                             |
|                                            | Algebra                                                |
|                                            | Statistics (Data)                                      |
|                                            | * Specific content was coded according to textbook chapter names |
| Financial content                         | Money and transactions                                  |
|                                            | Planning and managing finances                          |
|                                            | Risk and reward                                        |
|                                            | Financial landscape                                    |
| Mathematical literacy process (capabilities)| Communicating                                          |
|                                            | Mathematizing                                          |
|                                            | Representing                                           |
|                                            | Reasoning                                              |
|                                            | Solving problems                                       |
|                                            | Using language and operations                           |
|                                            | Using mathematical tools                                |
| Financial literacy process                | Identify financial information                         |
|                                            | Analyze financial information                          |
|                                            | Evaluate financial issues                              |
|                                            | Apply financial knowledge                              |
jointly prepared a youth series on the five virtues (principles of Confucian education) in financial education for middle school. These materials reinforce the philosophy of Chinese society and the values that should guide financial practices. Along with the 2011 changes, it is noticeable an effort to integrate students into the globalized finance system while protecting collective values in China.

In 2017, the financial literacy curriculum started to incorporate environmental issues in middle and secondary schools. The MOE issued the “Guidelines for Moral Education in Primary and Secondary Schools”, requiring schools to advocate for green consumption among students (Tang & Wang, 2021). For example, students should learn to develop living habits of diligence, thrift, low-carbon environmental protection, and conscientious labor practices. Within the various activities that were developed, the MOE aimed at broadening students’ horizons through popularizing financial knowledge and credit awareness.²

In 2017 and 2018, a series of replies from the MOE clarified the institution’s view of the role of mathematics in developing financial literacy. According to the MOE, the goal of mathematics education is to support students acquire the knowledge and skills of mathematics necessary to adapt to social life.³ As an example, probability concepts can be used to understand lottery tickets while arithmetic can be used to understand different types of loans.⁴ In that sense, the mathematics curriculum remained highly abstract and focused on the formal representations of scholarly mathematics. Financial numeracy, in that sense, figured as a form of application of mathematical knowledge.

5.2 Overview of financial numeracy tasks

We identified a total of 25 financial numeracy tasks in the Chinese mathematics textbooks from middle school. Table 2 presents the number of tasks situated in each chapter and in each grade. Instead of being concentrated around one single domain, the tasks covered different mathematical concepts of arithmetic, algebra, and statistics. Arithmetic (two tasks) is represented by the seventh-grade chapter on rational numbers and operations. Algebra, the most common domain (17 tasks), is represented in all three grades by chapters on linear equations, inequalities, and functions. Statistics (six tasks) is represented in the seventh and eighth grades through chapters on data collection and analysis. The tasks also covered a variety of financial situations related to personal finance (bank statements, products, services, budgets), business (pricing, profit, sales), and government (foreign trade, income per capita).

The results show a decreasing trend along the three years of middle school: the seventh-grade textbooks contained 13 financial numeracy tasks, whereas the eighth-grade textbooks contained nine, and the ninth-grade textbooks contained only three tasks. This trend seems to be consistent with the increasing formalization and de-contextualization of the mathematics content in the Chinese curriculum. In addition to that, the ninth-grade textbooks put a heavier emphasis on geometric concepts: five out of eight chapters are dedicated to geometric concepts such as circles, triangles, symmetry, and projections. Those concepts have much less to do with financial numeracy than arithmetic, algebra, and statistics.

The results also show a pattern of revisiting similar financial situations over the three years of middle school mathematics. For example, phone plans and billing methods appear both in seventh and eighth grades. In seventh grade, students solve those situations with linear equations to compare and contrast different options. In eighth grade, they create functions that describe the monthly payment based on usage. In some cases, the revisiting of situations happens across different mathematical domains. Sales prices and discounts, for example, are explored both in seventh and ninth grades. In seventh grade, students calculate absolute and percentage values associated with different discounts on a product. In ninth grade, they explore the relationship between the discounts, sales, and profit in quadratic functions. This pattern of revisiting can help students solidify their understanding of (a) the financial concepts underlying these situations and (b) how mathematics is used to model and make sense of real-life situations.
In the next three subsections, we provide examples of financial numeracy tasks situated in the domains of arithmetic, algebra, and statistics. For each domain, we discuss the solution to a PISA task along with a task from the Chinese textbooks. Our goal is to identify which the underlying mathematical practices are necessary to solve the PISA tasks, and whether the Chinese textbooks provide opportunities for students to learn them.

5.3 Arithmetic—money and transactions

The vast majority of financial situations faced by individuals in everyday life involve the use of numbers and arithmetic operations that must be well understood for effective decision-making. In this subsection, we unpack the solution of sample task from the 2015 PISA exam (Figure 2) and contrast it to the arithmetic content presented in Chinese mathematics textbooks.

The solution to this problem can be broken down into two main components: understanding how mathematical information is represented and using mathematical information to calculate the quantity in question. Thus, solving it requires (a) identifying the quantities requested and (b) calculating the total amount. Each of these steps has potential obstacles to student reasoning.

To identify the quantity requested, students must understand the mathematical representation of the financial information provided in the problem and find the quantities associated with the question.
In this problem, the mathematical representation is the table provided, the financial information is the bank statement containing all financial transactions. Each line represents one unique financial transaction, so we need to identify which lines contain the quantity in question. This quantity is expressed in the table as “transfer fee” and four lines contain such an expression (e.g., 5 November, 12 November, 19 November, and 26 November).

In the table presented, each line contains three columns with numbers (albeit some are left blank), hence we need to distinguish the appropriate number to solve the problem. Each financial transaction falls within the category of credit (first column) or debit (second column), and the account balance

![Table](image)

**Question 1**

What were the total fees charged by the bank in November?

![Figure 2](image)
(third column) is impacted by these categories differently. A credit transaction adds to the balance; a debit transaction subtracts from the balance. For example, whenever a transfer fee is recorded, the previous balance (indicated by the value in the previous line) is subtracted by 1.50 because it is a debit transaction.

Understanding the problem and its mathematical representation can be a challenge for students unfamiliar with those financial concepts and how they inform each other. Nonetheless, even students unfamiliar with bank statements can identify the values required to solve the problem if they are proficient in reading mathematical information represented in tables and can identify the arithmetical relationships between the quantities portrayed.

The second step will then be the calculation of the total amount. That entails adding up all four transfer fees charged to the account. Each transfer fee is worth the same amount (1.50), and there are four recorded transactions of this kind. An additive solution to the problem would then be:

$$1.50 + 1.50 + 1.50 + 1.50 = 6.00$$

Alternatively, a multiplicative solution is also possible:

$$1.50 \times 4 = 6.00$$

Despite the apparent simplicity of the final step toward the solution, a possible obstacle students face relates to the financial interpretation of the quantity (transfer fee) and its category (debit). Because debit transactions are subtracted from account balances, they can also be recorded as negative numbers. In fact, bank statements in some countries use negative numbers to represent debit transactions; others use parentheses to denote such transactions. An additive and multiplicative solution would be respectively as follows:

$$(-1.50) + (-1.50) + (-1.50) + (-1.50) = -6.00$$

$$(-1.50) \times 4 = -6.00$$

It is not uncommon for mathematics teachers to use financial contexts to teach about negative numbers and operations, therefore it is important to make sure students are familiar with them to fully understand bank statements. In China, data from the mathematics textbooks show that students are introduced to those mathematical concepts and financial contexts from at least seventh grade. Figure 3 presents an open-ended, introductory task from the Rational Numbers chapter of a seventh-grade textbook. The task portrays two contexts in which negative numbers are used to depict geographic (the topography of a landmass) and financial information (a bank statement). Unlike the PISA task, the bank statement shown in the task uses only one column to indicate both credit and debit transactions: credit transactions are represented by positive numbers and debit transactions by negative numbers.

Because such a task is open-ended, students can explore the financial context of bank statements through multiple angles, some of which can support the reasoning required to solve the PISA task both in terms of (a) mathematical representations of financial information and (b) calculating quantities.

The first question in this task involves the mathematical representation of financial information. By interpreting the meaning of positive and negative quantities in the bank statements, students are being exposed to the financial concepts of debit and credit: positive numbers represent transactions that add money to a consumer’s account, whereas negative numbers represent transactions in which money is subtracted from the account. They can also create a list of transactions and then categorize them into positive numbers (credit) and negative numbers (debit), hence creating a shared vocabulary that supports their understanding of rational numbers as well as bank statements and financial practices. Some examples of positive numbers include salary, transfer received, deposit, gift, prize,
award, refund, and interest (in case of savings account). Some examples of negative numbers include withdrawal, transaction fee, payment, transfer sent, bills, purchase, and penalties (in case of late payments).

The second question in the task involves situations in which positive and negative numbers are used. Although students can explore other situations than those depicted in the task, the bank statement can still be used to discuss such a question. As mentioned previously, the balance column in the image was left blank. Using arithmetic operations, students can fill out that column to see how positive and negative numbers impact the final account balance. Assuming a balance of 0 Yuan at the beginning of the statement, it is possible to calculate the final balance as

$$0 + 2,000.00 + (-1,000.00) = 1,000.00$$

Here, we add all numbers together to emphasize that an account balance is the result of all transactions in one single account. Each transaction is either positive or negative, but the balance equals the sum of all operations in a time range. The same way of thinking can be expressed to make sense of profit and loss as shown in Figure 4. This figure presents another seventh-grade arithmetic task from the Operations with Rational Numbers chapter. It provides the net balance of a food store at the end of each day for a week. Instead of using the term net balance (which already refers to the sum of all transactions), the task introduces the terms profit and loss as a way to indicate numbers that are positive (profit) and loss (negative). It then asks students to calculate the net balance at the end of the week.

To solve the problem, two possible approaches can be used. First, we can categorize each of the net balances into profit (positive values) and loss (negative values), add up each category to obtain the
The profit and loss of the food store for each day of the week are as follows (the surplus is positive):

\[ ¥132, \ -¥12.5, \ -¥10.5, \ ¥127, \ -¥87, \ ¥136.5, \ ¥98 \]

What is the total profit/loss for the week?

**Table 3. Categorized record of profits and losses of the food store.**

| Profits  | Losses   |
|---------|----------|
| ¥132    | -¥12.5   |
| ¥127    | -¥10.5   |
| ¥136.5  | -¥87     |
| ¥98     |          |
| **Total:** ¥493.5 | **Total:** -¥110 |

**Table 4. Statement-like record of profits and losses of the food store.**

| Day   | Daily Balance | Total Balance |
|-------|---------------|---------------|
| Day 1 | ¥132          | ¥132          |
| Day 2 | -¥12.5        | ¥119.5        |
| Day 3 | -¥10.5        | ¥109          |
| Day 4 | ¥127          | ¥236          |
| Day 5 | -¥87          | ¥149          |
| Day 6 | ¥136.5        | ¥285.5        |
| Day 7 | ¥98           | ¥383.5        |

total for profits and losses, and then compute the final balance by adding profits and losses. Table 3 presents the categorization and sum of the information from the task.

\[ \text{Net balance: } 493.5 + (-110) = 383.5 \text{ yuan} \]

An alternative approach to solving this problem involves recording each daily balance in a statement-like table. In this case, each daily balance adds up to the total until the end of the week when we can identify the final quantity requested in the problem (bolded in Table 4).

The first approach to solving this problem reflects the social practice of accounting for the final values and finding the most time-effective calculation. The second approach, on the other hand, reflects how bank statements are effectively portrayed in China (based on the previous task) and indicates how the financial balance is constructed over the seven days recorded. In both cases, however, arithmetic operations involving negative numbers support students’
understanding of financial information involving credit/profit and debit/loss, which in turn support their response to the PISA task.

5.4 Algebra—planning and managing finances

Many financial situations can be explored through Algebra concepts and algebraic thinking. In this subsection, we describe the solutions to two tasks from the PISA and Chinese textbooks and how a solution rooted in algebraic thinking might offer an advantage to students writing the PISA exam. Figure 5 presents a 2017 PISA task on the topic of phone plans. In this task, the character (Ben) needs to compare phone plans offered by four different companies and decide which one offers the lowest monthly cost (“best financial deal”) based on his pattern of usage.

| Company       | Monthly fee (zeds) | Cost of call per minute (zeds) | Number of free minutes per month | Cost of text message (zeds) | Number of free text messages per month |
|---------------|--------------------|-------------------------------|----------------------------------|---------------------------|----------------------------------------|
| Company 1     | 20                 | 0.27                          | 90                               | 0.02                      | 200                                    |
| Company 2     | 20                 | 0.25                          | 90                               | 0.02                      | 100                                    |
| Company 3     | 30                 | 0.30                          | 60                               | free                      | unlimited                              |
| Company 4     | 30                 | 0.25                          | 60                               | 0.01                      | 200                                    |

Ben lives in Zedland and has a mobile phone. In Zedland there are different kinds of phone plans available. The table below shows the details of four different phone companies. All costs are shown in zeds.

**Ben**

I speak on the phone for about an hour each day, but I very rarely send text messages.

Which phone company offers the best financial deal for Ben?

A Company 1
B Company 2
C Company 3
D Company 4

Figure 5. Programme for International Student Assessment (PISA) phone plans task (OECD, 2018, pp. 12–13).
The solution to this problem involves three steps associated with the data shared by the character (Ben) in the callout. The first step involves attributing a number to qualitative information by making estimations and assumptions about what those estimations imply. In this case, it means to discard the data about the cost of messages because the character “very rarely” sends text messages. Our assumption is that the cost of text messages is negligible since he does not use such a service significantly.

The second step involves unit conversation; in this case, units of time. It is a common practice in and in this case, it involves units that are typically explored in elementary mathematics classrooms. We need to convert the character’s daily usage (“about an hour each day”) into monthly usage (MU) in minutes. One possible approach is as follows:

- Convert hours into minutes: 1 h/day = 60 min/day.
- Calculate MU: 60 min/day * 30 days/month = 1800 min/month.

The third and final step involves the final calculation to find the best financial deal. We can use the data provided to calculate the monthly cost of each phone company to identify the lowest cost. In this problem, students are only being asked to find the lowest cost, therefore students can solve this problem numerically without the need for formal modeling. Based on their interpretation of each variable presented in the problem, they can surpass the linear equation and use arithmetical operations to find the solution. For example, let us look at the plan offered by Company 1:

- Discount the free minutes from the MU: 1800 – 90 = 1710. That represents the actual number of minutes that will be charged.
- Multiply the MU by the cost per minute: 1710 * 0.27 = 461.70. That represents the cost of calls for a whole month.
- Add the fixed monthly fee (MF) to the cost of calls: 461.70 + 20 = 481.70. That represents the total monthly cost for the plan offered by Company 1.

Table 5 shows the numerical results for each of the four companies. As we can see, Company 2 has the lowest monthly cost based on the character’s information.

Although the problem can be solved numerically, there is evidence to show it was designed for a solution based on algebraic thinking. Once we have disregarded the cost of text messages, the four plans can be compared in groups of two. Companies 1 and 2 offer the same fixed MF and the same number of free minutes (NFM) per month. The only difference between them is the cost of call per minute (CM). Consequently, we automatically conclude that Company 2 offers a better deal than Company 1. Similarly, between Companies 3 and 4, Company 4 offers a better deal. Finally, comparing Companies 2 and 4, we notice that both offer the same CM. However, Company 2 has lower MF and more free minutes per month. Between the two of them, Company 2 offers the best deal, and that is the final answer to the problem.

| Company      | Total monthly cost          |
|--------------|-----------------------------|
| Company 1    | (1800 – 90) * 0.27 + 20 = 481.70 |
| Company 2    | (1800 – 90) * 0.25 + 20 = 447.50 |
| Company 3    | (1800 – 60) * 0.30 + 30 = 552   |
| Company 4    | (1800 – 60) * 0.25 + 30 = 465   |
A linear equation can be constructed to define the monthly cost of each phone plan using the MU, NFM, CM, and the MF:

\[
Cost = (MU - NFM) \times CM + MF
\]

Students familiar with algebraic notation and thinking can efficiently solve the problem without inputting the actual values provided in the problem. They can use the linear equation to analyze the impact of each variable on the final monthly cost. When other variables remain the same, an increase in NFM will lower the cost, whereas an increase in CM or MF will heighten the cost.

A solution rooted in algebraic thinking offers two major advantages to students partaking in the PISA exam. First, it allows them to solve the question faster, saving them time for other, time-demanding tasks. Second, it does not require multiple arithmetic calculations with decimal numbers, which lower their chances of making a mistake leading to the incorrect answer.

Chinese students seem to be familiar with algebraic notations from a young age. Figure 6 shows a similar problem to the one from PISA. The problem comes from an eighth-grade textbook, specifically the chapter about linear functions, where students explore different representations (graphs, equations, etc.) and solve the problem through what it’s called the functional method (model a situation using linear equations before plugging in the appropriate numbers).

In this problem, like the PISA task, students are also required to compare two different phone plans. The problem does not provide a specific situation and does not ask students to find which plan is better financially; however, it does require students to figure out when both plans will yield the same monthly cost. Additionally, the problem specifies which method students are expected to use to solve it. The functional method described in the problem refers to the modeling of each billing method through linear functions. The total monthly cost depends on the monthly rental fee (MF), the local call fee per minute (CM), and the MU in minutes:

\[
Cost = CM \times MU + MF
\]

For each of the billing methods described in the problem, one unique function can be constructed.

---

**Figure 6.** Eighth-grade task situated in the Linear Functions chapter (Lin, 2013d, p. 98).

Consider the following two mobile phone billing methods:

|                           | Method 1 | Method 2 |
|---------------------------|----------|----------|
| Monthly rental fee (yuan/month) | 30       | 0        |
| Local call fee (yuan/min)   | 0.30     | 0.40     |

Use a functional method to solve when the two billing methods cost the same.
with MU as the only variable. We can then equate both functions and solve the resulting equation for MU. The solution is as follows:

\[
\text{Method } 1 = 0.30MU + 30 \\
\text{Method } 2 = 0.40MU \\
\text{Method } 1 = \text{Method } 2 \\
0.30MU + 30 = 0.40MU \\
30 = 0.40MU - 0.30MU \\
30 = 0.10MU \\
MU = \frac{30}{0.10} \\
MU = 300 \text{ minutes}
\]

If a customer uses their phone for 300 min a month, both billing methods are equivalent. For customers who use it for less than 300 min, billing method 2 is more cost-efficient; for customers who use it for more than 300 min, billing method 1 is more cost-efficient.

The same solution can be observed by representing both billing methods as linear functions in a graph (which is part of the functional method described in the Chinese textbook). Figure 7 shows two linear function graphs and their intersection at 300 min. Interestingly, the graph also shows the

![Figure 7. Graphs for phone plan billing methods (constructed on GeoGebra 6).](image)
monthly cost (120 Yuan). For a usage of less than 300 min (left of the graph), method 2 has a lower monthly cost (the red line is below the green); for a usage of more than 300 min (right of the graph), method 1 has a lower monthly cost (the green line is below the red).

Through this problem, students not only learn about the modeling of a real-life financial situation, but they also have the opportunity to learn about the relationship between variables in a function: the MU, and the total monthly cost. As the MU increases, the total monthly cost also increases, and that applies to both billing methods. However, despite starting off at a higher cost, method 1 increases at a lower rate than method 2 as illustrated by the slope of the red line being steeper than the green line. This is why, at one point, method 2 surpasses method 1 in the total cost.

5.5 Statistics (data)—financial landscape

Besides numbers and algebraic models, financial situations often require students to make sense of data which is represented in a variety of ways. In this subsection, we describe the solution to two tasks involving data representation and analysis. The first task, used in the 2012 PISA financial

![Rich Rock Share Price](image)

This graph shows the price of one Rich Rock share over a 12-month period.

| Time (months) |  |  
| Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Price (zeds) |  |  
| 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | 3.00 |

Which statements about the graph are true?
Circle “True” or “False” for each statement.

| Statement | Is the statement true or false? |
|---|---|
| The best month to buy the shares was September. | True / False |
| The share price increased by about 50% over the year. | True / False |

Figure 8. Programme for International Student Assessment (PISA) share price task (OECD, 2017a, p. 8).
literacy exam, presents a line graph describing the fluctuation in price of the shares of a fictional company (Figure 8). The 12 observations represent monthly fluctuations over the course of a year. The task then presents two distinct statements about such data and requests students to determine whether each statement is true or false.

The first statement involves interpreting statistical data from the visual representation provided. In other words, evaluating the statement is about analyzing a specific type of graph and finding the information requested. In this case, the variable in question is identified as “best month to buy”. Implicit to the task, however, is the equivalence between “best month” and “lowest price”, indicating a quantitative relationship between price and benefit to the investor.

This relationship in itself implicates knowledge of some financial concepts related to investment and how the price of a share might benefit individuals. The price of a share fluctuates over time as a reflection of the company’s value in the stock market. If an investor purchases the share at a low price and sells it later at a higher price, then the difference (in this case, positive) in price will be the profit made off the investment. When calculated in terms of percentage of the initial price, such a difference is defined as return on investment. Consequently, to maximize the profit (or the return on investment), an investor would benefit from (a) buying a share at its lowest price and (b) selling it at its highest price. Specifically in this task, students are being asked to find the first condition.

Aside from the financial concepts, being able to interpret the graph is a mathematical requirement for finding the necessary information. Two variables are presented in the graph, one in the x-axis (the independent variable, time), and the other in the y-axis (the dependent variable, price). The data points on the graph represent observations of a dependent variable (price) in relation to an independent variable (month), connected by a line to show the continuous fluctuation. Each data point is defined by a pair of the two variables (month and price). For example, in June the share price was 2.00; we can define such an observation as (June 2.00).

To find the lowest price, we need to verify which data point corresponds to the lowest value of the dependent variable located on the y-axis. A parallel line to the x-axis can be used to trace each data point’s corresponding price. Having found such a data point, we then move on to find the
corresponding independent variable (month) on the $x$-axis. Similarly, a parallel line to the $y$-axis can be drawn on that data point to find the month, which in this case is the month of September. Hence, in September, the share price was at its lowest, so the statement is true. Figure 9 indicates the position on the graph of both independent and dependent variables. It is important to note that we did not need to identify the price of the stock in September; in fact, the scale used in the graph does not precisely indicate such a price.

The second statement in the task involves a quantitative comparison of data points from the graph. Before engaging in comparison, the first step is to identify the values associated with the condition described in the statement. The graph presents data on the fluctuation of the share price over the course of 1 year (from June to May of the following year), so “over the year” indicates that we must attend to the values from the first and last data points, respectively. In addition to that, since the analysis is about the variation on the share price, the dependent variable values will be used. Let us define the share prices in June and May as Initial Price and Final Price, respectively:

$\text{Initial Price} = 2.00$

$\text{Final Price} = 2.50$

The statement in the task refers to percentage increase in the share prices. That means the percentage of the initial price (quantity of reference) represented by the difference between the final price and initial price. In other words, it compares the variation in price with the initial price. The calculation is presented below. The result shows that the share price increased by 25% over the year, so the statement is false.

\[
\text{Percentage increase} = \frac{\text{Final} - \text{Initial Price}}{\text{Initial Price}} \times 100\
\]

\[
\text{Percentage increase} = \frac{2.50 - 2.00}{2.00} \times 100\
\]
Overall, the PISA task required students to be fluent in two mathematical practices: interpreting data representation and comparing quantitative data. Evidence from the Chinese textbooks shows that students are introduced to these practices in similar financial contexts from seventh grade. Figure 10 presents a task from the chapter dedicated to data collection, sorting, and description. In the task, data from Chinese exports and imports over the years are presented in a table of numbers (measured in USD 100 million). Students are then asked to represent the data using an appropriate graph and then compare the two quantities.

Similar to the PISA task, the first part of this task involves data representation and interpretation. Consequently, some understanding of the financial concepts portrayed in the situation is important to appropriately select the graph. In the task, exports refer to the amount of money originated from products or services produced in a country (China) but sold to a buyer abroad. Imports refer to the amount of money originated from products or services produced abroad but sold to buyers in the country (China). These two concepts can be interpreted in the task as two distinct variables that do not depend on each other. The task presents the quantities of each variable over the course of seven years. It is important to notice that because time is part of the data, the most appropriate graphs will highlight fluctuations in the dependent variable(s) in relation to the independent variable. Some examples include bar and line graphs. Pie charts or tree maps are not appropriate because they typically represent parts of a whole without accounting for change in time.

Statistically, we can refer to time (in years) as an independent variable and exports/imports as two dependent variables. The data sets can then be represented as data points on a graph. We consider a data point to be the ordered pair of independent and dependent variable values. For example, in 2004, the volume of exports was 5,933 times USD 100 million, so the data point will be the ordered pair (2004, 5,933). Figure 11 provides an example of a graph that can be used to describe the data. The graph resembles the one from the PISA task, but instead of only one line, it shows two to indicate each of the dependent variables (imports and exports).
Further to the representation of data in a graph, the task also requires students to compare the two data sets. Evidently, the comparison should mobilize the same concepts presented in the respective chapter; hence, we must note that this is not a statistics chapter. While it presents some measures of central tendency, most of the content is dedicated to the analysis of data fluctuations. Here, we present a possible approach to comparing the two data sets based on the fluctuation of the two variables (exports and imports).

In data analysis, an initial comparison of data sets can be done qualitatively. Looking at the graph, for example, the volume of exports and imports were at a similar level in 2004. Although both variables fluctuated similarly over the years (increased in every year compared to the previous one, except for 2009), we notice that at the end of the time range, the volume of exports was noticeably higher than imports. Such a comparison indicates qualitatively a relationship between the variables that can be investigated quantitatively. Like the PISA task, we described in this subsection, we can use the concept of percentage increase to evaluate exactly by how much the volume of exports increased compared to the volume of imports. The calculation of each percentage increase is as follows:

\[
\text{Exports percentage increase:} \frac{15,777 - 5,933}{5,933} \times 100\% \approx 166\%
\]

\[
\text{Imports percentage increase:} \frac{13,962 - 5,612}{5,612} \times 100\% \approx 149\%
\]

While the imports increased by 149% from 2004 to 2007, the exports increased by 166%, a difference of 17% points. Other approaches to comparing the fluctuations of the two data sets are possible: calculate their means and SDs; calculate the percentage fluctuation between two consecutive years (e.g., 2008–2009, the only interval in which both variables recorded a decrease), find in which year the variables saw the highest increase (both in terms of absolute number and percentage). In any of these cases, the common thread is to include the independent variable (time measured in years) as a parameter to the quantitative comparison. Consequently, we argue that such a task includes all elements to support student reasoning in the PISA task.

6. Discussion

Despite evidence that mathematical processes play a significant role in developing financial literacy (Attard, 2018; Cordani, 2013; Savard, 2018), recent educational policies in China have not incorporated the topic in the mathematics curriculum to a significant degree. These results reflect the disciplinary nature of the curriculum in China, with a stronger focus on mathematical content in detriment of practices, competencies, and processes (Wang & Lu, 2018). Consequently, financial concepts have little space in a curriculum whose epistemology values mathematics as an academic discipline as opposed to the development of numeracy among students.

Nonetheless, the textbooks approved by the Chinese MOE seem to incorporate financial numeracy from a contextual dimension (Cavalcante, 2020; Savard & Cavalcante, 2021b). The contextual dimension refers to the use of financial contexts as a means to teach mathematics and increase motivation and engagement among students. Financial numeracy education from a contextual dimension heavily emphasizes the formal mathematical content present in such situations. In mathematical tasks, authenticity is not a significant concern under the contextual dimension; the context can often be replaced without any loss in intelligibility or mathematical sense.

That is not to say that the contextual dimension does not contribute to the development of financial literacy. As presented earlier, these tasks provide students the opportunity to learn relevant vocabulary and to use mathematical processes to make sense of the financial world. The main limitation of
Table 6. Analysis of processes from the Programme for International Student Assessment (PISA) financial literacy and Chinese textbook tasks.

| Task         | PISA financial literacy                                                                 | Chinese textbooks                                                                 |
|--------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| **Arithmetic** | Mathematizing: Identify rational numbers represented in a table (mathematizing)            | Mathematizing: Identify the use of rational numbers in a table (mathematizing)      |
|              | Using language and operations: Calculate quantities using arithmetic operations with rational numbers | Using language and operations: Calculate quantities using a sequence of arithmetic operations with rational numbers |
| **Algebra**   | Mathematizing: Assign a quantity to qualitative information                                | Mathematizing: Identify variables in a real-life situation                          |
|              | Representing: Estimate the impact of variables in an implicit linear function              | Representing + using language and operations: Write a linear function with multiple variables; Solve a linear equation |
| **Statistics**               | Communicating: Read quantitative information represented in a graph                        | Communicating + Representing: Create a graph to represent quantitative information   |
| **(Data)**     | Solving problems: Use statistical information (two data points) in quantitative analysis (comparison) | Reasoning + Solving problems: Use statistical information (two data sets) in quantitative analysis (comparison) |

Regardless of intentionality, the results of this study show that middle school mathematics textbooks in China support student performance in the PISA exam. Table 6 presents a summary of qualitative data presented in this article; it synthesizes the mathematical processes required to solve both the PISA tasks and those from the Chinese textbooks from all three mathematical domains, arithmetic, algebra, and statistics (data). The highlights represent the main differences between these tasks.

By contrasting the nature and structure of these tasks, we have identified four aspects of how Chinese mathematics textbooks support students in the PISA exam:

- **Mathematical complexity**: In all cases, the Chinese textbooks mobilize more complex processes in the solution of tasks. In arithmetic, the PISA task required students to identify rational numbers and use single arithmetic operations, whereas the Chinese tasks required students to make decisions before using rational numbers in calculations; they required students to not only identify and use rational numbers, but also identify how they are used in the situations (negative balance and profit/loss). In algebra, the PISA task implicitly presents the notions of variable and linear functions. That means students could solve such a task more efficiently by mobilizing these concepts to find the solution. We have evidence, from the Chinese task, that Chinese students do learn these concepts and
their applications in similar situations. Furthermore, they explore linear functions with more variables than the PISA task and learn to solve linear equations. In statistics, we noticed that the PISA task involves passive and less complex engagement from students. The task requires students to read from a graph and compare two data points in one set. The Chinese task, on the other hand, involved an active engagement from students (choose and create an appropriate graph for data visualization) on top of proposing a more complex type of data comparison (two data sets).

**Financial concepts:** The tasks we selected and presented in this article provide evidence that Chinese students engage in similar financial concepts as those required to solve the PISA tasks. It is possible for two tasks from similar financial situations to have distinct underlying concepts. Yet, the tasks we explored in our qualitative analysis required a similar understanding of bank statements, phone plans, and business finance. Even in the absence of further instruction on financial topics (which does not seem to be the case in China), this finding can help explain the performance of Chinese students in the PISA exam.

**Time:** Chinese students who participate in the PISA exam are typically in 10th grade. Our results show that financial numeracy is explored in Chinese mathematics classes from seventh grade, indicating that students have at least three years to make sense of the relationship between mathematics and financial situations. Not only do they engage in complex mathematical processes in similar contexts, but they also do so early enough to be able to mobilize them in the PISA.

**Pedagogical design:** In addition to learning financial numeracy at an early age, Chinese students keep working on these concepts over the years. Our findings of financial situations that are revisited under new mathematical concepts (and sometimes, domains) provide evidence that the pedagogical design of these textbooks promotes a deeper understanding of the financial situations being portrayed. Consequently, we argue that the design of these textbooks supports the performance of Chinese students in the PISA exam.

7. **Conclusion**

The goal of this article was to investigate how Chinese mathematics curriculum policies and textbook tasks could help explain the results obtained by Chinese students in the 2012 and 2015 PISA financial literacy exams. Our praxeological analysis permitted us to contrast the solution to PISA tasks with that of financial tasks from middle school mathematics textbook. Our results show that, despite the lack of attention to mathematics in the curriculum policies for financial education, the mathematics textbooks seem to support the performance of students in the PISA by (a) incorporating more mathematically complex content, (b) tackling equivalent financial concepts, (c) providing students with enough time to consolidate their understanding throughout middle school, and (d) designing pedagogy that revisits these concepts over the years.

Some of the limitations in this study include the limited size of our sample. In the textbook collection selected, we identified less than 30 financial numeracy tasks, therefore any inference about their potential to teach financial concepts must be taken with caution. In addition to that, we recognize that textbooks are just one out of multiple resources at a teacher’s disposal to teach mathematics. Our study did not investigate the extent to which Chinese teachers use these textbooks in their classes and how many of these tasks they require students to solve. Also, other aspects of mathematics education might play a role in the relationship between teaching and performance in the PISA exams. While we have not identified all mathematical processes in our data, the use of tools such as calculators, for example, can play a significant role in how students learn mathematics and perform in international assessments. Future research could investigate the use of rational or integer numbers in financial numeracy tasks and analyze to understand whether using friendly numbers (typically integers) instead of authentic numbers (typically rational) is an obstacle to the development of financial numeracy.
Overall, the article contributes to the development of the Anthropological Theory of the Didactic by promoting a rich interpretation of praxeologies as they intersect the theoretical fields of mathematics and finance. With the integration of new content areas in mathematics curricula worldwide (e.g., data literacy, digital literacy, and financial literacy), new frameworks are needed to make sense of how traditional mathematics interacts with these interdisciplinary, context-rich areas. Our theoretical framework helped us identify the bifurcation from the practice block (naturally interdisciplinary) to the justification block (traditionally disciplinary). While promoting rich tasks can merge different content areas in their solution, the underlying justifications require distinct understandings and epistemologies. The article also contributes to research on mathematical tasks and financial numeracy education. Research on mathematics textbooks often draws comparisons between textbooks from different countries (Fan et al., 2013). Our analysis contributes by presenting a method of contrasting two types of institutions that make use of tasks in different ways and with different goals. Research on financial numeracy education is still developing in mathematics education (Cavalcante, 2020). Our analysis illustrates the role of mathematical processes in the sense making of financial tasks both in classrooms and international assessments.

Finally, we must emphasize that we do not argue for financial numeracy to be implemented in mathematics with the goal of succeeding in international exams such as the PISA. Instead, our goal was to investigate whether mathematics education could be interpreted as one contributing factor to the success of Chinese students. Explaining their success in the PISA involves acknowledging the role of a variety of other factors: other subject areas (such as politics), parent interaction, financial habits of students (allowance, part-time jobs, etc.), socioeconomic factors, etc. Also, direct comparisons with other countries must be done with caution as they reflect vastly different realities. Future research has yet to investigate how mathematics education (formal and informal) contributes to the financial numeracy of students beyond standardized exams.

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Notes
1. Retrieved from: http://www.moe.gov.cn/srcsite/A26/s8001/202104/t20210419_526998.html
2. Reply to recommendation No. 5720 of the second session of the 13th National People’s Congress: http://www.moe.gov.cn/jyb_xsgk/xxgk_jyta/jyta_jiaocaiju/201909/t20190903_397212.html
3. Reply to the recommendation No. 7069 of the fifth session of the 12th National People’s Congress: http://www.moe.gov.cn/jyb_xsgk/xxgk_jyta/jyta_jijiaosi/201712/t20171220_322007.html
4. Reply to recommendation No. 3214 of the first session of the 13th National People’s Congress: http://www.moe.gov.cn/jyb_xsgk/xxgk_jyta/jyta_jiaocaiju/201812/t20181225_364787.html

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