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Comparative analysis of contextualization in mathematics textbooks in Morocco, Canada, and China

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ABSTRACT

Textbooks play a key role in mathematics learning by structuring concepts and influencing teaching methods as well as students' perception of the subject. The contextualization of mathematical concepts, by integrating real-world problems, is essential to encourage the application of knowledge to concrete situations. This study compares mathematics textbooks from Morocco, Canada, and China to analyze their pedagogical approaches, particularly regarding contextualization. Based on the theory of realistic mathematics education (RME), it examines how these textbooks make mathematics more concrete and relevant for students. By providing an international comparison, this study contributes to a better understanding of pedagogical practices and highlights the importance of appropriate contextualization to improve mathematics learning. It emphasizes the impact of editorial choices on how students perceive and engage with the subject. The analysis reveals that Chinese and Canadian textbooks offer a greater variety of contextualized problems and representations, which enhances students' understanding. In contrast, Moroccan textbooks adopt a more abstract approach, limiting students' motivation and performance.

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1. INTRODUCTION

It is clear that textbooks play an essential role in constructing mathematical knowledge by structuring, presenting and explaining mathematical concepts and problems. They provide learning opportunities for both students and teachers [1], systematically guiding the construction of links between the curriculum, teachers, students and the teaching environment [2]. Several studies highlight the importance of textbooks in the learning process, influencing teaching methods, question difficulties, and classroom activities [3]. The effect of textbooks on learning and teaching is significant because their content should reflect that of the school curriculum, many mathematics teachers prefer to use the textbook as a main teaching aid [4], but each book has its own characteristic and a teaching approach according to each country [5] and each country has its own study program which can influence the form of questions and teaching methods in this book.

This is the main idea of comparative analysis of textbooks which provides valuable information on students' performance expectations in different countries [6], as well as the priorities given to conceptual

understanding or mastery of procedures [7]. Research by Rezat *et al*. [8] and Toprak and Özmantar [9], for example, also showed the correlation between the quality of textbooks and student achievement in mathematics. This is why the comparison of textbooks between countries has become a topic of growing interest in recent years, with studies examining various aspects such as the formulation of mathematical problems and the content covered, for instance, Takeuchi and Shinno [10] conducted a comparative analysis of lower secondary school textbooks in Japan and England. Similarly, Toprak and Özmantar [9] examined fifth-grade mathematics textbooks used in Turkey and Singapore, while Huang *et al.* [11] carried out a comparative study focusing on algebraic questions in Chinese and Indonesian textbooks. These types of studies, along with findings from international assessments such as trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA), highlight the importance of understanding and analyzing textbooks in an international context.

Researchers at the Freudenthal Institute, such as Hans Freudenthal, Marja Van Den Heuvel, Jan de Lange, Martin Kendt and Michiel Doorman, have highlighted in their lectures the active involvement of students in the teaching and learning process [12]. They pointed out that teachers can reduce their unnecessary interventions by providing contextualized problems [13], which can motivate students to better understand mathematics, this motivation is closely related to their understanding of the concepts taught, which highlights the importance of textbooks in engaging students in their learning of mathematics [14]. According to Rezat *et al.* [3] the field of mathematics education is specifically defined by the interaction between teachers and learners, textbooks and mathematical knowledge should be used to explain the quality of teaching and learning processes. The main obstacles of the mathematics program are linked to its inconsistencies with mathematical concepts in the school curriculum; however, mathematics is directly linked to the contexts of daily life to be easier to teach and more motivating for students. This is why mathematics is more focused on the contexts where this knowledge emerges in the real life of the learner and students are also motivated when they understand mathematics.

Based on this explanation, this research aims to make an original contribution by exploring the contextualization of algebra exercises in textbooks from 3 culturally and geographically distinct countries (Morocco, Canada, and China) and the role of real-life contexts in mathematics learning and their impact on students' motivation and understanding. This comparison is based on the types of representations of exercises (problems) in a well-contextualized and meaningful context for the student, derived from their daily life. As mentioned previously and according to the theory of realistic mathematics education (RME). The international comparative analysis of mathematics textbooks is an essential approach to understanding the different pedagogical approaches adopted across educational systems. This diversity can influence students' motivation towards mathematics. One of the main innovations of this research is the articulation between the analysis of textbooks and the theory of RME, rarely exploited in international comparisons. Moreover, the study establishes a direct link between the quality of contextualized exercises. By highlighting these aspects, this research offers a new perspective on the influence of textbooks on success in mathematics, also opening avenues for the improvement of educational content specifically for Morocco.

Some textbooks emphasize practical applications and real-world problems, which can help students see mathematics as useful and relevant to their daily lives [15]. For example, in China, students generally show strong performance in international surveys such as TIMSS 2019 [16] results show that China consistently ranks among the best in the world, particularly in mathematics, where Chinese students achieved exceptionally high scores, reflecting strong educational practices. Similarly, Canada ranks very high, within the top 10 globally, which indicates a robust educational system, although challenges in equity remain. In contrast, Morocco ranks among the lowest scores, far from the average.

Textbooks may focus more on theory and procedures, which may not generate the same level of engagement among all students. This influences students' motivation towards mathematics as an essential subject in education [17]. So, contextualization in textbooks is essential to make mathematics relevant to students. It can manifest itself through the integration of real-world problems that encourage students to apply mathematical concepts to real-world situations. This can not only improve students' understanding but also increase their interest and engagement in the subject.

The notion of RME was developed by H. Freudenthal, who also founded a new school of mathematics education known as "realistic mathematics education" [18]. RME, often referred to as realistic mathematics teaching, is a distinct approach to teaching and a reform in mathematics education led by Freudenthal [19]. According to Freudenthal [19], mathematics is a human endeavor [20]. As a result, he thought that mathematics should be a practice of mathematization rather than a closed system. In recent years, RME has become one of the main trends in mathematics education. Freudenthal developed it in the Netherlands over several decades. Therefore, RME aims to make mathematics instruction more applicable, practical, and relevant for the vast majority of students [4] and to foster a deeper understanding of mathematics by connecting abstract concepts to concrete situations [21]. RME is characterized by diverse real-life situations that serve as sources for

developing mathematical concepts, instruments and procedures, where concepts were taught in a formal and atomized manner. RME aimed to reform the traditional approach to mathematics. teaching of mathematics which were significantly separated from reality. In RME, the connection between mathematics and real life is not only present at the conclusion of the learning process, but also serves as a resource for the teaching and learning process in meaningful contexts, encouraging students to imagine, model, and solve mathematical problems by highlighting the progressive construction of mathematical knowledge, beginning with the concrete and moving toward the abstract.

The current curriculum orientations in many countries for example in Canada, each province and territory have one or 2 ministries responsible for education, headed by a minister. These departments focus solely on the direction of education of the country [22] moreover there is not a single school system, this variety keeps the Canadian mathematics curriculum follows a conceptual approach that focuses on the processes of critical thinking, problem solving, and real-world applications. In lesson planning, nothing obliges teachers and students to use and follow previously determined textbooks [11] but teachers have a lot of leeway regarding their order of study. The English-speaking education system in Canada outside Quebec has 3 phases: "elementary school" in 6 years up to "grade 6", "junior high school" 2 years "grade 7 and 8", and "senior high school" 4 years from "grade 9" up to "grade 12" [22].

In China, education is considered the main path to social and economic success, and the competition to get into the best schools and universities. That is why China values an education based on rigor and discipline. For compulsory education in China is 9 years allows students over 6 years old throughout the country to benefit from primary education from 1st to 6th grade except Shanghai (5 years) and in middle schools from 7th to 9th year and upper secondary education in 3 years (from 10th to 12th year).

In Morocco national reforms aimed at modernizing education and making it more international have led to the introduction of more universal content and the improvement of students' skills, particularly in mathematics. Like the emergency education plan (2009-2012) and the strategic vision for reform (2015-2030), which are examples of policies that sought to reform the content of textbooks to promote mathematical logic among learners. The basic education coincides with the law of compulsory education for all children over 6 years old in primary education, which is 6 years, secondary college in 3 years, and 3 years in secondary qualifying. It is the Ministry of National Education that develops teaching programs and methods, supervises the design of school textbooks, and ensures the training of teaching and school administration staff; it monitors the structures, programs, and teaching methods. This is the idea of contextualization in mathematics textbooks from 3 countries (Canada, China, and Morocco) constitutes the main basis of our study.

2. METHOD

The idea of contextualization in mathematics textbooks from 3 countries (Canada, China, and Morocco) constitutes the main basis of our study to examine the mathematics textbooks to understand not only the specific skills they seek to develop in students but also the underlying pedagogical principles that guide the design of these textbooks. The main objective is to examine the types of exercises proposed in each textbook and to see how motivation influences student learning in the different cultures of the 3 countries, thanks to the RME theory. By analyzing these aspects, the study seeks to provide crucial information that can guide future decisions regarding the curricula and teaching methods adopted by textbook authors, particularly in Morocco. To what extent does contextualization in mathematics textbooks influence the motivation and performance of Moroccan, Canadian, and Chinese students, using this variety of TIMSS international survey results as an example?

In other words, we seek to shed light on how educational and curricular choices are influenced and how this information can be used to improve the effectiveness of textbooks and mathematics teaching, particularly in Morocco given the poor results in international surveys. The Canadian education system values diversity and inclusivity; this reflects the development of the individual, creativity, and lifelong learning of the learner. Teaching in Canada prioritizes student-centered learning. Teachers are seen as guides. Recent reforms emphasize the development of science, technology, engineering, and mathematics (STEM) skills to develop critical thinking and the application of mathematical skills in real-world contexts [23].

2.1. The selection of textbooks

The series of school textbooks selected for Canada in our study is "Math Makes Sense 7" for level 7 published by the publishing house Pearson Education Canada, Toronto, among the reasons for choosing this textbook is compatible with the Canadian mathematics curriculum and the most used across the provinces of Canada, we can easily access and obtain it. The textbook is composed of several units, each unit contains lessons and exercises in 3 phases of activity or launch exercises called "launch" and "mid-unit" practical course exercises and at the end a unit of exercises which contains exercises and investigation problems [24].

The 2 most popular series of mathematics textbooks in China in terms of the number of regions where they are used in both cycles are those published by People's Education Publishing House (PEP) and Beijing Normal

University Publishing House (BNUP). These are the Shanghai mathematics curriculum standards for primary and secondary schools and the mathematics curriculum standards for compulsory education, which are implemented in China's compulsory education system [3]. Mathematics textbook for compulsory education of the People's Republic of China, is a series of textbooks written according to the mathematics course standards of the Ministry of Cultural Education, 2012 edition, and the most widely used series in China in terms of the number of regions. It is composed of 2 volumes for each level, one for each semester. We will examine the 7th-grade textbook, both volumes at the same time, we will be interested in our study with the 7th year manual the 2 volumes in this level are classified according to the course chapter which contains 3 types of exercises: course activity exercises, practice exercises, and review question and problem type exercises. The selected Moroccan mathematics school textbook is Maxi Maths approved by the national Ministry of Education from Edition Plus [25]. It is composed of course chapter contains course activities and application exercises, integration, and deepening.

2.2. Selected algebra chapter

After selecting the textbooks, we used the content analysis method. Also, for ease of study, we chose a sample chapter to examine the distribution according to the aspects: purely mathematical problems (non-contextualized) and contextualized problems by counting take into account the types of representations of each contextualized problem (textual, illustrated, or combined between the illustrated and the textual) whether they are course activities, course application exercises or reinforcement exercises and the structure of the chapters in these 3 manuals, we also looked at the textbooks from the standpoint of comparison in terms of distribution, as previously noted, in order to determine the similarities and differences in how algebra chapters are represented across the 3 textbook series. In the Table 1 the distribution of courses in the algebra chapters in the 3 textbooks.

Table 1. Distribution of algebra chapter in textbooks from Canada, China, and Morocco

Algebra chapter	Canada	China	Morocco
Chapter 1	Patterns and relations	Relative numbers	Sequence of operations
Chapter 2	Integers	Addition and subtraction of relative numbers	Numbers and fractional writings
Chapter 3	Fractions, decimals and percent's	Quadratic equations of a variable	Relative numbers
Chapter 4	Operations with fractions	Linear equation system in 2 variables	Operations on relative numbers
Chapter 5	Equations	Real numbers	Powers
Chapter 6			Development and factorizations
Chapter 7			First degree equations with a single unknown

2.3. Chapter selected samples

The distribution of algebra chapters varies from textbook to textbook. For example, the part of relative numbers and the operations (addition and subtraction) of which we are going to reverse is presented differently. In the Canadian manual, this part is in chapter 2, while in China, it is divided between chapters 2 and 3, but in the Moroccan manual, it is between chapters 3 and 4.

2.3.1. Canadian school textbook "Math Makes Sense"

The Table 2 gives the percentage of each type of activity in the sample chapter, as well as the percentage of non-contextualized (purely mathematical) and contextualized problems and the different modes of expression in the school textbook "Math Makes Sense 7".

The analysis of Table 2 highlights trends in different mathematics activities and the modes of expression used (textual, illustrated, and combined). In the "explore" activity, all problems are contextualized, while in other activities, there is a mix of pure mathematical and contextualized problems. Most problems are expressed verbally, with some illustrated or combined. Overall, as activities progress towards reviews or tests, there is an increase in contextualized problems, reflecting a pedagogical approach that assesses both mathematical understanding and real-world application, offering varied challenges to test students' skills.

2.3.2. Chinese school textbook "Mathematic Volume 1"

Table 3 highlights different activity types, including practical exercises, integrations, consolidations, and exercises divided into 3 parts. There is significant variation in the distribution of problems across activities. For example, "practice 1" and "practice 2" emphasize contextualized problems (87.5% and 62.5%), while the consolidation phase focuses more on purely mathematical problems (66.7%). Modes of expression also vary: "practice 1" uses both text (71.4%) and combined text and illustrations (28.6%), while "practice 2" uses only text. Overall, there is a strong presence of contextualized problems across activities, indicating an emphasis on applying math concepts in real-world contexts, while consolidation focuses on reinforcing fundamental

concepts. The exercises show a range of problem types, with contextualized problems prevailing and textual expression being dominant. This variety in problem structure may affect how students engage with and demonstrate their math skills.

Table 2. Type of activity in Canadian textbook

Canada type of activity	Purely mathematical problem (%)	Contextualized problems (%)	Mode of expression		
			Textual (%)	Illustrated (%)	Combined (%)
Explore	0	100	85.7	14.3	0
Practice	33.3	66.7	75	12.5	12.5
Assessment focus	63.6	36.4	75	25	0
Reflect and share1	71.4	28.6	75	0	25
Reflect and share2	75	25	66.7	0	33.3
Mid-unit review	44.4	55.6	100	0	0
Revision test	33.3	66.7	100	0	0
Unit review	50	50	75	0	25

Table 3. Type of activity in Chinese textbook

Type of activity	Purely mathematical problem (%)	Contextualized problems (%)	Mode of expression		
			Textual (%)	Illustrated (%)	Combined (%)
Practical 1	12.5	87.5	71.4	0	28.6
Consolidated	66.7	33.3	33.3	33.3	33.4
To integrate	70	30	33.3	0	66.7
Practical 2	37.5	62.5	100	0	0
Exercises part 1	25	75	83.3	0	16.7
Exercises part 2	33.3	66.7	75	0	25
Exercises part 3	53.8	46.2	66.7	0	33.3

2.3.3. Moroccan textbook "Maxi Math"

Table 4 shows the distribution of problem types across different activities. Course activities primarily feature contextualized problems (63.6%), while application exercises focus almost entirely on purely mathematical problems (93.75%), suggesting an emphasis on practicing fundamental concepts. Integration exercises have a majority of purely mathematical problems (80%) and a smaller proportion of contextualized ones (20%). Deepening exercises contain a significant number of contextualized problems, encouraging the application of mathematical knowledge in more complex or real-world situations. Regarding modes of expression, course activities mainly use textual and combined forms (text and illustration), while application exercises prioritize combined expression. Integration and deepening exercises also use mixed approaches, with a notable proportion of combined text and illustration. In summary, the Table 4 highlights the adaptation of problem types and modes of expression to different learning objectives, with a strong focus on strengthening abstract mathematical skills rather than applying them to real-world contexts.

Table 4. Type of activity in Moroccan textbook

Type of activity	Purely mathematical problems (%)	Contextualized problems (%)	Mode of expression		
			Textual (%)	Illustrated (%)	Combined (%)
Course activities	36.4	63.6	50	0	50
Application exercises	93.75	6.5	50	50	0
Integration exercises	80	20	33.3	0	66.7
Deepening exercises	68.2	31	28.6	28.6	42.8

3. RESULTS AND DISCUSSION

Moroccan textbook: the course activities emphasize the application of mathematical concepts in real-world contexts, with a greater proportion of contextualized problems. This shows a willingness on the part of the textbook authors to connect abstract concepts to the students' concrete experiences, which is very effective in developing their practical understanding of mathematics. The application, integration, and advanced exercises are primarily focused on purely mathematical problems, emphasizing the practice of fundamental math skills without contextualization, which indicates a concern for consolidating basic math skills. However, this is not sufficient for learners at this level who are encountering a new concept (relative numbers) for the first time, as it does not help them see the relevance of mathematics in their lives. This negatively impacts the motivation of the learners.

Chinese textbook: the various types of activities presented in the Chinese school textbook combine contextualized problems and purely mathematical ones to focus on both the practice of fundamental math skills and their relation to the learner's daily life, although this contextualization remains moderate, still leaving ample room for abstract exercises and analytical skills. This shows learners the importance of mathematics for economic progress, thereby encouraging them to refine their skills. The different modes of problem expression, such as textual, illustrative, or a combination of both, enhance comprehension and strengthen the perception of these skills' usefulness. In summary, the Chinese textbook offers a good balance between technical practice and the contextualization of mathematical concepts but could benefit from further developing exercises applied to concrete situations to optimize practical understanding.

Canadian textbook: the different types of activities (integration exercises, advanced ones) present a balanced distribution between purely mathematical problems and contextualized problems: the balanced distribution between abstract mathematical problems and contextualized ones is essential to providing students with a comprehensive understanding, both of theoretical concepts and their practical utility. The course activities that are entirely composed of contextualized issues imply that they promote the use of mathematical knowledge in circumstances that are actually relevant to everyday life. The diversity of exercise types (explore, practice, assessment focus, reflect and share, revision test, and unit review) allows students to practice both theoretical and applied problems, fostering a comprehensive understanding that enhances their interest and engagement. The Canadian mathematics textbook often includes multicultural examples and emphasizes the application of mathematics in various professional and everyday contexts. Which integrate various situations of contextualized mathematical problems with local and modern examples, such as cost calculations and temperature in the course of rational numbers in different modes of expression.

In summary, for the Canadian and Chinese textbooks, there are variations in the distribution of problem types across the different phases of the course. The modes of expression used are either textual or combined, reflecting a balanced educational approach. The distribution between purely mathematical problems and contextualized problems varies from one activity to another, suggesting a balanced pedagogical approach. This variety allows students to develop both their abstract problem-solving skills and their ability to apply these skills in real-world situations [22]. The use of various modes of expression, such as text and a combination of text and illustrations, reflects an effort to address the different learning styles of students in Canadian and Chinese textbooks [11]. It also provides students with the opportunity to strengthen their understanding of mathematical concepts through visual representations. However, the authors of Moroccan textbooks make less effort in diversifying exercise types at higher levels, in contrast to lower levels and more recent textbook editions. By integrating contextualization into textbooks and various teaching phases, it helps create a more dynamic and relevant learning environment, which promotes better understanding and application of concepts by students. Moreover, contextualized activities with different types of representation intended for younger students could favor illustrations to facilitate the understanding of mathematical concepts, especially in algebra, which is more symbolic. They could also include a greater proportion of contextualized problems to encourage learners to apply mathematical concepts in everyday life situations.

4. CONCLUSION

In conclusion, the poor results of contextualized problems in the Moroccan textbook at different stages of education may guide the authors of the Moroccan textbook to diversify the mathematics problems to cover both the mastery of basic concepts in the algebra chapters. Moreover, the textual representation of contextualized problems will enable learners to develop their ability to interpret and solve problems by following a sequential logic, as found in the 3 school textbooks. Illustrated problems allow for the visualization of abstract concepts, making mathematics more accessible and intuitive. Visual representations are particularly effective for learners who have a visual memory or who understand better. They also simplify complex concepts by making them concrete. By combining these 2 modes, the textbooks allow students to transition from a concrete understanding (through illustrations) to an abstract understanding (through text) and to develop a comprehensive vision of mathematics that encompasses both theory and practice. This diversity of representations is therefore crucial to address the different learning styles of students and to promote a better assimilation of mathematical concepts.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

INFORMED CONSENT

Informed consent was obtained from all individuals included in this study. Participants were fully informed about the objectives of the research, and their participation was voluntary. For studies not involving human subjects, this section may be stated as “not applicable”.

DATA AVAILABILITY

All data generated or analyzed during this study are included in this published article.

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