



A Comparative Analysis of Ratio and Proportion Problems in Libyan and Turkish Mathematics Textbooks¹

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ABSTRACT

This study investigates the similarities and differences between ratio and proportion problems in Libyan mathematics textbooks (8th and 9th grades) and Turkish mathematics textbooks (6th and 7th grades). A content analysis methodology, based on a three-dimensional framework developed by Li, involving mathematical features, contextual features, and performance requirements is used and the use of technology is also considered. The results can be summarized as follows. In general, there were only small differences in the results for all three dimensions. Most of the problems analyzed required using multiple computation procedures to produce numerical answers, and focused more on the cognitive domain of knowing but less on applying and reasoning. In addition, none of the problems in the Libyan textbooks required the use of technology, while 1% of the problems in the Turkish ones did.

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1. Introduction

Textbooks play an important and fundamental role in education, especially mathematics education, due to their close relationship with classroom education for both students and teachers. They also help teachers to prepare their lessons and impart knowledge to students (Li, 2000; Alajmi, 2012). According to Ravitch (2003) and Valverde, Bianchi, Wolfe, Schmidt, & Houang (2002), textbooks are important for shaping instructors' and students' views on school subjects. In particular, Valverde et al. (2002) state that "The textbook is the essential and primary tool in the educational process. It contains the educational material in an organized manner that helps the student remember or refer to the material. The teacher should not consider the textbook as the sole reference to the educational process or the only source of knowledge that the student receives. It is an organized tool to help it."

This makes it clear that textbooks are fundamental information sources that play key roles in supporting learning and education. They have also received attention from the international educational research community for decades (Nicol and Crespo, 2006; Fan and Zhu, 2007; Charalambous, Delaney, Hsu, and Mesa, 2010; Alajmi, 2012; Erbaş, Alacaci, & Bulut, 2012).

Although the precise roles textbooks play differ between classrooms, teachers, and students, Gelfman, Podstrigich, & Losinskaya (2004) summarize them as follows:

- Teach and support students so they acquire good knowledge and correct information.
- Achieve a balance between clear information and accurate details.
- Offer new questions and queries.

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- Encourage student creativity.
- Help students to understand the structure of the material.
- Motivate and promote learning.
- Account for individual differences among students.
- Help students to acquire good learning habits.
- Develop students' ability to think in different ways and at all levels.
- Help learners to gain the desired skills and solve problems using scientific thinking

A Trend in International Mathematics and Science Study (TIMSS) survey found that, in most countries, instructors consider textbooks to be essential references when working out how to present particular subjects in their classrooms (Beaton, Mullis, Martin, Gonzalez, Kelly, & Smith, 1996).

According to a study by Schmidt, McKnight, Valverde, Houang, & Wiley (1997) on students in Norway, Spain, and the United States, school education is still highly dependent on textbooks, and students become increasingly dependent on them in more advanced stages of study. In addition, Beckman (2004) suggests that Singapore's textbooks were the reason behind the excellent performance of their 8th-grade students in the TIMSS, and Yeap (2005) agrees that they are key to Singaporean students' superior mathematics results.

For all these reasons, many countries have tried to set textbook quality standards, highlighting their impact on students' performance and demonstrating their differences and similarities. Many educational studies have confirmed that textbook analysis is an important tool for highlighting the reasons behind differing student performance levels (Alajmi, 2012; Li, 2000; Mesa, 2004; Sonk & Senk, 2010; Valverde et.al, 2002). Therefore, analyzing textbook problems gives us information about the mathematical skills and competence we should expect of students.

Carter, Li, & Ferrucci (1997) analyzed the topic of adding and subtracting integer numbers in intermediate-level Chinese and British textbooks. This comparison revealed that while their pedagogic features were similar, their expectations as to the students' mathematical proficiency were not.

Li (2000) developed a framework, known as "dimensions of the requirements of the problem," in order to analyze textbook problems. This analyzes such problems in terms of three dimensions, namely their mathematical, contextual, and performance requirements, and has formed the basis of several subsequent studies.

Stigler, Fuson, Ham, & Kim (1986) considered the similarities and differences between word problems presented in elementary-level American and Soviet textbooks. This comparison showed that the American textbooks contained fewer word problems than Soviet ones, that more of them required only one procedure, with fewer multiple-procedure problems, and that their mathematical and cognitive requirements were lower.

Conklin (2004) analyzed mathematics textbooks from Germany, America, and Japan using Li's framework, considering their size, weight, structural organization, page length, and question features.

Hu (2011) also used Li's framework to analyze the response types and performance requirements of particular questions. The results of the analysis showed that all three texts confirm the cognitive expectations of representation. Most of the problems are included in purely mathematical contexts. The problems in the Chinese text confirm problem-solving.

İncikabi & Tjoe (2013) compared ratio and proportion problems in intermediate-level American and Turkish mathematics textbooks, in terms of their mathematical and contextual features and performance requirements. Their approach was similar to Li's, but also included a technology component. In general, Turkish textbooks included more multi-step problems than the U.S. Textbooks, Turkish textbooks were less in the cognitive domain of knowing. For the use of technology, none of the problems in the Turkish textbooks required the use of technology, while the textbooks in the U. S. required the use of technology at 6.9%

One of the most important factors motivating this study is that Libyan mathematics textbooks have yet to be analyzed and compared with those from other countries. Libyan mathematics textbooks are compared with them with Turkish textbooks because Turkey is a more-developed country in various fields, and the progress of societies and countries is based on their educational development. This study therefore aims to illuminate the similarities and differences between ratio and proportion problems in 8th- and 9th-grade Libyan mathematics textbooks and 6th- and 7th-grade Turkish ones. The same approach of İncikabi and Tjoe (2013) has been used and aim to answer the following questions.

1. How do the ratio and proportion problems in Libyan and Turkish textbooks compare in terms of their mathematical features?
2. How do the ratio and proportion problems in Libyan and Turkish textbooks compare in terms of their contextual features?
3. How do the ratio and proportion problems in Libyan and Turkish textbooks compare in terms of the type of response required?
4. How do the ratio and proportion problems in Libyan and Turkish textbooks compare in terms of their cognitive requirements?

2. Methodology

As noted above, this study considers the topic of ratios and proportions in the Libyan and Turkish mathematics curricula. This topic is covered in Libyan textbooks designed for the 8th and 9th grades, and in Turkish ones intended for the 6th and 7th grades. Both countries discuss this topic fully during these two years. The Libyan and Turkish textbooks selected for this study were all printed for the 2018 academic year, and were investigated in their original languages (Arabic and Turkish, respectively).

This study uses content analysis to analyze the content related to ratio and proportion problems in both countries' curricula in light of the above research questions. We use Li's three-dimensional framework, because it was specifically designed to analyze mathematics questions in textbooks, and apply it to selected examples, exercises, and questions from the textbooks. Each problem was encoded based on the three dimensions, and the use of technology was also considered. The problem dimensions used in this study were as follows.

Mathematical Features

Single computation procedure required (SC)

Multiple computation procedures required (MC)

Contextual Features

Purely mathematical context in numerical or word form (PM)

Illustrative context with pictorial representation or story (IC)

Context requiring the use of one or more representations (RP)

Diagram

Graph

Model

Picture

Table

Manipulation

Context requiring the use of technology (TC)

Computer

Scientific calculator

Graphing calculator

Internet connection

Other

Performance Requirements

Response Type

Numerical answer only (NA)
 The numerical expression only (NE)
 Explanation or solution required (ES)
 Cognitive Requirement (Mullis, Martin, Ruddock, O'Sullivan, & Preuschoff, 2009)
 Knowing (K)
 Applying (A)
 Reasoning (R)

Two Turkish and two Libyan textbooks were chosen, and each of the selected problems was encoded using the above dimensions. The cognitive domains specified in TIMSS 2011 (Mullis, Martin, Ruddock, O'Sullivan, & Preuschoff, 2009). were used. The problems were encoded by several researchers, who discussed and agreed on how to encode each item, and the encoder agreement rate was 86%. Two typical encoding examples are presented below.

Example 1 (Libyan textbook): Find the value of x if $7:13 = 21:x$.

Encoding: This problem requires multiple procedures (MC), and is encoded as having a purely mathematical (PM) context, requiring a numerical answer (NA) response, and having a cognitive domain of knowing (K) because it requires the unknown value to be calculated.

Example 2 (Turkish textbook): If you have 2 cups of rice and 3 cups of water, find out how many cups of water you need for each cup of rice.

Encoding: This problem requires multiple procedures (MC), and is encoded as having an illustrative context (IC), requiring a numerical answer (NA) response, and having a cognitive domain of knowing (K) because it requires the unknown value to be calculated.

3. Findings

In order to answer the research questions, the results of analyzing the ratio and proportion problems taken from the Libyan and the Turkish textbooks are now presented, in terms of their mathematical features, contextual features, performance requirements, and use of technology. In general, these results show only small differences between the two countries.

To answer the first research question, we looked at the mathematical features of the textbook examples, finding that most problems analyzed required multiple computation procedures (88% and 72% for the Libyan and Turkish textbooks, respectively), with 12% and 28%, respectively, having purely mathematical contexts. These results are summarized in Figure 1.

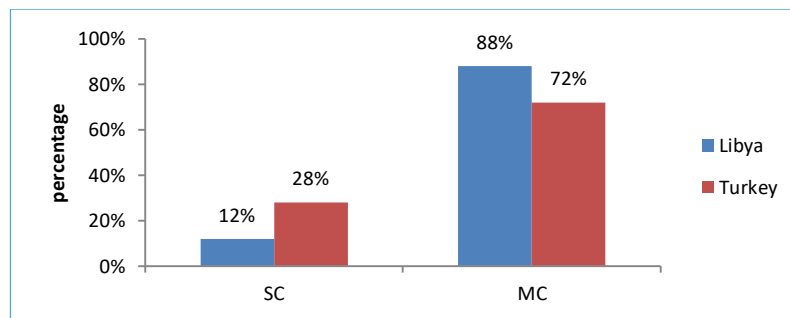


Figure 1. Summary of the results for the first dimension (mathematical features)

To answer the second research question, we looked at the examples' contextual features, finding that most of the ones in Turkish textbooks had a purely mathematical context in numerical or word form (52%), while 18% had an illustrative context involving a pictorial representation or story. Likewise, most of the problems in Libyan textbooks had a purely mathematical context in numerical or word form (72%), while 11% had an illustrative context. These results, summarized in Figure 2, indicate that the Turkish textbooks contained more problems with illustrative contexts than the Libyan ones did.

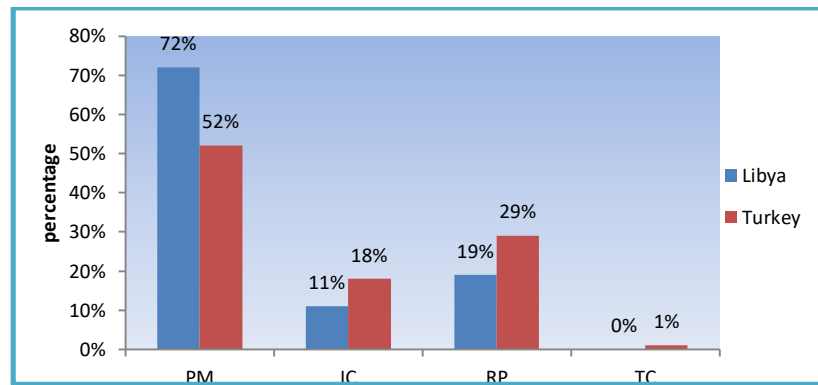


Figure 2. Summary of the results for the second dimension (contextual features)

For contexts that required a representation, the results show that the Turkish textbooks used diagrams (1%), graphs (3%), models (1%), pictures (1%), tables (20%), and manipulation (3%), while the Libyan ones used diagrams (12%), graphs (5%), models (0%), pictures (1%), tables (0%), and manipulation (1%). These results, summarized in Figure 3, indicate that the Turkish textbooks had higher proportions of models, tables, and manipulation, while the Libyan ones had higher proportions of diagrams and graphs, and both countries used pictures equally often. As for technology, none of the problems in the Libyan textbooks required the use of technology, but 1% of the ones in Turkish textbooks did.

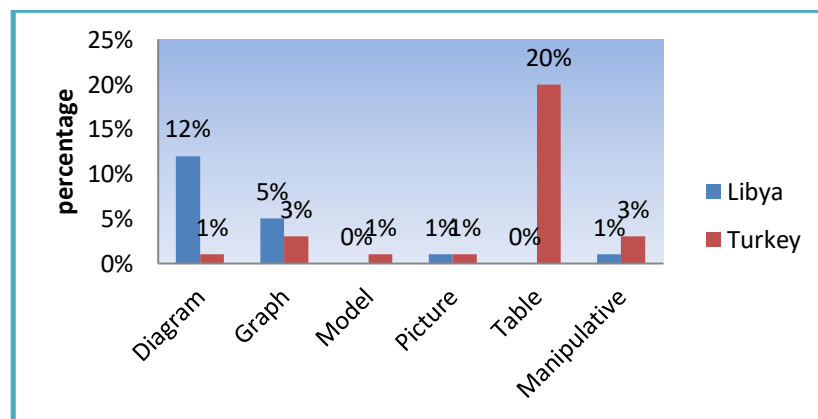


Figure 3. Summary of the results for contexts that required representations (RP)

To answer the third research question, we looked the response types, finding that the problems in the Libyan textbooks often required a numerical answer (95%), but seldom an explanation or solution (5%), and never a numerical expression (0%). In contrast, while Turkish textbooks also frequently required a numerical answer (79%), they more often asked for an explanation or solution (18%), and occasionally for a numerical expression (3%). These results are summarized in Figure 4.

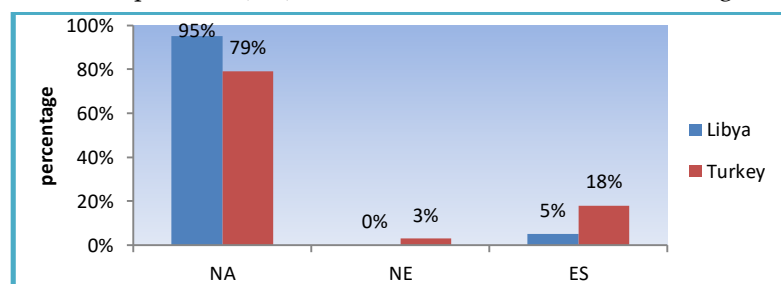


Figure 4. Summary of the response type results

To answer the fourth research question, we looked at the cognitive domains (defined in the TIMSS 2011 mathematics framework). These results showed that, in cases, the majority of problems required knowing (63% and 57% for the Libyan and Turkish textbooks, respectively), followed by applying

(26% and 34%), and finally reasoning (11% and 9%). These cognitive requirement results are summarized in Figure 5.

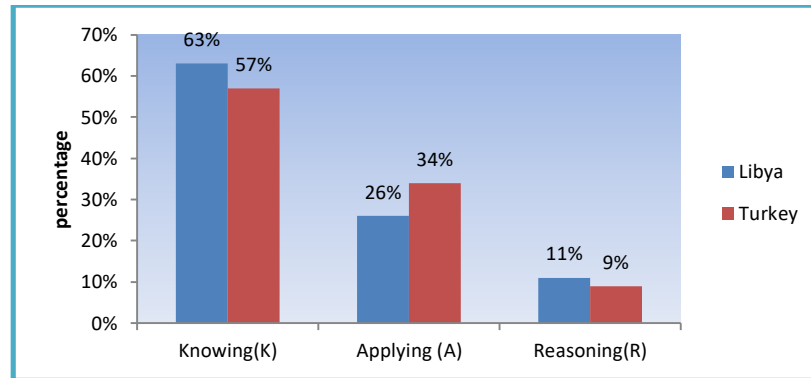


Figure 5. Summary of the cognitive requirement results

4. Discussion and Conclusion

The objective of this study was to investigate the similarities and differences between ratio and proportion problems in 8th- and 9th-grade Libyan mathematics textbooks and 6th- and 7th-grade Turkish mathematics textbooks, using content analysis to understand the students' performance. As we noted, Turkish students are taught about ratios and proportions earlier than Libyan students. Stevenson & Bartsch (1992) found that Japanese students performed better than American ones due to encountering topics earlier, so we believe this is a significant advantage for the Turkish educational system.

An analysis of problems from the two countries' textbooks showed that they typically required multiple procedures more often than one-step procedures, particularly in the Libyan textbooks. This is considered to be a good feature, because it encourages students to select and think about appropriate strategies for multi-step problems, developing their ability to think about solving different types and levels of problems. They thus gain both the desired problem-solving skills and a broader and deeper understanding of the subject. Even though our aim was to compare textbook problems, the results for purely mathematical problems, which made up 12% and 28% of the problems in the Libyan and Turkish textbooks, respectively, made us think about our expectations of the students' competence and problem-solving abilities Problem.

Context often requires the use of representations, and here Turkish textbooks used tables most frequently, followed by graphs, manipulation, diagrams, models, and pictures, in that order. In contrast, Libyan textbooks favored diagrams, followed by graphs, pictures, and then manipulation. Turkish textbooks used more tables, manipulation, and models, while Libyan ones used more diagrams and graphs. It should be noted, however, that both countries provided students with a variety of representations, which, as Ainsworth (2006) found, enable them to achieve a better and deeper understanding of the topic.

With regard to technological context, none of the problems in the Libyan textbooks required the use of technology, and it was only rarely used in the Turkish ones. We believe this failure to use technology will have a negative impact on students, because we are now in an era where the technology needed to work with such problems exists and has a positive impact on students, providing them with a deeper understanding and a faster way to solve problems.

When we analyzed the examples' performance requirements, we found that the Libyan textbooks often required a numerical answer, but seldom an explanation or solution, and never a numerical expression. In contrast, while the Turkish textbooks also frequently required numerical answers, they were more likely to ask for an explanation or solution, and occasionally a numerical expression. Based

on the cognitive domains defined in the TIMSS 2011 mathematics framework, we found that most of the problems in both countries' textbooks required knowing, with the cognitive domain percentages for ratio and proportion problems being consistent with those determined by the TIMSS evaluation.

Although the aim of this study was to compare textbook problems in Libya and Turkey, it has also highlighted the significance of analyzing such problems. Content analysis gives us a good opportunity to understand the impact of textbooks on student performance and ability in mathematics (İncikabi & Tjoe, 2013). Our results indicate that analyzing textbooks and the problems they contain shows us the impact textbooks have on students' achievements in mathematics. Combining two different types of analysis is a more promising way to detect this impact than either analysis alone (Li, 2000).

Based on our analysis, we recommend that textbooks in both countries should include more examples requiring the use of technology. Additional effort is also needed to find ways to help students to improve their facility with mathematical problems. As such, we recommend conducting extended studies of textbooks and comparing additional content presentation characteristics. Such studies are both feasible and important for furthering our knowledge of the possible effects of textbooks on classroom education and students' mathematical performance..

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