



Interdisciplinarity in Data Analysis Through the Primary School Textbooks in Greece and Singapore

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ABSTRACT

Data analysis is one of the most popular fields of mathematics and includes statistics and probability. These two mathematical domains are some of the most well-known, influencing everyday life and the various sciences. Their teaching lays the foundation for primary education and culminates in secondary education. Probability and statistics are necessary for today and the future of several professions. This research attempts to highlight the multidisciplinary character of these two disciplines through the textbooks of primary education in Greece and Singapore. It aims to highlight the dependence of mathematics teaching on interdisciplinarity through textbooks. The textbook analysis was chosen because books offer varied learning opportunities. The researchers selected the books, partaking in the comparative analysis. After defining the basic principles dividing lines for the differentiation of the exercises, the analysis was conducted. It included two stages. In the first stage, the activities of the books were examined in their framework application. Then, their interdisciplinary character was accentuated in the scientific field. The results reveal a substantial dependence of data analysis on interdisciplinarity. More interesting is that the distribution of interdisciplinary exercises is prevalent in the scientific milieu.

KEYWORDS

Probabilities; statistics; multidisciplinary; textbooks; Greece; Singapore.

INTRODUCTION

Probability is a relatively new domain of mathematics and impacts everyday life. In fact, thanks to its broad range of applications, the distinguished mathematician-astronomer Marquis de Laplace suggested that its theory had the specifications to be the most important field of human knowledge (Ross, 2010). Moreover, statistics is a mathematical domain, beneficial for every science due to its use in research and data analysis. It is now reflected in every educational system, as their teaching encompasses all education levels (Gao, 2014). A direct correlation between these two mathematical domains exists; the introduction of their theory in primary education is done altogether through the data analysis.

The present study has attempted to compare and present the multidisciplinary data analysis through the textbooks of Greece and Singapore. Singapore's choice stands out as a model because students from there have high mean scores in international research programs such as PISA and TIMSS (Mullis et al., 2015). More specifically, in the last PISA program in 2018, where both countries participated, Singapore was the second in mathematics out of 78 countries, while Greece was forty-fourth. In fact, when grouping the countries based on their cognitive levels, Singapore was among the four countries with a mathematical knowledge level of 4, while Greece was at level 2 (Schleicher, 2019). Therefore, this study aims to improve the teaching of data analysis, through the differences between the development of the frameworks of each activity in the two countries' textbooks and the variety of their interdisciplinary characteristics.

Data Analysis, Probabilities, Statistics, and Interdisciplinarity

The prominence of teaching data analysis, probability theory and statistics, is evident through the daily events, specifically the daily stochastic processes. The impact of theories on a broad range of applications, and their utility in various sciences, could gain the interest of the global research and educational community in mathematics teaching. In fact, the National Council of Teachers of Mathematics in America, known as NCTM (Ferrini-Mundy, 2000; NCTM, 2014), endorses the vitality of introducing probability, and therefore statistics, into mathematics curricula is of utmost relevance. This fact is confirmed today by their crucial role at every education level (Langrall, 2018).

Many educators consider probability and statistics the leading disciplines of mathematics as they have direct application in everyday life and other sciences (Konold, 2002). The connection of their theory with the uncertainty, the decision making, and the modeling of stochastic processes reinforces their involvement in other sciences (Borovcnik & Kapadia, 2010; Reia et al., 2019). For example, one can find many examples of probability and statistics applications in various sciences. They find applications in investment decisions, medical decisions for administering medicines, court decisions judging the guilt of the accused based on the existing data, planetary motion predictions, athletes' performance predictions, weather

forecasts, applications of quantum physics, and many more (Rubel et al., 2016; Ross, 2010; Upshur, 2013).

Primary Mathematics Textbooks and Interdisciplinarity

Many researchers have investigated mathematics and its teaching of mathematics as they hold status in everyday life and the other sciences. Therefore, the teaching principles of mathematics are constantly studied and revised (Yang et al., 2010). Textbooks, as proven, provide enormous learning opportunities for students (Sievert et al., 2019). Hence, one's mathematical knowledge may directly depend on the textbook. Accordingly, a constant endeavor to improve Math textbooks is present.

Textbooks have specific relevance for primary school. Many countries update them occasionally to incorporate novel teaching practices and connect their activities to daily situations (Yang et al., 2010). Usually, a new mathematical concept's introduction is done through other sciences, where children can understand its practicality (English, 2009). It makes interdisciplinarity exceedingly critical for the textbooks and generates the need to adjust the curriculum in primary school (English, 2009). However, it is worth mentioning that the benefits of interdisciplinarity for students pose a challenge for teachers, as they require knowledge beyond mathematics (Nguyen & Krause, 2020).

Singapore and Greece

Singapore has a population of 5,703,600 inhabitants ("Singapore Population – Worldometer," 2021). Not being a populous country is an advantage for developing a flexible yet strong curriculum (Ginsburg, & Leinwand 2005; Ministry of Education [MOE], 2012). The country's educational system is renewed and reinforced at regular intervals, adapting to the requirements of an increasingly globalized society (Wang & Lu, 2018). A child in Singapore must attend six years of primary education and four or five years of secondary education, depending on the high school type each student attends (Ministry of Education [MOE], 2013).

Many researchers worldwide believe that the education system following specific characteristics, can be characterized as a prodigious model (Ginsburg & Leinwand, 2005). Indeed, a crucial role in the success of its educational system for a country relies on the belief of individual citizens that education is critical for the survival of them and their country (Kaur & Har, 2009). The usual prevailing trend is knowledge and skills acquisition, directly impacting everyday life (Erbilgin, 2017; Kaur & Har, 2009). Thus, it boils down to a strictly structured and spiral curriculum in mathematics (Mullis et al., 2015). That is why Singapore has become known to the global educational community. Also, the performance of the country's students in the international PISA and TIMSS programs depicts it as a role model for other countries (Gurría, 2018; Mullis et al., 2015; TIMSS, 2015; Wang & Lu, 2018; Schleicher, 2019). The direct result is the Singaporean education system and the textbooks used in the country, a yardstick for comparison for many researchers worldwide.

Greece's population is almost twice Singapore's, and thanks to her past, it possesses an unmatched history in education. Today, its educational system experiences frequent changes to adapt to the new data and be a modern European educational system conforming to world standards. The system's principal objective is to have a critical thinking citizen with a broad range of knowledge (Gouvias, 2012). Also, in Greece, a student must complete six years of primary education and additional six years of secondary; before attending the university (Eurydice, 2022).

METHOD FOR THE COMPARISON OF SCHOOL TEXTBOOKS

Interdisciplinarity is one of the primary factors highlighting the enormous number of mathematics applications in various sciences or everyday situations. It directly affects concentrated students' interests (Kloosterman & Stage, 1992; Tachie & Kariyana, 2022). Therefore, the purpose of this paper is not merely to highlight the prominence of interdisciplinarity in mathematics. It also aims to demonstrate the dependence of teaching a specific mathematical concept on interdisciplinarity through the activities of the textbooks. Besides, this research plans to compare the differences in the multidisciplinary presentation in the exercises in the school textbooks of the two countries and examine the main disciplines involved in interdisciplinary activities.

The primary supervisory tool in Greek and Singapore schools is the school textbook (Kaur, 2010). Thus, in the present study, the essential sources used were the standard curricula of each country and the textbooks used in primary school. In the Greek educational system, until today, students are provided with a specific school textbook by the State. Yet, in Singapore, it is not the standard practice, various approved ones are available so that teachers can choose the book meeting their needs and instruct students to buy it (Ministry of Education [MOE], 2012). The researchers in this study have selected the version used in most comparative studies worldwide of those books series. This version has been available in English and other languages used in various countries. Indeed, of the books selected from each country, the analysis included only the chapters dealing with common concepts related to statistics, probability, or data analysis. Thus, from the textbooks of Greece, the analysis included only those of the primary school's last two grades, while Singapore contained all from all six grades.

Table 1. School Textbooks of the Study

Greece	Singapore
Cassiotti, O., Kliapis, P. & Oikonomou, Th. (2013). <i>Mathematics in elementary school</i> . ITYE Diofantos (in Greek).	Marshall Cavendish Education. (2021). <i>Primary Mathematics 1B, 2B, 3B, 4A, 5B, 6B U.S. Edition</i> . Singapore.
Vryonis, K., Doukakis, S., Karakosta, V., Baralis, G., & Stavrou, I. (2018). <i>Primary School Mathematics</i> . ITYE Diofantos (in Greek).	

Teaching experts in mathematics have debated data analysis and probability and statistics in primary and secondary education in recent years (Batanero et al., 2016). Greece follows a different logic from Singapore in distributing mathematics curricula in Primary and Secondary education. It is because the Greek education system, at its core, aims at learning the concept (Cassiotti et al., 2013; Vryonis et al., 2016), while the corresponding Singaporean system focuses on the learning the process (Marshall Cavendish Education, 2021; Ministry of Education [MOE], 2015). Of course, the variety of topics and the multidisciplinary approach used by the textbooks of the two countries when teaching the chapters of data analysis in the primary school depict meaningful differences.

For the analysis conducted in the present work, the researchers set some principles regarding the categorization of the activities. More specifically, they analyzed them one by one and collected the results in a sorting table before the final tables were generated. An activity was considered interdisciplinary if the topic were a trigger for discussion in another scientific field. The emphasis was that the separation of the activities concerning the framework structure depended on whether the activities included a daily context for the student (daily life or game, these are daily context activities). It might also involve a context, providing scientific information not directly of interest to the specific age group of students (scientific context), or activity not fitting into a specified context. Those not included in the above contexts are called activities of another context.

No special coding was necessary for the needs of the present study. However, to ensure its reliability and validity, the researchers analyzed the activities twice with an interval of three months. The two analyses' results were exactly the same as the development frameworks of the activities were clear.

RESULTS

The following tables depict the results. The first table shows the analysis of the activities regarding the framework of the exercises and multidisciplinary ones. Then, a table on the multidisciplinary exercises, comprising the two manuals and the respective scientific fields, pursues. Every table includes the set of all primary textbooks of each country related to data analysis, probability, and statistics. The total number of the exercises portrayed in every table is from the whole set of the books selected.

Table 2. Activity Analysis Between the Selected Books and Chapters

Exercises framework analysis	Greece		Singapore	
	<i>f</i>	<i>f%</i>	<i>f</i>	<i>f%</i>
Frameless activities	6	35.2%	0	0%
Daily context	7	41.2%	43	100%
Scientific context	4	23.5%	0	0%
Activities of another context	0	0%	0	0%
Total	17	100%	43	100%

The table above demonstrates the results of the analysis of all activities from the textbooks of the two countries. It included the implementation of the activities. As depicted in the table, in Greece, the activities were distributed in different contexts scientifically and daily besides without a framework. However, in Singapore, where the number of activities was much higher, they were characterized as only in children's daily context.

Table 3. Multidisciplinary Exercises and Interdisciplinary Branches Between the Selected Books and Chapters

Multidisciplinary sector	Greece		Singapore	
	<i>f</i>	<i>f%</i>	<i>f</i>	<i>f%</i>
Environmental studies	3	17.6%	1	2.3%
Economy	0	0%	10	23.3%
Language-literature	1	5.9%	4	9.3%
Physics	1	5.9%	7	16.3%
Sociology	3	17.6%	3	6.9%
Biology	0	0%	1	2.3%
Sport	2	11.7%	1	2.3%
Total of interdisciplinary exercises	10	58.8%	19	62.7%

Table 2 shows that both countries critically promote interdisciplinarity through their textbooks. More specifically, in Greece, the exercises are part of a multidisciplinary framework by 58.8% and in Singapore by 62.7%. The activities considered interdisciplinary and classified according to the field belonging to the table below, matched a single interdisciplinary field, no activities were present in more than one field. One could also see that Singapore textbooks had a broader range of multidisciplinary content than the corresponding Greek ones. Also, in Singapore, the primary percentage of exercises was combined with economic issues. In contrast, in Greece, most activities corresponded to more social issues and environmental studies.

DISCUSSION

Mathematics is a science directly linked to other positive sciences besides the humanities and social sciences (Ross, 2010). Of course, students have difficulties learning mathematics and often wish to avoid this learning process (Kloosterman & Stage, 1992). Much research has addressed this issue. The NCTM supports the perception that the way students learn is as critical as what they do (NCTM, 2014). In fact, a general view supported by many researchers holds that the textbook is the primary factor in offering learning opportunities to students. Thus, it can impact the students' knowledge levels by presenting activities and topics (Sievert et al., 2019). It can also increase the interest in textbook comparison studies.

The interdisciplinary factor in the teaching of mathematics appears particularly beneficial in primary school (English, 2009). At that young age, students find it easier to understand a new mathematical concept by using it in various situations than by understanding it through a theoretical mathematical framework (Nguyen & Krause, 2020). It has led to interdependence in the teaching of mathematics and interdisciplinarity. As the results revealed, both countries had a critical level of the multidisciplinary approach to their activities in the data analysis chapters. More specifically, they seemed to exceed the percentage of 50% for the multidisciplinary activities, with a slight difference between them. But the interdisciplinary impact of Singapore's activities covered more fields. In fact, there was also a critical difference in the scientific domain bringing together the most interdisciplinary activities for each country. In Singapore, this domain was economics, in Greece, the social and environmental sciences. Yet, Greece had an increased number of frameworks for its exercises, while Singapore generated its activities only in a daily context.

A meaningful difference that emerged and was not part of the primary objectives of the research was the difference between the number of exercises in the textbooks of Greece and Singapore from the chapters analyzed. The assessments above can partially justify the difference in the two countries' positions in the last competition of the PISA. Thus, the outcomes from this research can help explain the difference in the student's levels both in mathematics and sciences. However, a need for increasing the number of exercises in Greek textbooks and the variety of frameworks in Singapore books is evident. Comparative textbook research worldwide, parallel with the integration of technology in the education system, will be a critical

issue for the future (Espino et al., 2020). Research like this study may suggest possible improvements or shortages for textbooks in different countries.

CONCLUSION

The present work has attempted to highlight mathematics through the interdisciplinarity shown by the activities of textbooks. For the research, Greece's and Singapore's primary schools, were selected. Singapore is a country whose mathematics curriculum is superior and leads students to achieve high places in the international competitions PISA and TIMSS. In fact, after a thorough study, this country's textbooks, were often used in comparative textbook studies worldwide. The two countries were substantially different concerning the mathematics curriculum and the knowledge required in each grade. The substantial difference in the two countries' performance in the last PISA competition was a decisive factor in their selection. Subsequently, a series of textbooks, were selected from each country for the data analysis. Data analysis is a common beneficial mathematics domain requiring no special needs of knowledge or skills.

Interdisciplinarity is a factor used in the teaching of mathematics to prove to students the utility of the concept taught. In the present study, a crucial dependence of mathematical activities on interdisciplinarity existed. The two countries, although showing several differences in the activities they develop, ended up having a very slight difference in the percentage of interdisciplinary exercises they used in their chapters. Also, differences seemed to exist in the number and choices of the areas, where the multidisciplinary exercises were extended. The outcomes of this research can highlight the utility of interdisciplinarity in textbooks and can be used as guides in upgrading mathematics teaching or the mathematics curriculum.

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