



## Comparative Analysis of Data Analysis and Probability Topics between IB and Non-IB Mathematics Textbooks

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| Article Info                                                                                 | Abstract                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
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| Received<br>March 29, 2024                                                                   | It is imperative to explore the organization of contemporary teaching and learning methods in data analysis and probability within mathematics curricula, with a specific focus on comparing non-IB and IB approaches. This study analyzed how the contemporary teaching and learning of data analysis and probability was organized through an analysis of two textbooks as an intended mathematics curriculum (non-IB and IB respectively) by discussing similarities and differences between the two. It employed content analysis method to examine structural features, technology usage, and real-life connections by focusing on the topic in depth, exploring content, organization, and representation. This study results disclosed that both open-ended and closed-ended item formats were recommended, without clear superiority. Descriptive examples and percentages were provided to guide curriculum developers and support teachers in enhancing student learning outcomes. The study hopes to assist middle school students in achieving higher scores in international assessments such as PISA and TIMSS. It emphasizes the potential for revising mathematics curricula and textbooks to better meet students' needs, drawing inspiration from the success of the IB program. |
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| Comparison Study;<br>Content Analysis;<br>IB Programme;<br>Turkish Mathematics<br>Programme. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

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## INTRODUCTION

Textbooks play a significant role in shaping the curriculum and teaching practices in classrooms (Weinberg & Wiesner, 2011). It is important to investigate the similarities and differences between Turkish mathematics textbooks recommended by the Ministry of National Education's (MoNE) Middle School Mathematics Programme and the Middle Year Programme mathematics textbooks used in international schools following the International Baccalaureate (IB) programme. Given the need, the focus of a needed study should specifically be on the treatment of data analysis and probability concepts, with the knowledge of consistently reported students' difficulty with this topic (Andini & Jupri, 2017; Bufo et al., 2022).

Data analysis and probability is a popular concept of mathematics. The first foundations of knowledge of data analysis are laid starting from primary school, and in high school (i.e. upper secondary education) (the K-12 curriculum), it culminates into great detail with an emphasis on probability concept (Altunsaray & Baltacı, 2023). Data analysis and probability is related to daily life. We use the knowledge and skills of this concept to calculate and solve problems in different sciences. According to the National Council of Teachers of Mathematics (2000), it is emphasized among significant mathematics content standards: (a) Numbers and operations, (b) Algebra, (c) Geometry, (d) Measurements, and (e) Data Analysis and Probability. Each concept should be taught and learnt based on the child's age, developmental level and concept specific needs. Mathematics teachers use different instructional activities, real life examples, make students engaged in hands-on or technology-based activities, 3D and concrete materials, create mathematical tasks to cultivate students, and technology supported learning activities (e.g., Lavidas et al., 2022; Zorzos & Avgerinos, 2022) so that students can develop mathematical knowledge and learn mathematical thinking skills in an effective and efficient way. Hence, the paradigm shift adopts from teacher-centered to student-centered teaching and learning.

In an increasingly interconnected world, active participation in a global community is crucial, starting with individual human engagement. A collaborative society that continually strives for self-improvement can generate added value in the development process. As individuals enhance their knowledge and skills, they also benefit from the global knowledge and skills that have been developed, leading to mutual growth and exponential development within the society at large. Mathematics education plays a vital role in this process, as it equips individuals with essential problem-solving and critical thinking skills (Hoyles et al., 2022; Saralar, 2020). However, expectations and performance in mathematics vary among students, influenced by factors such as teachers, government policies, and educational systems, which differ from country to country. Various elements, including school climate, teacher beliefs, teaching methods, textbooks, and students' preconceptions, have been proposed to impact mathematics performance (Hoyles et al., 2022; Saralar, 2020). Assessing students' performance on an international scale allows for comparison and evaluation of educational systems worldwide. Two notable international assessments, the Trends in International Mathematics and Science Study (TIMSS) and The Program for International Student Assessment (PISA), are used to evaluate students' mathematics performance. These assessments measure students' knowledge and skills through test responses, providing valuable insights into the strengths and weaknesses of different educational systems.

In the case of Türkiye, the TIMSS 2019 examination revealed that Türkiye ranked 20th out of 39 participating countries at the 8th-grade level (MoNE, 2020). The assessment highlighted that 20% of participating students achieved the highest levels of mathematics proficiency, while another 20% failed to reach even the lowest level of proficiency. Similarly, in the PISA 2018 assessment, Türkiye ranked 42nd out of 79 participating countries (MoNE, 2019). In data analysis and probability, Turkish students demonstrated a diverse range of proficiency levels according to the TIMSS 2019 examination (MoNE, 2019). Approximately 20% of participating students excelled in applying analytical methods and understanding

probability concepts effectively. However, a concerning 20% of students struggled to grasp even the foundational aspects of these mathematical domains, reflecting a notable gap in attainment levels across the cohort. These results indicate the need for improvement in Turkish students' mathematical success.

To understand the potential factors contributing to these disparities, it is essential to examine the influence of textbooks on mathematics education outcomes. They provide a structured framework for learning and serve as a primary resource for teachers and students. The content and organization of mathematics topics covered in textbooks can significantly impact students' understanding and performance.

This study analyzes textbooks to identify disparities in data analysis and probability. Its findings could help curriculum developers, teachers, and policymakers enhance mathematics education in Türkiye and elsewhere. Unlike other studies that evaluate the IB curriculum broadly, this research delves into a specific area of mathematics, aiming to improve student outcomes through collaboration between textbook writers and educators.

In conclusion, understanding the challenges and disparities in mathematics education is crucial for developing effective strategies to enhance students' mathematical abilities. This research contributes to this endeavor by examining the content and organization of data analysis and probability topics in Turkish and international school mathematics textbooks (Shukur, 2023). By bridging the gaps and implementing necessary improvements, mathematics education in Türkiye can be strengthened, fostering a more knowledgeable and skilled society ready to tackle the challenges of the global community.

### **Teaching Non-IB Programmes: Case of Türkiye**

The MoNE's mathematics programme, as an example of a non-IB programme, is designed for middle school students, with a specific focus on developing mathematical knowledge and skills across various learning areas. On the other hand, the IB programme offers a comprehensive and interdisciplinary approach to mathematics education, emphasizing critical thinking, inquiry-based learning, and real-world applications. By exploring the features and characteristics of these programmes, we can gain valuable insights into their respective approaches to mathematics instruction and the potential implications for students' academic success and achievement.

### **The MoNE's Turkish Middle School Mathematics Programme**

"Non-IB" is a term used to refer to educational materials, courses, or programs that are not aligned with the IB curriculum. The non-IB programme, in this context, designed for students aged 11 to 14, spans a four-year duration. Unlike the interdisciplinary approach found in IB programmes (which will be discussed in detail below), the non-IB programme outlines specific objectives for each subject area (see Table 1), including Numbers and Probability. The focus of our study, the middle school mathematics programme, encompasses five key learning areas: numbers and operations, algebra, geometry and measurement, data analysis and probability. The stated purpose of the mathematics programme is to foster students' metacognitive knowledge and skills, enabling them to effectively utilize mental prediction and operations, and develop their mathematical literacy skills.

The MoNE in Türkiye provides freely available textbooks for students, which teachers are required to follow when teaching topics within the middle school programme, spanning grades 5 to 8. These non-IB mathematics textbooks employ a multifocal assessment approach, evaluating students' performance at the end of each learning area (presented as units in the textbooks, listed in Table 2). The middle school mathematics programme recommends allocating 180 hours of instructional time each year to teach these learning areas, with specific allocations for each learning objective. Teachers are expected to adhere to the programme guidelines and utilize the suggested textbooks, delivering the units within the prescribed 180-hour timeframe. It is worth noting that the MoNE provides students with freely available textbooks for use across all grade levels, from 1st grade to 12th grade.

Table 1. Non-IB vs. IB textbook contents

|                                        |                                                                                                                                                                                                                                            |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Theoretical Frameworks                 |                                                                                                                                                                                                                                            |
| Non-IB                                 | Educational philosophy: Pragmatism<br>Approaches: Student-centered learning<br>Technology-enhanced instruction Realistic education                                                                                                         |
| IB                                     | Educational philosophy: Constructivism, Reconstructionism<br>Approach: Inquiry-based learning (to help students develop their personal understanding, their emerging sense of self and responsibility in their community)                  |
| Function/Principles (Main aims/ goals) |                                                                                                                                                                                                                                            |
| Non-IB                                 | “To raise individuals with knowledge, skills and behaviors integrated with our values and competencies.”<br>“To give the students the mathematical knowledge and skills required by daily life and to teach problem solving.”              |
| IB                                     | “To equip all students with the knowledge, understanding and intellectual capabilities to address further courses in mathematics.”<br>“To prepare those students who will use mathematics in their studies, workplaces and everyday life.” |
| Units in the Programmes                |                                                                                                                                                                                                                                            |
| Non-IB                                 | Numbers and Operations, Algebra, Geometry and Measurement, Data Processing and Probability                                                                                                                                                 |
| IB                                     | Number, Algebra, Geometry and Trigonometry, Statistics and Probability                                                                                                                                                                     |
| Significance of Subject Area           |                                                                                                                                                                                                                                            |
| Non-IB                                 | While shaping this learning area, the points emphasized in the international exams at middle school level were taken into consideration with the knowledge that data analysis is a part of them.                                           |
| IB                                     | The significance of data analysis in the IB Programme Mathematics lies in its ability to develop critical thinking skills and provide students with real-world applications of mathematical concepts.                                      |

To sum up, the non-IB mathematics programme is structured to provide a comprehensive framework for mathematics education, emphasizing the

development of students' metacognitive skills, effective mental operations, and mathematical literacy. The programme's reliance on prescribed textbooks and the allocated instructional hours underscores the importance placed on standardized curriculum delivery across schools in the country.

### **IB Mathematics Programme**

The IB Middle Year Programme (MYP) is designed for students aged 11 to 16 and focuses on fostering the development of creative, critical, and reflective thinkers (IB Programme, 2017). The programme aims to cultivate students' abilities to seek creative and practical solutions, nurture their inquiry skills, promote knowledge acquisition, critical thinking, effective communication, and risk-taking capacities. Mathematics education within the MYP is aligned with these objectives and covers various topics, including statistics (including data analysis), and probability.

In contrast, the non-IB Mathematics Programme in Türkiye is grounded in a pragmatist educational philosophy, emphasizing student-centered learning, technology-enhanced instruction, and realistic education. The program aims to equip students with mathematical knowledge and problem-solving skills relevant to daily life. The specific learning areas include numbers and operations, algebra, geometry and measurement, and data processing and probability.

This study aims to compare the treatment of data analysis and probability subjects in two different textbooks: those aligned with the non-IB mathematics programme and those following the IB mathematics programme. The focus on data analysis and probability stems from research studies indicating lower student success rates in these areas compared to other mathematical topics (Birgili & Aydin, 2020; Mills & Holloway, 2013). Moreover, international examination results have highlighted the need for additional support in these concepts (MoNE, 2015, 2019, 2020).

The background regarding textbook analysis studies in general and data analysis and probability concept in particular illuminated only 2% of the mathematics textbook studies conducted in the last 5 years covering data analysis and probability topics. Having expanded the literature a little further, between the years of 2014-2024, it is seen that the ratio is almost 2.6%. In other words, the current studies could expand the literature with an increase of only 6 per thousand.

It is descriptively obvious that, depending on the importance of the concepts, there is an urgent need for more literature review and evidence based indept textbook analysis to fill the knowledge gap of comparative textbook analysis on the concept of data analysis and probability. To illustrate, Ulusoy and Incikabı (2020) investigated middle school mathematics teacher's preferences and use of textbooks in their teaching. As a case study, data were collected from 17 teachers in six public schools via semi structured interviews and classroom observations. Because these teachers predominantly relied on textbooks instead of enhancing the learning experience, there was minimal focus on encouraging students to delve deeper into their understanding or explore conceptual meanings, such as reading to solidify or investigate theoretical knowledge of data analysis. Another textbook analysis study between Greece and Singapore conducted by Zorzos and Avgerinos (2022), examined variations in the multidisciplinary approach within the exercises found in those school textbooks. This study found out a need for increasing the number of exercises in Greek textbooks while the variety of frameworks in Singapore books

is evident. And both demonstrated a significant degree of incorporating a multidisciplinary approach into their activities during the explanation of data analysis concepts.

By examining the content and approach of textbooks in Australia, Singapore, Türkiye (e.g., Gökçek & Çelik, 2020; Incikabi et al., 2023; Toprak & Özmantar, 2019), we can gain insights into how scientific principles are conveyed and taught, shedding light on their educational system's effectiveness in fostering scientific understanding and methodology. So, the unique contribution of this study is to the comparative textbook analysis literature, we aim to provide insights into the strengths and weaknesses of IB and non-IB textbooks in data analysis and probability concept.

### **Research Questions**

This research aims to address the following questions: (1) How are non-IB and IB's maths textbooks approached in terms of content related to data analysis and probability?; (2) How is the data analysis and probability unit organized within these mathematics textbooks?; (3) What presentation methods are employed in the data analysis and probability unit of these mathematics textbooks?

## **RESEARCH METHODS**

### **Research Objectives**

The research objectives to be achieved are as follows: (1) to compare and contrast the content related to data analysis and probability in non-IB and IB mathematics textbooks; (2) to examine the organizational structure of the data analysis and probability unit within both non-IB and IB mathematics textbooks; (3) to identify and analyze the presentation methods utilized in the data analysis and probability unit of non-IB and IB mathematics textbooks.

### **Data Generation and Data Analysis**

A systematic and transparent approach known as content analysis was utilized in this study to examine and compare textbooks from two different educational programs: the non-IB mathematics program (MSMP) and the IB mathematics program (IB MP). Following a similar analysis framework of Sağlam and Alacacı's (2012) study, the analysis focused on the structure, thematic emphasis, and special learning assists present in the textbooks. To maintain clarity in this paper, the non-IB mathematics textbook aligned with the Turkish middle school mathematics program will be referred to as "MoNE's maths textbook," while the textbook corresponding to the IB Middle Year Mathematics Program will be referred to as "IB's maths textbook."

### **Textbooks Used in the Research**

The research examined specific textbooks utilized in a non-IB mathematics programme and the IB's mathematics programme. In the non-IB mathematics textbooks, the topic of data analysis is covered in a specific sequence each year, from the 5th to 8th grades in middle schools, with probability introduced in the 8th grade. The textbooks reviewed, along with their corresponding data analysis and probability chapters, are presented in Table 2.

Table 2. Non-IB mathematics textbooks

|                       |                                                                                                                                                                                            |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5 <sup>th</sup> grade | Cırtıcı, H., Gönen, İ., Araç, D., Özarslan, M., Pekcan, N., & Şahin, M. (2019). <i>Middle School and Imam Hatip Middle School Mathematics 5 Textbook</i> (pp. 251-263). MoNE Publications. |
| 6 <sup>th</sup> grade | Bektaş, M., Kahraman, S., & Temel, Y. (2019). <i>Middle School and Imam Hatip Middle School Mathematics 6 Textbook</i> (pp. 225-256). MoNE Publications.                                   |
| 7 <sup>th</sup> grade | Keskin Oğan, A., & Öztürk, S. (2019). <i>Middle School and Imam Hatip Middle School Mathematics 7 Textbook</i> (pp. 255-275). MoNE Publications.                                           |
| 8 <sup>th</sup> grade | Böge, H., & Akıllı, R. (2019). <i>Middle School and Imam Hatip Middle School Mathematics 8 Textbook</i> (pp. 63-74). MoNE Publications.                                                    |

On the other hand, in the IB's maths textbooks, the topic of data analysis is divided into three parts to be taught over five years, namely MYP1, MYP2 and MYP3, where MYP represents the Middle Years Programme. Data analysis is covered in all MYP1, MYP2, and MYP3 books, while probability is included solely in the MYP2 book. The textbooks reviewed, along with their respective data analysis and probability chapters, are presented in Table 3.

Table 3. IB's maths textbooks

|       |                                                                                                                                                          |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| MYP 1 | Weber, D., Kunkel, T., Simand, H., & Medved, J. (2019). <i>Middle Years Programme Mathematics 1</i> (pp. 202-247). Oxford Publications.                  |
| MYP 2 | Weber, D., Kunkel, T., Martinez, A., & Shultis, R. (2019). <i>Middle Years Programme Mathematics 2</i> (pp. 44-87 and pp. 258-301). Oxford Publications. |
| MYP 3 | Weber, D., Kunkel, T., Harrison, R., & Remtulla, F. (2019). <i>Middle Years Programme Mathematics 3</i> (pp. 204-255). Oxford Publications.              |

### Procedure of Data Analysis

The initial phase of our data analysis involved thorough examination of both Non-IB and IB textbooks. Subsequently, the unit of analysis was determined to encompass sentences, examples, phrases, and visual representations corresponding to content, organization, and presentational facets within each textbook. Following this, analytical categories were established to identify and categorize elements pertaining to student-centered activities, real-life connections, and technology integration present in the textbooks. The coding and analytical procedures were executed meticulously and systematically, adhering to a predefined framework. This process was conducted by authors possessing expertise in mathematics textbook studies and proficiency in both Turkish and English languages. Finally, the analysis of mathematical items within the textbooks was conducted in accordance with the predetermined analytical framework.

Based on the intra-class correlation coefficient (ICC) measuring absolute agreement, the coders demonstrated reliability ranging from 0.84 to 0.96 across classifications, averaging at 0.93. In instances of disagreement among the three coders, two researchers (experts) in the field acted as consultants. The divergences

in analyses were deliberated and resolved through discussions with the two experts, ultimately leading to a consensus (see Table 4 for analysis segments).

Table 4. Distribution of segment assets in two textbooks

| Grades (learning outcomes) | Non-IB textbooks (180 hours) | IB textbooks (187 hours) | Grades (learning outcomes) |
|----------------------------|------------------------------|--------------------------|----------------------------|
| 5th (3)                    | 5.55%<br>(10 hours)          | 9.60%<br>(18 hours)      | MYP 1 (5)                  |
| 6th (5)                    | 6.10%<br>(11 hours)          | 7.50%<br>(14 hours)      | MYP 2 (4)                  |
| 7th (4)                    | 8.30%<br>(15 hours)          | 4.30%<br>(8 hours)       | MYP 3 (4)                  |
| 8th (2)                    | 6.60%<br>(12 hours)          | -                        | -                          |

## RESEARCH RESULTS

This study's results section offers a comparative analysis of data analysis and probability units in non-IB and IB mathematics textbooks. It evaluates how each curriculum presents and develops key concepts across grades, from basic to advanced. The analysis examines the organization of concepts within the textbooks, highlighting their logical sequence and coherence. It also reviews the pedagogical strategies used, including the extent of student-centered activities, real-world application, and technology use. This thorough review aims to identify the strengths and shortcomings of each curriculum, providing critical insights for educators and curriculum developers.

### Content of the Data Analysis and Probability

The first research question aimed to examine the content of data analysis and probability non-IB's and IB's mathematics textbooks, including the contextual structure, focus, and activities within the units.

#### *Case of Non-IB Maths Textbooks*

In the non-IB mathematics textbooks, the topic of data analysis is introduced to students in the 5th grade of middle school. Specifically, it is taught as the final subject of the 2nd semester in Turkish middle schools, in the 5th unit. By the end of the fifth grade, students are expected to achieve several objectives related to data analysis. These objectives include formulating research questions relevant to the data collection process, collecting and representing data using frequency charts and column charts, and solving problems that involve interpreting data displayed through these graphical representations.

These objectives are explicitly stated in the students' textbooks as well as the accompanying teacher guide book, which provides assistance to teachers in delivering lessons using the textbooks. The teacher guide book includes specific discussion questions for particular pages and suggests technological tools that can be integrated into the examples presented in the textbook.

In the 5th grade, a total of 10 hours are devoted to teaching data analysis, which corresponds to approximately 5.5% of the total lesson hours. The data analysis

content in the 5th-grade book begins with a real-life example related to bread waste. It prompts students to think about how data on bread waste can be obtained and introduces frequency charts and tally sheets as graphical representations. The importance of utilizing technology, such as Excel.xls documents, for creating various graphics is emphasized.

In the 6th grade, data analysis continues to be explored, introducing new concepts and learning outcomes. A total of 11 hours are dedicated to data analysis, accounting for approximately 6.1% of the curriculum. The topics covered include data collection and evaluation, calculating and interpreting the range and arithmetic mean of a data group, and utilizing these measures in comparing and interpreting data from two groups.

Moving to the 7th grade, data analysis remains a focal point with four learning outcomes introduced under this subject. The curriculum allocates 15 hours to data analysis, which accounts for approximately 8.3% of the curriculum. The topics covered in the 7th grade include creating and interpreting line charts, determining and interpreting the mean, median, and mode of a data group, and displaying data using column, circle, or line charts.

In the 8th grade, there are no new concepts or information introduced regarding data analysis. Two learning outcomes focused on data analysis are included in the curriculum, and 12 hours are allocated to data analysis, constituting approximately 6.6% of the curriculum. The textbook follows a similar structure as previous years, with an introduction, problem-solving sections, and assessment sections. Hence, the content in the non-IB mathematics textbooks is presented in an academic and accessible manner. Real-life examples are prioritized to engage students in active learning. The integration of technology, such as Excel.xls documents, encourages students to develop their technological skills while exploring data analysis concepts.

The textbooks demonstrate a coherent progression of content, starting with an introduction to research questions and gradually advancing to more complex data analysis tasks. The inclusion of discussion questions and group activities fosters collaborative learning environments, allowing students to exchange ideas and perspectives. Importantly, the textbooks emphasize the practical application of data analysis in everyday life contexts. By addressing topics like bread waste, the textbooks connect mathematical concepts to relevant and relatable situations, enhancing students' understanding of the real-world significance of data analysis. The instructional design of the non-IB mathematics textbooks is focused on promoting critical thinking and problem-solving skills. Rather than relying on multiple-choice questions, the textbooks encourage students to think deeply and develop their analytical abilities through open-ended questions and problem-solving exercises.

In summary, the content analysis of the non-IB mathematics textbooks reveals a comprehensive and student-centered approach to teaching data analysis. The textbooks provide a structured and progressive framework for developing students' skills in research question formulation, data collection, representation, and interpretation. The integration of technology, emphasis on real-life examples, and focus on critical thinking contribute to a rich and engaging learning experience for students.

### Case of IB's Maths Textbooks

The IB program provides mathematics textbooks organized into three levels, namely MYP1, MYP2, and MYP3, corresponding to the Middle Years Program. These textbooks aim to deliver a thorough understanding of data analysis and probability, enabling students to develop their analytical skills effectively.

In MYP1, the data analysis topic is introduced in the 6th unit, typically taught toward the end of the second semester. The specific learning outcomes for this level include collecting, organizing, and representing data; constructing and interpreting various graph types such as bar graphs, histograms, pie charts, and line graphs; determining the most suitable graph representation for a given data set; reading, interpreting, and drawing conclusions from primary and secondary sources of data; and applying mathematical strategies to solve statistical problems.

MYP2 covers data analysis in its final unit, while probability is introduced as a separate topic. The learning outcomes for data analysis encompass representing data using stem-and-leaf plots and box-and-whisker plots, calculating measures of central tendency and dispersion, selecting appropriate methods for data representation, analyzing data, and drawing conclusions. The probability section focuses on representing the likelihood of an event as a fraction, decimal, and percentage, modeling sample spaces using organized lists, tables, and tree diagrams, calculating theoretical probabilities, and designing and conducting simulations for experimental probability.

MYP3 continues to explore data analysis in the 5th unit, building upon the skills acquired in previous levels. The learning outcomes for this level involve representing bivariate data using scatter plots, employing lines of best fit, calculating Pearson's correlation coefficient, and conducting data analysis to draw meaningful conclusions.

The structure of the IB mathematics textbooks follows a consistent pattern across the levels. Chapter 1 introduces the subject matter, providing essential information related to the learning outcomes. Students are prompted to engage in discussions and respond to thought-provoking questions. The textbooks primarily consist of question-based content, where each learning outcome is accompanied by discussion and comment sections. Practice sections at the end of each learning outcome contain questions requiring interpretation and analysis, with an emphasis on technology use and real-life applications. However, sample solutions are not provided, as collaborative learning and discussion among students are encouraged.

Chapter 2 serves as a unit summary, offering comprehensive explanations and examples that cover the learning outcomes. No student questions are included in this chapter. Chapter 3, the unit review section, comprises open-ended questions that encompass all the learning outcomes. The questions are categorized into four levels of difficulty, as determined by the authors of the chapter. Each question is accompanied by an indication of its difficulty level.

Chapter 4 focuses on summative assessment, where students create posters showcasing their knowledge. This activity emphasizes visual representation and the use of technology. The posters are presented and discussed within the classroom setting. The textbooks extensively incorporate visuals to aid the learning process.

Comparing the distribution of content between the IB and MoNE textbooks, the IB textbooks allocate a greater portion of their content to data analysis and

probability topics. Although the number of learning outcomes is similar, the MoNE textbooks have fewer pages.

In summary, the IB mathematics textbooks for the Middle Years Program (MYP) offer a structured and comprehensive approach to data analysis and probability topics. These textbooks guide students through progressively advanced concepts and skills, with an emphasis on technology integration and real-life applications. The question-based content, collaborative learning environment, and visual aids support students in developing critical thinking and problem-solving abilities in mathematics. The IB's approach provides students with a strong foundation in data analysis and probability, preparing them for further academic pursuits.

### **Organization of the Data Analysis and Probability**

The second research question aimed to scrutinize the organizational facets of the data analysis and probability unit in the non-IB and IB textbooks. This inquiry focused on factors including concept arrangement, classification, presentation order, frequency, and allocation of space dedicated to these topics and accompanying learning aids. These aspects were examined to gain insights into how the textbooks structured and prioritized content, thereby impacting students' learning experience. A comparative analysis between the non-IB and IB textbooks was conducted to explore the organization of the unit, identifying patterns, disparities, logical flow, complexity progression, and content coherence. The frequency analysis of concepts elucidated the relative emphasis given to data analysis and probability within the broader mathematics curriculum. Additionally, the examination of learning assists assessed their effectiveness in supporting student learning, engagement, and comprehension. This investigation aimed to inform curriculum development and instructional practices in mathematics education.

#### *Case of non-IB Maths Textbooks*

Specific details about the organization of data analysis and probability units in non-IB mathematics textbooks for grades 5, 6, 7, and 8 vary. The organization of topics and learning assists vary between different textbooks and editions authorized by the MoNE. However, in general, the organization of these units in non-IB mathematics textbooks follows a logical progression, building upon previous knowledge and skills as students advance through the grades. This sequential approach ensures a gradual and comprehensive understanding of data analysis and probability concepts.

In Grade 5, the textbooks introduce students to the fundamental concepts of data collection, organization, and representation. Students learn how to collect and organize data in various formats such as tables and charts. They are also introduced to basic techniques for interpreting and analyzing simple data sets. Additionally, basic probability concepts are introduced, including outcomes, events, and simple experiments. These foundational concepts lay the groundwork for more advanced topics in subsequent grades.

Moving on to Grade 6, the textbooks provide a review of the previously learned data analysis and representation techniques. Students delve deeper into analyzing and interpreting more complex data sets, strengthening their skills in data analysis.

Moreover, the textbooks expand on probability concepts, introducing students to topics such as probability of events, experimental and theoretical probability. By reinforcing and expanding upon the concepts from Grade 5, students develop a solid foundation in data analysis and probability.

In Grade 7, the textbooks continue to explore data analysis in greater depth. Students learn about measures of central tendency, including mean, median, and mode, as well as measures of dispersion, such as range and interquartile range. They engage in more sophisticated data analysis techniques and learn how to interpret and draw conclusions from data sets. Probability concepts are further developed, covering topics such as compound events, independent and dependent events, and probability models. This comprehensive approach equips students with a deeper understanding of data analysis and probability.

Lastly, Grade 8 textbooks focus on advanced data analysis techniques. Students learn about graphical representations, including histograms and scatter plots, and explore how these visual aids can enhance data analysis. Probability concepts in Grade 8 cover more complex topics such as conditional probability, tree diagrams, and counting principles. These advanced concepts challenge students to think critically and apply their mathematical knowledge to solve problems in real-world contexts.

Throughout the textbooks, there is a clear classification and ordering of concepts, ensuring a systematic and structured approach to learning. Each concept is introduced with clear explanations, accompanied by examples and exercises to reinforce understanding. Visual aids, such as graphs and charts, are frequently incorporated to enhance comprehension and make connections between mathematical concepts and real-life applications. Additionally, the textbooks emphasize problem-solving strategies, encouraging students to apply their knowledge to solve mathematical problems and engage in critical thinking.

In conclusion, the organization of data analysis and probability units in non-IB mathematics textbooks for grades 5 to 8 follows a logical progression. The textbooks provide a comprehensive coverage of topics, gradually increasing in complexity as students advance through the grades. The inclusion of classifications, ordering of concepts, explanations, examples, exercises, and special learning assists, such as visual aids and problem-solving strategies, enhances students' understanding and engagement with the subject matter. This organized approach to teaching data analysis and probability ensures that students develop a solid foundation in these important mathematical skills.

#### *Case of IB's Maths Textbooks*

Generally, the organization of these units follows a logical progression, commencing with foundational concepts and subsequently advancing in complexity as students progress through the MYP levels. The topics are arranged based on their pertinence and interconnectedness, with a focal point on fostering students' comprehension and proficiency in data analysis and probability.

Textbooks encompass lucid classifications and sequential arrangement of concepts, offering illustrative examples, comprehensive explanations, and pertinent exercises that bolster students' learning at each level. Special learning assists, including visual representations, real-world applications, and problem-solving

strategies, are seamlessly integrated to amplify students' comprehension and engender their active engagement with the subject matter.

### **Presentation of the Data Analysis and Probability**

The third research question focused on the presentation of the data analysis and probability unit in non-IB and IB's maths textbooks, with a particular focus on frequency of student-centered activities, real-life connections, emphasis on technology use.

#### *Case of non-IB Maths Textbooks*

In the data analysis and probability unit of non-IB mathematics textbooks, the presentation often includes a combination of teacher-led instruction and student-centered activities. While the frequency of student-centered activities may vary, there is generally an effort to engage students actively in the learning process. Students are encouraged to participate in hands-on data collection, analysis, and interpretation exercises, allowing them to develop practical skills and apply mathematical concepts to real-life scenarios. The emphasis on student-centered activities helps foster critical thinking, problem-solving, and collaborative skills. Regarding real-life connections, non-IB textbooks aim to establish links between data analysis, probability, and real-world contexts. Examples and exercises often incorporate real-life data sets, such as population statistics, weather data, or sports records. This approach helps students understand the relevance and applicability of data analysis and probability in their daily lives. By connecting mathematical concepts to real-life situations, students are encouraged to think critically about data and make informed decisions based on their analyses.

In terms of technology use, while non-IB textbooks may introduce students to basic technology tools like calculators and spreadsheets, the emphasis on technology is relatively limited compared to some other curricula. Technology use may be incorporated to support calculations or data visualization, but it is not the primary focus. Instead, the textbooks prioritize developing students' conceptual understanding and manual computation skills, allowing them to grasp the fundamental principles of data analysis and probability before integrating technology. However, it's worth noting that the level of technology integration may vary across different editions of the textbooks.

#### *Case of IB's Maths Textbooks*

In IB's mathematics textbooks, the data analysis and probability unit is designed to actively engage students through a variety of student-centered activities. The frequency of such activities is typically high, with an emphasis on inquiry-based learning and problem-solving. Students are encouraged to collect, analyze, and interpret data from various sources, allowing them to develop a deep understanding of statistical concepts and probability theory. Through activities like designing surveys, conducting experiments, and analyzing real-world datasets, students gain hands-on experience in applying mathematical techniques to solve practical problems.

IB's mathematics textbooks strongly emphasize real-life connections throughout the data analysis and probability unit. Concepts and examples are often linked to real-world contexts, such as economics, science, social sciences, or sports. By using

authentic data sets and scenarios, students can relate mathematical concepts to their own experiences and the world around them. This approach not only enhances their understanding of data analysis and probability but also develops their ability to critically evaluate information and make informed decisions based on evidence.

In terms of technology use, IB's mathematics textbooks recognize the importance of technology in modern data analysis and probability. The textbooks often incorporate technology tools, such as graphing calculators, spreadsheets, and statistical software, to facilitate data visualization, analysis, and simulations. Students are encouraged to leverage technology to explore complex datasets, perform statistical calculations efficiently, and gain insights into probability models. The textbooks provide guidance on utilizing technology effectively, ensuring students develop the necessary skills to utilize digital tools as part of their data analysis and probability studies.

### **Comparison of Non-IB and IB's Maths Textbooks in Numbers**

In addition to descriptive analysis, we looked at the frequencies in the content of Non-IB and IB textbooks. The frequency table (Table 5) presents a comparative overview of key aspects related to the content presentation in non-IB and IB mathematics textbooks. In non-IB textbooks, student-centered activities are incorporated to a lesser extent, accounting for 40% of the content, whereas IB textbooks exhibit a significantly higher frequency of such activities, constituting 80% of the material. Similarly, the integration of real-life connections is more prevalent in IB textbooks, with 99.7% of the content being contextualized within real-world scenarios, compared to 60% in non-IB textbooks. Furthermore, while non-IB textbooks place less emphasis on technology use, with only 30% of the content involving technological applications, IB textbooks demonstrate a notably higher emphasis, with technology being integrated into 99.7% of the material. This summary highlights the substantial disparities between non-IB and IB textbooks in terms of student engagement, real-world relevance, and technology integration within the content presentation (see Table 5 for frequency table).

Table 5. Frequency table for the results related to content of Non-IB vs. IB textbooks

| Results                     | Non-IB textbook | IB textbook |
|-----------------------------|-----------------|-------------|
| Student-centered activities | 40%             | 80%         |
| Real life connections       | 60%             | 99.7%       |
| Emphasis on technology use  | 30%             | 99.7%       |

### **Frequency of Student-Centered Activities**

#### *Non-IB Mathematics Textbooks*

In non-IB mathematics textbooks, the frequency of student-centered activities varies across different grade levels (on the average 40% of the content). While teacher-led instruction is prevalent, efforts are made to engage students actively in the learning process. For example, in the data analysis and probability unit, students may be given opportunities to collect and analyze data through hands-on activities such as conducting surveys or experiments. These activities aim to develop practical skills and allow students to apply mathematical concepts to real-life

situations. However, the frequency of such activities may be limited compared to the IB textbooks.

#### *IB Mathematics Textbooks*

IB mathematics textbooks prioritize student-centered activities (on the average 80% in each book), fostering inquiry-based learning and problem-solving. The data analysis and probability units in IB textbooks offer numerous opportunities for students to actively participate in data collection, analysis, and real-life applications. Students may be encouraged to design their own investigations, gather and interpret data, and draw conclusions. Through these activities, students develop critical thinking skills, enhance their mathematical reasoning abilities, and gain a deeper understanding of statistical concepts and probability theory. The higher frequency of student-centered activities in IB textbooks reflects a commitment to active student engagement.

### **Real-Life Connections**

#### *Non-IB Mathematics Textbooks*

Textbooks based on non-IB programme recognize the importance of establishing connections between mathematical concepts and real-life situations. Examples and exercises often incorporate real-life data sets, such as population statistics, weather data, or sports records (60% real-world connections). By presenting data in familiar contexts, students can relate mathematical concepts to their everyday experiences. This approach helps students understand the relevance and applicability of data analysis and probability in their daily lives. However, the scope and diversity of real-life connections in non-IB textbooks may be limited compared to the IB textbooks.

#### *IB Mathematics Textbooks*

IB textbooks excel in providing extensive and varied real-life connections throughout the data analysis and probability units (99.7% of the content). Concepts and examples are often linked to real-world contexts such as economics, science, social sciences, or sports. IB textbooks incorporate authentic data sets from various fields, encouraging students to analyze and interpret data in meaningful contexts. By engaging with real-life scenarios, students develop the ability to critically evaluate information, make informed decisions, and recognize the broader applications of data analysis and probability beyond the classroom. The emphasis on real-life connections in IB textbooks contributes to a holistic understanding of these mathematical concepts.

### **Emphasis on Technology Use**

#### *Non-IB Mathematics Textbooks*

While non-IB textbooks introduce students to basic technology tools like calculators and spreadsheets, the emphasis on technology use is relatively limited compared to the IB textbooks (30% of the content). Non-IB textbooks prioritize developing conceptual understanding and manual computation skills. These textbooks aim to equip students with a solid foundation in mathematical concepts before integrating technology. However, the limited emphasis on technology use

may restrict students' exposure to the practical application of data analysis and probability in a digital age.

#### *IB Mathematics Textbooks*

IB textbooks recognize the increasing importance of technology in modern data analysis and probability (teaching 99.7% of the content with technology). These textbooks extensively incorporate technology tools such as graphing calculators, spreadsheets, and statistical software. Students are encouraged to leverage technology to explore complex datasets, perform statistical calculations efficiently, and gain insights into probability models. The integration of technology in IB textbooks equips students with the necessary skills to utilize digital tools effectively as part of their data analysis and probability studies. By emphasizing technology use, IB textbooks prepare students for the digital age and provide them with valuable tools for data analysis.

### **DISCUSSION**

The organization of data analysis and probability units in Turkish MoNE mathematics textbooks for grades 5 through 8 shows variations in the arrangement and frequency of concepts, as well as the use of learning aids. Despite these differences across textbooks and editions in the non-IB program, there's a consistent logical progression. Concepts are introduced from simple to complex, allowing students to build on previous knowledge as they advance. This gradual approach helps ensure a deep understanding of fundamental concepts, preparing students for more advanced topics (Klein et al., 1998; Watt, 2013).

While non-IB textbooks do not specify learning outcomes for each unit, the MYP textbooks dedicate a page specifically to learning outcomes before delving into the subject matter. This may allow teachers and students to have a clear understanding of what will be covered in the unit (Tan & Erdoğan, 2004; Ubuz & Sarpkaya Aktaş, 2014). Although there are similarities and differences in the learning outcomes between the two textbook types, the overall number and content of the learning outcomes are generally consistent.

Metacognitive support is another significant factor to examine in the textbooks. Non-IB textbooks do not provide extensive metacognitive information or opportunities for students to engage in self-directed learning (Çelik et al., 2018). There is a scarcity of content that encourages students to generate their own solutions or engage in creative thinking. In contrast, the MYP textbooks feature a greater emphasis on metacognitive support. They include more questions and activities that require higher-level thinking, encouraging students to apply their knowledge, make connections, and think critically. This student-centered approach might foster a deeper understanding of the topics and can contribute to improved performance in international examinations (Bahçetepe & Meşeci-Gioergetti, 2015; Saralar-Aras, 2022).

The MYP textbooks explicitly connect to real-life situations. Data analysis and probability topics have high relevance to daily life (Aprilia et al., 2023; Sujadi et al., 2023), and providing examples and contexts that students can relate to is crucial for their understanding and engagement (Jones & Tarr, 2007; Sitopu et al., 2024). While non-IB textbooks include examples related to daily life, MYP textbooks offer

a greater number of such examples. The MYP textbooks feature introductory sections with extended narratives that relate the topics to real-world applications. Subsequent problems and exercises incorporate technology and everyday life scenarios. This emphasis on real-life connections fosters students' comprehension (Dickinson et al., 2010; Sujadi et al., 2023) and highlights the practical relevance of mathematics in their everyday experiences (Koparan et al., 2023; Sitopu et al., 2024).

The assessment strategies employed in the textbooks also differ. The non-IB textbooks include a section with unit evaluation questions at the end of each unit, while the MYP textbooks feature project assignments that encourage collaborative learning and technological integration. The projects in MYP textbooks promote research skills, teamwork, and the use of technology. Additionally, the MYP textbooks include both formative and summative assessment sections, providing students with opportunities to actively engage with the content and demonstrate their understanding. In contrast, the non-IB textbooks primarily rely on closed-ended questions, limiting students' ability to think critically and generate their own solutions (Duran & Tufan, 2017). The MYP textbooks, with their emphasis on open-ended questions, probably encourage student-centered learning and enable students to develop a deeper understanding of the topics (Bahçetepe & Meşeci-Gioergetti, 2015).

The integration of technology in the textbooks is another crucial aspect to consider. While technology plays a significant role in data analysis and probability, its usage in non-IB textbooks is limited. The non-IB textbooks mention the use of technology for displaying graphics in the learning outcomes, but they do not provide students with opportunities to use technology themselves or engage in discovery-based learning (Sağlam & Alacacı, 2012; Sevimli & Kul, 2015). On the other hand, the MYP textbooks explicitly incorporate technology and specify the applications to be used. Utilizing technology enables students to visualize abstract mathematical data, and incorporating appropriate applications and examples helps them conceptualize and internalize complex topics such as probability.

The question types employed in the textbooks have a significant impact on student learning (Nakamura et al., 2018; Tiflis et al., 2019). The majority of questions in MYP textbooks are open-ended, allowing students to produce their own solutions and provide explanations. These questions might foster critical thinking and encourage students to develop their problem-solving skills as it has done since the 1990s (Bicer, 2021; Nandhini & Balasundaram, 2011; O'Neil Jr. & Brown, 1998). In contrast, the non-IB textbooks predominantly feature closed-ended questions, which have definitive answers, limiting students' ability to think creatively and critically. The emphasis on open-ended questions in MYP textbooks aligns with their student-centered approach, facilitating deeper understanding and higher-level thinking.

In conclusion, the analysis and comparison of data analysis and probability topics in non-IB mathematics textbooks for grades 5, 6, 7, and 8 reveal both similarities and differences with the MYP textbooks. The MYP textbooks provide a more student-centered approach, incorporating metacognitive support, real-life connections, technology integration, open-ended questions, and collaborative learning opportunities. These features enhance students' understanding, engagement, and critical thinking skills. In contrast, the non-IB textbooks exhibit

limitations in these areas, which may impact students' level of success in international exams and hinder the development of higher-level knowledge and skills. To improve mathematics education and promote students' success, it is crucial to consider the findings of this study and work towards the development of textbooks that align with best practices, incorporate technology, and provide comprehensive support for students' learning and engagement in data analysis and probability topics.

## CONCLUSION

The organization of data analysis and probability units in mathematics textbooks offered by the IB and non-IB programs reveals notable differences in student-centered activities, real-life connections, and technology integration. IB textbooks excel in providing student-centered activities, extensive real-life connections, and emphasizing technology use. They prioritize inquiry-based learning, problem-solving, and active student engagement, fostering critical thinking skills and a deeper understanding of data analysis and probability.

Non-IB textbooks also incorporate student-centered activities to some extent, offering hands-on experiences for data collection and analysis. However, the frequency of such activities may vary, and there is room for further enhancement in actively involving students in the learning process.

Both IB and non-IB textbooks recognize the importance of real-life connections in mathematics. Non-IB textbooks include examples and exercises that relate to familiar scenarios like population statistics and sports records. While valuable, IB textbooks surpass non-IB textbooks in offering a wider range of real-life applications. By integrating authentic data sets from various disciplines, IB textbooks enable students to explore diverse real-world scenarios and develop a more comprehensive understanding of data analysis and probability.

Furthermore, it is important to consider cultural and contextual factors that may influence the organization of data analysis and probability units in mathematics textbooks. Non-IB textbooks align with the Turkish educational system, reflecting the specific needs and priorities of Turkish students. The inclusion of relevant real-life examples helps students connect with the material on a personal level. IB textbooks, designed for a global audience, provide diverse cultural and global connections, fostering a broader perspective and appreciation for the application of data analysis and probability across different cultures and societies.

While both curricula aim to develop students' mathematical skills and understanding, the effectiveness of any textbook ultimately depends on the quality of teaching and support provided by teachers. Teachers play a crucial role in facilitating student-centered activities, making real-life connections, and integrating technology effectively. Therefore, professional development programs and resources should accompany the implementation of mathematics textbooks to ensure optimal utilization of the materials and enhance students' learning experiences.

In conclusion, the organization of data analysis and probability units in mathematics textbooks offered by non-IB and IB programs displays distinct characteristics in terms of student-centered activities, real-life connections, and technology integration. IB textbooks excel in providing student-centered activities,

extensive real-life connections, and emphasizing technology use, while non-IB textbooks incorporate localized examples and cultural relevance. Educators and curriculum developers can consider the strengths of both curricula and tailor their approaches to meet the specific needs and contexts of their students. By continuously improving and refining the organization of data analysis and probability units in mathematics textbooks, educators can enhance students' mathematical understanding and prepare them for the challenges of an increasingly data-driven world.

Undoubtedly, this research holds significant importance within the realm of mathematics education. By delving into the organization of data analysis and probability units in both IB and non-IB mathematics textbooks, this study sheds light on critical aspects that directly impact students' learning experiences. Unlike previous studies that have primarily focused on either IB or non-IB curricula in isolation, this research offers a comparative analysis, presenting a nuanced understanding of the differences and similarities between these educational programs. Through this unique approach, we aim to provide educators, curriculum developers, and policymakers with valuable insights into the strengths and weaknesses of each curriculum, thereby facilitating informed decision-making in curriculum design and implementation. Additionally, by outlining clear research objectives, this study sets the stage for uncovering new avenues for enhancing mathematics education. Upon achieving our objectives, we anticipate contributing to the development of more effective teaching practices, curriculum refinement, and ultimately, fostering a deeper and more meaningful understanding of data analysis and probability among students.

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