

# STATISTICAL THINKING AT EARLY PRIMARY SCHOOL LEVELS: CURRICULUM PERSPECTIVES IN UAE TEXTBOOKS

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## ABSTRACT

*Developing statistical thinking is vital to fostering students' critical thinking; however, it requires suitable curricula, appropriate textbooks, and well-prepared teachers. For many decades, statistics education was almost absent in the K–12 education in the Arab world. During the past few years, noticeable education reform efforts at all educational levels have introduced advanced curricula that aim to equip students with the skills that would enable them to compete internationally. This study aims to analyze the new statistics curricula in the United Arab Emirates (UAE), as a leading educational model, and assess their alignment with the best international practices in developing statistical thinking at the primary school levels. Content analysis of the statistics component in mathematics textbooks from Grades 1–4 in UAE will be conducted, benchmarking the statistics content with the best international practices. Finally, recommendations on efficient and practical approaches to ensure appropriate development of statistical thinking at early educational stages are showcased.*

**Keywords:** *Statistics education research; Statistical thinking; Primary schools; Arab world; United Arab Emirates*

## 1. INTRODUCTION

The past few decades have witnessed a steady increase in the interest in data and information accompanied by significant efforts to emphasize the role of statistics in the development and prosperity of societies. In light of this, there is a remarkable consensus among educators and policy makers that statistical thinking and competence in data processing and interpretation should be part of modern education (Burrill & Biehler, 2011; Engel, 2017). More recently, the challenges of utilizing statistical thinking to make informed and evidence-based decisions have been highlighted by the deluge of COVID-19 pandemic data (Backhaus, 2020; Pearce et al., 2020).

In response to the growing need for more statistical skills, reform initiatives have been implemented globally to increase school-level exposure to statistics content (Zieffler et al., 2018). Many countries such as the United States, Australia, New Zealand, and Israel have made significant steps to incorporate statistical thinking in school mathematics curricula (e.g., Australian Curriculum, Assessment and Reporting Authority, 2022; Bargagliotti et al., 2020). The Arab world, despite a late start is no exception. For many decades, statistics education has been almost absent in the K–12 education in the Arab world with very limited coverage of basic concepts in probability and statistics late in secondary education as part of the mathematics curricula. During the past few years, education reform efforts at all educational levels have taken place in a few Arab states such as the United Arab Emirates (UAE), Oman, Jordan, and Egypt (Elbehary, 2019a; Hijazi & Alfaki, 2020).

The UAE has made great strides in educational development over the past few decades to meet its strategic vision of being among the best countries in the world by 2021, the Golden Jubilee of the Union (UAE Cabinet, 2010). With these aspirations and ambitions, the UAE has become a role model

regionally and globally (Al Gurg, 2020). To achieve its national agenda, the UAE has transformed its education system by introducing new curricula and adopting new pedagogical practices, aiming at being among the best in the world in reading, mathematics, and science. Additionally, the vision of building the knowledge economy requires Emirati human capital equipped with the 21<sup>st</sup> century thinking and innovation skills. Statistical thinking is a must for knowledge-based human capital. The new curricula addressed the values and the needs of the UAE society such as spreading tolerance (Alhashmi et al., 2020), achieving gender equality (Al-Qatawneh & Al Rawashdeh, 2019), promoting national culture and identity (Alhosani, 2022), and fostering Arabic language (Maluch & Thomure, 2021). Yet virtually no research has been conducted to evaluate the ability of the statistics component in the new curricula to develop statistical thinking among the new UAE generations.

Developing statistical thinking requires suitable curricula and appropriate textbooks besides well-prepared teachers. Therefore, the purpose of this study is to investigate the potential of the new statistics curricula in the UAE, as a leading educational model, in developing statistical thinking at the primary school level. More specifically, the study will review and assess the content of the statistics component in the primary school textbooks from a statistical thinking perspective and discuss the readiness of primary teachers to facilitate the development of students' statistical thinking.

## **2. OVERVIEW OF K–12 EDUCATION IN UAE**

### **2.1. THE UAE EDUCATION SYSTEM**

The UAE is a constitutional federation of seven emirates: Abu Dhabi, Dubai, Ajman, Sharjah, Umm Al Quwain, Fujairah, and Ras Al Khaimah (UAE Government, 2022a). It is a quasi-federation country established in 1971, where the emirates operate like the states in the United States. Abu Dhabi is the largest emirate in terms of area and oil production, while Dubai is the most populous emirate and is a global business hub. The UAE's total population is 10.1 million of whom around 12% are UAE nationals (Global Media Insights, 2022).

The educational system in the UAE is nearly evenly run by the public and private sectors. Public schools provide free education for the UAE nationals and citizens of the Gulf Cooperation Council (GCC) countries. Additionally, public schools are open for high-achieving expatriate students (UAE Government, 2022b) and private schools are open to both expatriates and the UAE nationals for a fee.

According to the UAE Ministry of Education ([MoE], 2020), the UAE educational system is divided into four tiers covering 14 years of education: Kindergarten (KG1–KG2), Primary (Cycle 1, Grades 1–4), Preparatory (Cycle 2, Grades 5–8), and Secondary (Cycle 3, Grades 9–12). In Cycle 3, students are divided into three streams based on their performance and preference. The advanced stream qualifies students to study Science, Engineering and Medicine while the general stream prepares graduates to study applied sciences and the applied stream focuses on technical and vocational preparation.

The MoE oversees all educational affairs in the UAE including schools, colleges, and universities. The MoE manages public schools as a unified system with the same curricula. Conversely, the MoE does not directly run private schools nor their curricula (except Arabic language, social studies and Islamic studies), yet it develops general guidelines and standards that all schools should follow and implement fully (UAE Government, 2022b). Moreover, the local educational authorities, such as Abu Dhabi's Department of Education and Knowledge (ADEK), previously known as Abu Dhabi Educational Council (ADEC), and Dubai's Knowledge and Human Development Authority (KHDA), work under the MoE guidelines to supervise and inspect public and private schools in the different emirates (Alhosani, 2022). To address the needs of expatriate communities in the UAE, private schools offer various curricula systems such as American, British, Indian, as well as the MoE system.

In a remarkable effort to diversify the public education sector in Abu Dhabi, ADEK introduced twelve "charter schools" in 2019 as a third model in addition to the existing schools in the emirate. The charter schools offer American-based curriculum and are operated by private education operators. The new schools are free for Emirati and GCC students who live in Abu Dhabi (ADEK, 2022). The new system started with kindergarten students and students of Grades 1 to 5, with higher level classes starting sequentially. Currently, there are 32 charter schools operating in the emirate of Abu Dhabi. This year, the MoE started an analogous project of 10 schools across the other six emirates, with the

intention of raising that number to 28 within three years. The goal is for the new schools to follow the same model of the Charter schools in Abu Dhabi (The National, 2022).

In the year 2020–2021, there were 600 public schools providing education to 286,550 students and 657 private schools enrolling 826,993 students (UAE MoE, 2021). As indicated by Kippels and Ridge (2019), the private school sector was growing at a remarkable pace to meet the growing demand of expatriates. While the enrollment in public schools increased by 4.4% over the 2015–2020 period, the corresponding rate for private schools was 20.3% (UAE MoE, 2021).

## **2.2. EDUCATIONAL REFORM**

Since its establishment in 1971, the UAE has embarked on several reform initiatives to improve the quality and effectiveness of its educational system (Kippels & Ridge, 2019; Matsumoto, 2019; Ridge et al., 2017;). Historically, the UAE tended to borrow curricula reforms from the United States, United Kingdom, and Australia, yielding an unsustainable curriculum reform process. As an alternative, Ridge et. al. (2017) noted the need to have a strong national curriculum authority with evident involvement of the UAE nationals to protect the national and cultural identity.

The first notable reform initiative was led by ADEC in 2010 by implementing the New School Model (NSM) with the objective of improving student learning experiences and to raise academic outcomes of Abu Dhabi students (Badri & Al Khaili, 2014). Moreover, this initiative focused on implementing bilingual teaching (Arabic and English) and adopting English as a medium for instruction in science and mathematics to better prepare students for university.

The most recent educational reform initiative in the UAE was part of its 2021 vision of being among the best countries in the world through building a diversified knowledge economy (UAE Cabinet, 2010). The UAE 2021 vision emphasized the development of a first-rate educational system through a complete transformation of the existing educational system and teaching methods. The introduction of an advanced curricula aimed to equip students with skills of the 21st century and enable them to compete internationally.

In 2017, the Emirati School Model (ESM) was launched in all public schools to produce graduates meeting the aspirations of the nation. As part of the newly adopted model, a new curriculum was introduced as a result of 3-year collaborative efforts between the MoE and ADEK. Moreover, new curriculum standards frameworks for all subjects were developed in an effort to modernize the public educational sector by replacing the traditional educational pedagogies and practices and obsolete curricula (UAE MoE, 2021). Similar to NSM, English was proposed as the language of instruction for science and mathematics classes in the new model. With 2017–2018 as a transition year, the ESM was adopted and immediately implemented in 2018–2019 at all grade levels. Undoubtedly, this reform was a significant step towards building the national human capital as a vital pillar of the aspiring knowledge economy.

## **2.3. TEACHER CAPACITY**

Historically, the UAE relied on expatriate teachers from Arab countries including Egypt, Jordan, Lebanon, Palestine, and Syria in addition to a small number of Emirati (Gallagher, 2019). As a result of the launch of the NSM in 2010, ADEC managed to recruit thousands of native English-speaking teachers, known as English Medium Teachers (EMT), from countries with well-established effective educational systems such as the United States, Canada, United Kingdom, Australia, and New Zealand. The newly hired teachers replaced Arabic-speaking teachers to teach English, mathematics and science, together with a small number of Emirati EMTs.

By recruiting teachers from Arab and Western countries, the UAE strives to prepare Emirati national teachers locally via in-country teacher educational programs. Currently, the three public higher educational institutions—United Arab Emirates University, Zayed University, and Higher Colleges of Technology—are offering several teacher education programs besides the arts and sciences specializations with no pedagogical training. In 2007, ADEC established Emirates College for Advanced Education (ECAE) as the first dedicated teachers' college to provide high-quality teacher education and train the national teachers in Abu Dhabi and the UAE. Additionally, ECAE offered Postgraduate Diploma in Education for specialization degree holders. Despite these efforts, the MoE is

facing difficulties in attracting Emirati teachers, particularly male teachers. According to Statistics Centre-Abu Dhabi (SCAD), the Emirati teachers in Abu Dhabi constitute 38% of teachers in Abu Dhabi public schools and less than 1.2% in the private schools, while male Emirati teachers represent only 5.7% of the teaching staff in public schools (SCAD, 2020).

In another quest for improvement, the MoE launched in 2018 the Professions Licensing System to register all in-service and novice teachers who meet the high standards in pedagogy and subject specialization required (UAE MoE, 2021). All teachers in UAE were required to obtain the license by the end of 2020.

## **2.4. MATHEMATICS CURRICULUM AND STATISTICS CONTENT**

Mathematics education was no exception to the recent reform and, as expected, probability and statistics are core components in the new mathematics school curricula. A team of experts worked on developing the new curricula and corresponding textbooks. According to UAE MoE (2017), the new mathematics curriculum framework was designed in alignment with international practices (such as the United States, Singapore, China, and Japan), as well as the specific mathematics specifications of the international exams, such as TIMSS, PISA, Gulf Mathematical Olympiad and the International Mathematical Olympiad. The framework identified four major domains covering the new K–12 curriculum: Numbers & Operations, Algebra & Functions, Geometry & Measurement, and Data Analysis & Probability. The framework adopted the learning outcomes developed by The National Council of Teachers of Mathematics ([NCTM], 2000). The content of data analysis and probability spans over the K–12 levels except Grade 9 and Grade 12 (for advanced stream). Probability is covered in Grades 7, 10, 11, and partially in Grade 12, while the data analysis component is covered in Grades 1 through 6 and 8.

The learning outcomes for Cycle 1 highlight the contribution of mathematics in the new curriculum by emphasizing the use of mathematics and scientific knowledge in solving mathematical and numerical problems, and conducting applied projects (UAE MoE, 2020). By the end of Cycle 1, as described in the UAE MoE (2017), students should be able to collect, record, present data using basic charts, read charts, and interpret the results. These learning outcomes are in line with the data content domain in TIMSS Mathematics for fourth grade (Lindquist et al., 2017). It is worth noting that, as per the MoE guidelines, generalist teachers teach almost all subjects in Grades 1 and 2 while subject teachers teach Grades 3 and 4. In public schools offering mathematics in English, the English Medium Teachers teach English, mathematics, and science for Grades 1 and 2 students.

In line with the NCTM standards, the MoE signed a 7-year agreement with McGraw-Hill Education to procure all K–12 mathematics instructional materials. The curriculum content was aligned with the UAE National Standard Framework and addressed the UAE culture and its needs (Sahoo, 2016). The new textbooks were also translated into Arabic. In the new MoE curriculum, English is proposed as the instructional language for mathematics. However, mathematics is taught in English in the emirate of Abu Dhabi while it is still taught in Arabic in the other emirates (Kippels & Ridge, 2019).

## **3. THEORETICAL BACKGROUND**

### **3.1. STATISTICAL THINKING AT PRIMARY SCHOOL LEVEL**

According to Ben-Zvi and Garfield (2004), statistical thinking involves an understanding of why and how statistical investigations are conducted by recognizing and understanding the entire investigative process. Considerable research has been carried out to characterize statistical thinking at different educational levels starting from primary schools (Jones et al., 2000), to middle schools (Mooney, 2002) and secondary schools (Pfannkuch & Horring, 2004), ending by university (Chance, 2002). The developed frameworks characterize statistical thinking as presenting and interpreting data at the early stages to seeing the “big picture” at the college stage.

The framework developed by Jones et al. (2000) is comprised of four constructs along with the key statistical elements representing each construct (Table 1). The first construct focuses on reading data displays and extracting explicit information as well as making straightforward connections between displays and the original data. The second construct emphasizes data organization, reduction, and

characterization using center and spread measures. The third construct involves constructing data displays including displays that exhibit different organizations of the data. Lastly, the fourth construct includes reading between and beyond the data. As described by Jones et al. (2000), reading between the data covers making comparisons (e.g., largest, smallest, greater than) and using other mathematical concepts and operations to interpret the data. Conversely, reading beyond the data involves making predictions and inferences from the data.

It is worth noting that the framework includes four levels of statistical thinking across each of the four constructs. The statistical thinking levels are idiosyncratic, transitional, quantitative, and analytical. The framework has been used in assessing the level of statistical thinking among school children (Jones et al., 2000; Jones et al., 2001; Nisbet et al., 2003; Putt et al., 2000;) and developing frameworks to characterize statistical thinking among older students (Chan et al., 2016; Groth, 2003; Mooney, 2002).

Table 1. Description of constructs of the statistical thinking framework (Jones et al., 2000)

Construct	Key elements
Describing Data Displays	(a) reading data displays, (b) showing awareness of elemental graphing conventions (e.g., title, axis labels), (c) recognizing when different displays represent the same data, and (d) evaluating different displays of the same data.
Organizing and Reducing Data	(a) grouping and ordering data, (b) recognizing that information may be “lost” in a reorganization of data, (c) describing data in terms of representativeness or typicality, and (d) describing data in terms of spread.
Representing Data	(a) completing a partially constructed data display, and (b) constructing displays to represent different organizations of a data set.
Analyzing and Interpreting Data	(a) comparing and combining data (reading between the data), and (b) extrapolating and predicting from the data (reading beyond the data).

### 3.2. STATISTICS TEACHER PREPARATION AND TRAINING

There is a general consensus among statistics educational communities that the preparation and training of teachers of statistics at all educational levels is a serious challenge to statistics education (Ben-Zvi & Garfield, 2004; da Ponte & Noll, 2018; Estrella et al., 2015; Jacobbe, 2010; Leavy, 2010; Martignon, 2011). This concern stems from the fact that statistics at the school level is a component of the mathematics curriculum and is therefore delivered by mathematics teachers, who likely lack proper training and preparation in teaching statistics (Reston & Bersales, 2011) and probably have not attended courses in applied statistics nor involved, as learners, in the processes of statistical investigations (Ben-Zvi & Garfield, 2004; Leavy, 2010).

In primary schools, many teachers are generalists and, as noted by Jacobbe (2010), the vast majority do not possess suitable statistical training and the required in-depth content knowledge to teach statistics and probability effectively. This situation might hamper their ability to make full use of rich problems and correct the systematic errors made by students. More seriously, it is likely they will share with their students a variety of probabilistic and statistical misconceptions (Estrella et al., 2015; Stohl, 2005).

Generally, mathematics teachers are expected to have adequate mathematical content knowledge to develop and promote mathematical thinking of their students, but they may not have adequate exposure to statistics to develop their statistical thinking since mathematical thinking and statistical thinking are quite different (Peck et al., 2008; Wild & Pfannkuch, 1999;). Therefore, as stressed by Leavy (2010), statistical content knowledge is critical for teachers of statistics.

The aforementioned facts necessitated a call for reforming the pre-service teacher educational programs through enriching content knowledge, promoting modern pedagogies and developing statistical reasoning and thinking required to support teaching statistics in schools (Leavy, 2010). As emphasized by Jacobbe (2010) and Leavy (2010), undergraduate courses in statistics do not necessarily prepare pre-service teachers to teach the statistics content at the primary school. To address some of the issues, the American Statistical Association (ASA) and NCTM published a joint position statement on

preparing Pre-K–12 teachers of statistics and data science (ASA & NCTM, 2022). The statement details a set of practical measures to be considered by stakeholders to provide high-quality preparation and professional development for pre-service and in-service teachers.

### **3.3. ROLE OF TEXTBOOKS**

Textbooks are major conveyors of the curriculum and play a major role in modern education in different school subjects (Fan et al., 2013). Moreover, teachers and students use textbooks as a central resource for teaching and learning (Hadar, 2017; Son & Diletti, 2017; Weiland, 2019). Moreover, teachers who have limited or no subject knowledge tend to rely more on textbooks. As noted by Hadar (2017), textbooks reflect what the students would learn, according to the curriculum, if they solve all the given exercises in the textbook.

As for mathematics textbooks, Alajmi (2012) emphasized the role of textbooks as a guide for teachers in lesson planning. Moreover, textbooks have an evident influence on what and how teachers teach in addition to the choice and content of assessment tools. Alajmi and Reys (2010) noted that when a certain topic is not included in the textbook, it is unlikely to be covered in the classroom. Macintyre and Hamilton (2010) asserted that teachers place a high degree of trust in the content covered in the adopted textbook, which leads to an acceptance that the textbook is the curriculum. Interestingly, the study of Haggarty and Pepin (2002) showed that about 50% of American teachers are textbook bound.

Regarding pedagogical styles, Fan and Kaeley (2000) reported that textbooks influenced the adopted teaching styles. They showed that teachers who use different types of textbooks tend to utilize different teaching strategies, which indicated that textbooks seem to play a role in teachers' pedagogical styles. Törnroos (2005) emphasized that textbooks shape the instruction in the classroom by identifying the content discussed, while Stern and Roseman (2004) asserted that the content of a textbook can determine the methods of learning. Briefly, the learning experience of the student will be shaped by what subject textbooks offer.

Another aspect of textbooks that is worth considering is the presence of the students' culture in the textbook verbally and pictorially. BouJaoude and Noureddine (2020) considered textbooks as cultural supportive tools that have a significant cultural mission with influence on individuals' development. As noted by Van den Heuvel-Panhuizen and Elia (2013), in the early childhood period students move from informal learning at home to formal learning at school. This necessitates the need to ensure that learning of mathematics will be connected to the everyday experiences of students. Undoubtedly, this should be reflected in their textbooks as a central source of learning for mathematics to make sense to them. Van den Heuvel-Panhuizen et al. (2009) argued that this connection is made easier using picture books, which may be read in group settings.

The main objective of content analysis of textbooks is to improve the students' learning (Son & Diletti, 2017), and possibly their achievement (Hadar, 2017). More specifically, textbook benchmarking and comparative studies are intended to identify the strengths and weaknesses in textbooks to help improve the content included and its presentation. As reported by Weiland (2019), several studies have been conducted to explore the statistics component in school textbooks and assess its alignment with the Pre-K–12 Guidelines for Assessment and Instruction in Statistics Education (Bargagliotti et al., 2020). Typically, the textbook analysis included common themes such as physical characteristics, structure of lessons, and problem analysis (Alajmi, 2012). As elaborated by Son and Diletti (2017), problem analysis might include among others: mathematical features, contextual features, response types, cognitive demand, and relevance of non-textual elements.

## **4. METHODOLOGY**

### **4.1. TEXTBOOK SELECTION**

The MoE mathematics textbooks for Grades 1 to 4 taught in the academic year 2020/2021 were selected (Carter et al., 2020a, 2020b, 2020c, 2020d). Both English and Arabic editions were considered. The statistics chapter from the English edition of each textbook was used in the content analysis.

## 4.2. CODING SCHEME

In this study, the unit of analysis is defined as a statistical activity. Following the approach of Jones et al. (2015), exercises and examples were divided into simple tasks to facilitate the coding process. Each task was coded based on the statistical thinking framework developed by (Jones et al., 2000). As described earlier, the framework consists of four constructs: describing data displays (D), organizing and reducing data (O), representing data (R), and analyzing and interpreting data (A). Table 2 presents examples of tasks coded for each construct. Additionally, tasks were classified based on response type as either open-ended or closed-ended questions. Closed-ended problems have only one solution while open-ended problems have more than one answer. In Table 2, only the first example was classified as open-ended.

Table 2. Examples of selected activities coded using the statistical thinking framework

Construct	Activity
Describing Data Displays	Write one sentence about the data in the graphs. (Carter et al., 2020c, p. 708)
Organizing and Reducing Data	Use the data in the chart to answer the question. How many students like beefburger? (Carter et al., 2020b, p. 491)
Representing Data	Yasmin kept a tally chart of all the times her cat did a trick. Display the data in a scaled picture graph and a bar graph. (Carter et al., 2020c, p. 706)
Analyzing and Interpreting Data	Use your line graph to make a prediction about the temperature of the water in the pot after 5 minutes. (Carter et al., 2020d, p. 870)

## 5. RESULTS AND DISCUSSION

### 5.1. CHARACTERISTICS OF STATISTICS CONTENT

Table 3 presents the characteristics of the statistics content in the mathematics curriculum covered in the textbooks by grade. In terms of pages, statistics content constitutes 3.9 to 7.8% of the mathematics curriculum. This size is inconsistent with the fact that statistics content is around 20% of TIMSS exams. There is only one chapter in each grade taught in Term 2 in Grades 2 and 4 while covered in the last term in Grades 1 and 3. As noted by Jones et al. (2015), when all the topics were to be covered in limited time, topics near the end of the textbook are more frequently omitted or covered sparingly. Table 3 also indicates that there is redundancy in the topics covered such as bar and picture graphs. Although the coverage of such topics is expected to provide deeper insights for higher levels, this redundancy could be minimized without affecting the curriculum significantly.

Table 3. Content and physical characteristics of the statistics chapters

Grade	Mathematics Curriculum		Statistics Component				
	Chapters	Pages	Chapter	Pages	Term	Chapter Title	Topics
1	10	746	7	48 (6.4%)	3	Organize and Use Graphs	Tally Charts, Picture Graphs, Bar Graphs
2	12	780	8	62 (7.8%)	2	Data Analysis	Take a Survey, Picture Graphs, Bar Graphs, Line Plots
3	14	876	12	50 (5.7%)	3	Represent and Interpret Data	Collect and Record Data, Picture Graphs, Bar Graphs, Line Plots
4	16	904	13	28 (3.9%)	2	Data	Line Graphs, Circle Graphs

## 5.2. ANALYSIS OF STATISTICAL THINKING

Table 4 summarizes the percentage of the tasks that mapped to each construct in the statistical thinking framework. Overall, tasks were mapped to the four constructs in all grades except “Describing data displays” in the first two grades. Obviously, the majority of tasks address the third and the fourth constructs. As noted earlier, the statistics chapter in Grade 4 covers two topics, which explains the small number of tasks compared to the other grades. All tasks in Grades 1 and 2 are closed-ended while more open-ended questions are given in Grades 3 and 4. Not surprisingly, students in the first two grades are still at the stage of learning vocabulary and making simple sentences. Nevertheless, well-trained teachers should be able to overcome this by asking open-ended questions verbally.

Table 4. Percentage of statistical tasks addressing each construct and question type, by grade

Level	No of questions	Construct				Question Type	
		D	O	R	A	Open-ended	HOT
Grade 1	105	0.0%	17.1%	31.4%	51.4%	0.0%	3
Grade 2	122	0.8%	13.9%	37.7%	47.5%	0.0%	3
Grade 3	120	17.5%	4.2%	39.2%	39.2%	29.1%	5
Grade 4	52	15.4%	11.5%	34.6%	38.5%	14.9%	1
Total	399	7.5%	11.5%	36.1%	44.9%	10.5%	12

D=Describing Data Displays, O=Organizing and Reducing Data  
R=Representing Data, A=Analyzing and Interpreting Data

Figure 1 shows a typical problem from Grade 1 where students are given a data display and are asked to report the frequency of a certain category (O) or combine the frequencies of two or more categories (A) to report a total. A similar pattern of mapping is observed in Grade 2. Figure 2 shows a common problem from Grade 2, which to some extent is similar to the problem in Figure 1. Besides the aforementioned tasks, students are asked to identify the categories with highest and lowest frequency, which requires comparing the frequencies of the various categories (A).

7. Use the tally chart in Exercise 6 to make a bar graph.

**Favorite Sea Animal**

Whales										
Dolphins										
Sharks										

0 1 2 3 4 5 6 7 8 9

Use the graphs above to answer the questions.

8. How many people choose dolphins?  
\_\_\_\_\_

9. What sea animal got fewer than 5 votes?  
\_\_\_\_\_

10. How many people choose sharks and whales?  
\_\_\_\_\_

11. How many students were surveyed?

Figure 1. Example of a typical problem - Grade 1 (Carter et al., 2020a, p. 554)



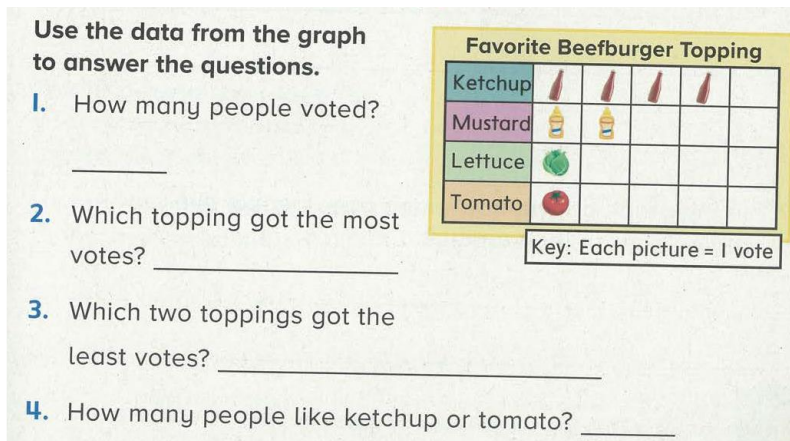
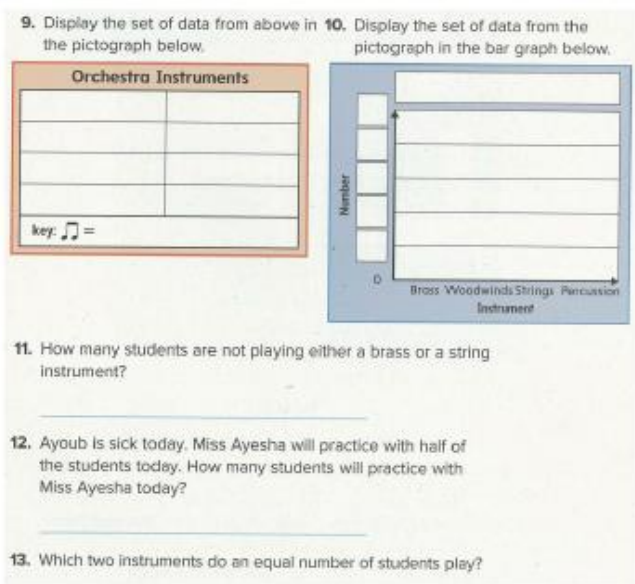
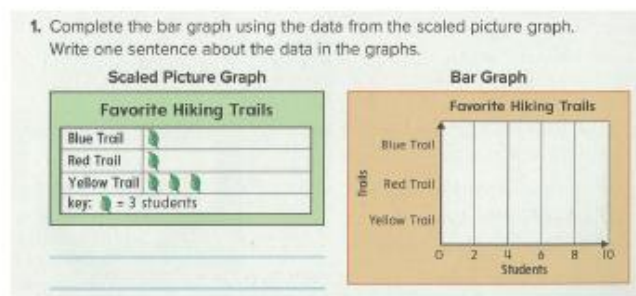


Figure 2. Example of a typical problem - Grade 2 (Carter et al., 2020b, p. 505)

In Grades 3 and 4, there is more emphasis on describing data displays using open-ended questions as shown in Figure 3b and Figure 4b (Problem 5). The task shown in Figure 3a addresses “representing data”, as well as comparing and combining categories (A). The task presented in Figure 4a addresses only comparing categories (A), whereas the task presented in Figure 4b requires producing a double line graph (R) and comparing the two lines (A). It is worth noting that a few activities addressing prediction (A) using line graph were given.



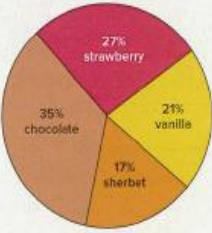
(a)



(b)

Figure 3. Examples of typical problems - Grade 3 (Carter et al., 2020c, p. 724, 707)

Badria surveyed 40 people about their favorite ice cream. The circle graph shows her results. Use the graph to answer each question.



5. Which group includes the fewest number of votes? \_\_\_\_\_

6. Approximately what percent of people like strawberry over vanilla? \_\_\_\_\_

7. Which group includes the highest number of votes? And approximately by what percentage?.

(a)

The table shows population data for two cities.

Year	City Population	
	City A	City B
1900	1,716	1,641
1910	2,106	2,814
1920	2,064	4,050
1930	2,219	7,691
1940	3,469	10,383
1950	4,252	10,113
1960	7,006	10,975
1970	8,902	9,494
1980	14,260	9,289
1990	17,892	7,976
2000	22,497	7,828

4. Create a double line graph to show the populations from 1900 to 2000.

5. Write a few sentences to describe each city's population change and how the cities' populations compare over time.

6. How much larger was the population of City B than City A in 1960?

(b)

Figure 4. Examples of typical problems - Grade 4 (Carter et al., 2020d, p. 865, 859)

The last column in Table 3 shows the number of high-level thinking questions (HOT) in each chapter, while Figure 5 shows one example of HOT questions from each grade. Overall, the questions are limited and as mentioned earlier, it is expected well-prepared teachers will be able to generate more HOT questions based on the composition of the students in the class. It is worth noting that higher-level questions could be extracted from TIMSS and other international mathematics exams.

**HOT Problem**

Noura is having a pizza party. She asks her guests to pick their favorite kind of pizza. If she orders one kind, which one does she order? Explain.

Favorite Pizza Topping		
Topping	Tally	Total
Cheese		7
Beef		3
Vegetables		2

(a) Grade 1

**HOT Problem** 10 more people were surveyed for the graph above. 3 more people like board games. 3 more people like video games. The rest like playing outside. Now how many people like each activity?

(b) Grade 2

**HOT Problems**

6. **Practices** **Reason** How would the graph at the right change if you changed the symbol value to 2?

7. What might the scale for a bar graph that displays the same data with the symbol value of 4 be?

Pen Pal Letters Received	
Saleh	☒ ☒ ☒
Sultan	☒ ☒ ☒ ☒
Saeed	☒ ☒

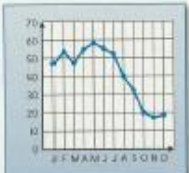
key: ☒ = 4 letters

(c) Grade 3

**HOT Problems**

10. **Mathematical Practice** **Make Sense of the Problem** This line graph has several parts missing. Create a story and a context to go along with the graph. Create axes labels and a title for the graph.

11. **Building on the Essential Question** Write a math problem that can be solved by making a line graph. Then make the line graph. Solve.



(d) Grade 4

Figure 5. Examples of HOT problems in Grade 1 (Carter et al., 2020a, p. 518), Grade 2 (Carter et al., 2020b, p. 518), Grade 3 (Carter et al., 2020c, p. 706), and Grade 4 (Carter et al., 2020d, p. 860)

### **5.3. PRESENCE OF CULTURE**

As noted earlier, it is recommended in early education to incorporate the students' culture in the learning resources to facilitate the learning transition of the student from home to school. Although the textbooks were modified to fit the local culture and environment, the content analysis of the four chapters indicated that the culture is not well-presented. Although the content of textbooks has been modified to reflect the Arab culture, the illustrative images in these textbooks still reflect non-Arab characters and cultural representations. A few questions contain uncommon words and contexts, at this age, such as sports activities (baseball, sledding, hockey), animals (hamster, blue jay, robin) and cactus types (saguaro, prickly pear, hedgehog). Conversely, culture-related representations such as Emirati national dress, national dishes (meat, rice), animals (camels, horses, falcons), plants (palm trees, mangrove), and sport activities (soccer, jiu jitsu) were completely absent. Undoubtedly, including uncommon or abstract settings at this age might distract the student from a supposedly simple question.

## **6. CONCLUDING REMARKS AND RECOMMENDATIONS**

In this paper, content analysis of the statistical content in the mathematics textbooks for Grades 1–4 is reported. In the analysis, statistical tasks were mapped to the constructs of the statistical thinking framework for children (Jones et al., 2015) and the various characteristics of the statistics content by grade were explored. The results of the study indicated that the statistics component in the textbooks represented less than 8% of the curriculum, which is significantly low compared to the share of statistics in international exams. Additionally, statistics topics were placed at the end of the curricula, which might not receive proper coverage especially when the amount of time available is limited. As noted by Jarrah (2020a), English Medium Teachers spend considerable time teaching English instead of mathematics and science, which likely affects the chance of covering all required topics. Regarding the level of the activities, the majority of tasks focused on representing, analyzing and interpreting data. Across grades, there is substantial redundancy in data displays, mainly bar and picture graphs, with no added value to higher levels of statistical thinking. Despite the modifications made in preparing the new textbooks, the Emirati culture is still absent, which hinders establishing the connection between learning statistics and daily experience of students.

Considering these results, we believe that the statistics content should be increased in textbooks used in MoE schools. The current statistics content could be aggregated in two or three grades while introducing basic analysis of quantitative data in Grade 3 or 4. Alternatively, the notion of chance and randomness could be introduced in Grade 4, which is globally acceptable (Leavy & Hourigan, 2019). Additionally, there is a need to raise the level of the tasks to develop higher levels of statistical thinking and reasoning. Although the notion of comparison between the categories was highlighted, there is a need to emphasize comparing groups using data displays such as bar and pie graphs. It is also recommended to incorporate some questions at all levels to address “reading beyond the data” through making inferences and predictions. As emphasized by Frischemeier (2020), statistics teachers can start building future statisticians at an early age in primary school. To ensure fair and proper coverage, statistics chapters should be placed in a reasonable location in the textbooks. Finally, promoting the presence of the Emirati culture and national identity should be a priority to the UAE educational decision-makers.

Undoubtedly, a new curriculum requires a new pedagogy and well-trained teachers to ensure better delivery of the content. As described earlier, preparing and training mathematics teachers and statisticians to teach statistics is a global challenge. The Arab world is no exception to this challenge (Elbehary, 2019b). Gallagher (2019) indicated that teacher education, in general, is a challenging enterprise while Zembat (2010) highlighted the gap between the current knowledge of the UAE mathematics teachers and the ideal level. Recently, Jarrah (2020b) found that difficulties transferring theoretical knowledge to practice is a major challenge facing pre-service mathematics teachers in the UAE. Pre-service mathematics teachers learn mathematics and statistics from courses delivered by the mathematics department and are generally taught by a mathematician who may not have a background in pedagogical knowledge. This creates a dichotomy between subject matter knowledge and pedagogy.

There is no doubt that content knowledge is necessary, but it is definitely not sufficient. The United Arab Emirates University (UAEU) is the major supplier of Emirati Early Childhood and Mathematics teachers. Surprisingly, the two mathematics for teachers courses included in the Early Childhood Program have no statistics content (UAEU, 2020a). Additionally, the mathematics program includes a probability course, while another applied course in probability and statistics is classified as an elective course. Consequently, neither generalist teachers nor subject teachers have much content knowledge in statistics. The same could be said about the English-speaking teachers who are coming from countries where statistics teacher preparation is a challenge. Similarly, this concern applies to teachers from Arab countries, which have very similar educational programs to the ones offered in UAE. The solution to this problem is two-fold. First, the UAE MoE should organize training workshops for existing mathematics teachers on how to teach statistics and develop students' thinking skills. Although the UAE MoE provides professional development opportunities to all in-service teachers, to the knowledge of the authors, training on statistics content knowledge and corresponding pedagogical knowledge is not available. Second, urgent reform of mathematics programs and professional teaching degrees is needed to ensure the proper preparation of future teachers to teach statistics the way it should be taught.

Teaching mathematics curriculum in English for native Arab students at early age is another factor that is likely to affect the students' learning of statistics. As noted by Ibrahim and Alhosani (2020), English is not the native language of Emirati students and is rarely used at home, which makes it challenging for the students to understand problems set within certain contexts. According to Jarrah (2020a) and Ibrahim and Alhosani (2020), English Medium Teachers have serious difficulties in explaining mathematics and science to students with varying levels of English proficiency, which forces them to spend time explaining the concepts and problems in simpler language. This leaves teachers with very limited time to focus on activities that develop critical thinking and creativity. This situation deserves more attention and evaluation from the educational decision-makers in UAE. Overall, the curriculum of statistics in Cycle 1 provides reasonable content to develop the statistical thinking of students conditional on the availability of well-trained statistics teachers and students with high English proficiency if the subject is taught in English.

The study reported in this paper is limited to the content of mathematics textbooks used in public schools and private schools teaching the MoE curricula. It would be worthwhile for an investigation to include the textbooks used by the private schools offering different curricula.

Finally, the other Arab countries share the UAE similar culture and ambition of building viable education system. Hence, our recommendations from this study, which aimed to promote the development of statistical thinking at the school level, are also applicable to other Arab countries.

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