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THE NECESSITY OF REVISING PRIMARY SCHOOL CONTENT OF PROBABILITY IN EGYPT TO ENHANCE STUDENTS' PROBABILISTIC REASONING

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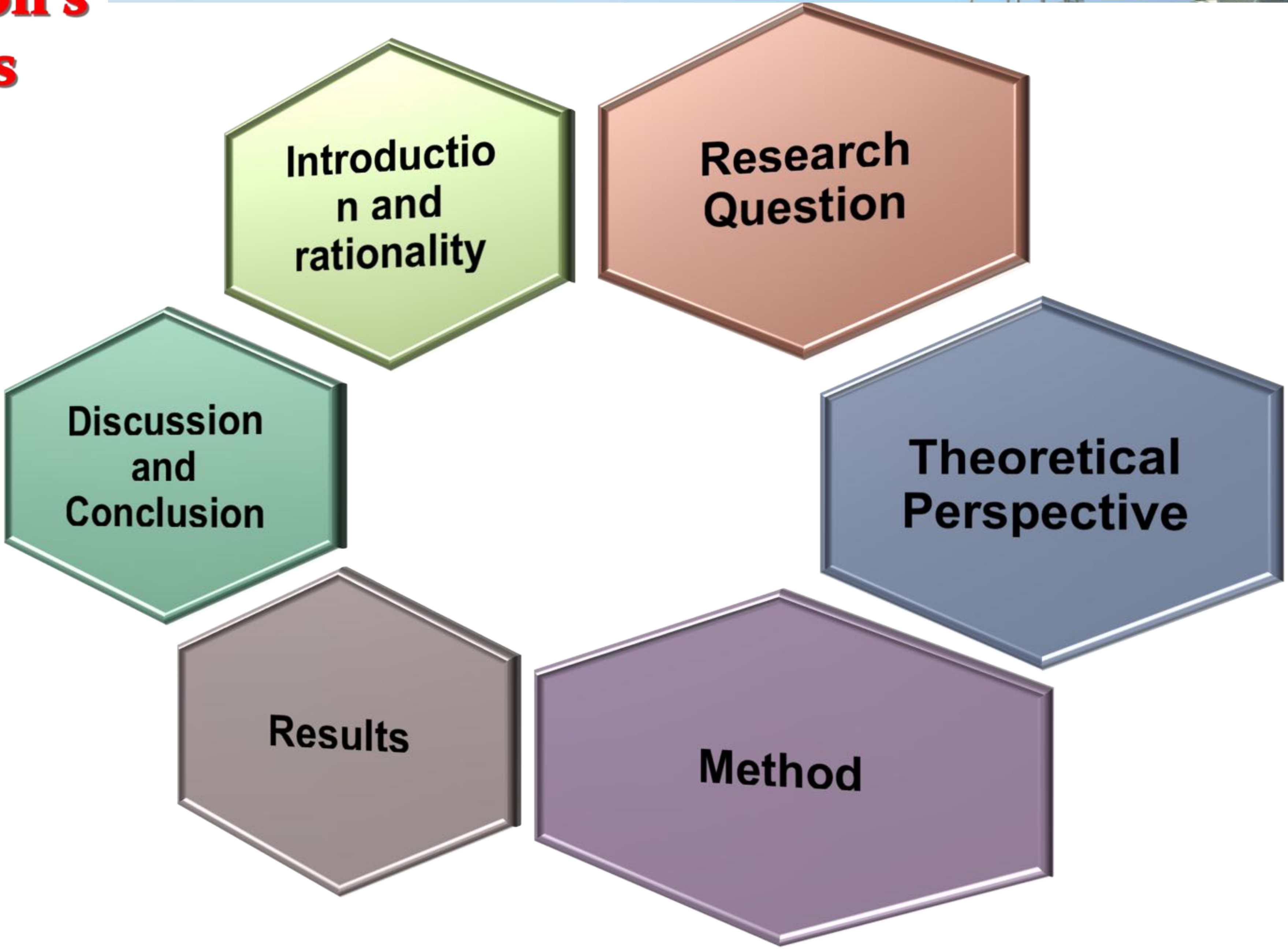
Presentation's Outlines



Introduction

- According to Hacking (1990), "the most decisive conceptual event of the twentieth century has been the discovery that the world is not deterministic".
- The term "**probabilistic revolution**" signals a shift from a deterministic conception of reality, phrased in terms of universal laws of stern necessity, to one in which probabilistic ideas have become central. Besides, viewing chance as an integral part of natural phenomena(Kruger, Daston & Heidelberger, 1987).

- Although, long discussion through mathematics education platform tends to focus on developing students' mathematical thinking that has deterministic and logical characteristics. **Enhancing students' probabilistic reasoning is the central concern in the case of probability education.**
- **Probabilistic reasoning** refers to make a decision under uncertainty whenever the randomness and variability are recognized (Falk and Konold, 1992; Savard, 2014). Hence, teaching probability seeks to **overcome students' deterministic**

- Many challenges in the area of probability education have been stated through literatures. While many researchers agrees on lack of teacher preparation to teach such content (Batanero, *et al.*, 2004; Pecky and Gould, 2005; Ainley and Monteiro, 2008). other aggravating factors relevant to the **school textbooks has been identified, for example:**

- It sometimes **presents a too narrow view of probability**, applications are mostly restricted to games of chance, and some of the stated definitions for the probabilistic concepts are incorrect (Batanero *et al.*, 2004 as cited in Chernoff and Sirirman, 2015).

- Batanero *et al.*, (2016) have stated; although, the probability content has been authorized in many different stages from primary to teacher education curriculum. Including a topic in the curriculum does not automatically assure its correct teaching and learning; the specific characteristics of probability, such as a multifaceted view, or the lack of reversibility of random experiments, are not usually found in other areas. this

- Moreover, **the connection among mathematics, statistics, and probability** has been identified as one challenge, which cause a difficulty for students to separate between the idea of chance and the deterministic reasoning that mostly employed in other

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❑ Rationale of the resea

- This aforementioned situation is crucial in the **context of developing countries, Egypt as well, wherein substantial importance is always assigned to address the textbook activities**. Particularly the case of statistics education as stated by Innabi (2014, p.3) "**Very little research on statistics has been conducted in the Arab world**". Moreover, the study identified the need to change the educational community perception towards understanding statistics and its importance. Therefore, paying attention to statistics research can be an endeavor to shed light on this area within the discussion of Mathematics education community.

How is the situation within the Egyptian context?

Source: http://english.ahram.org.eg/

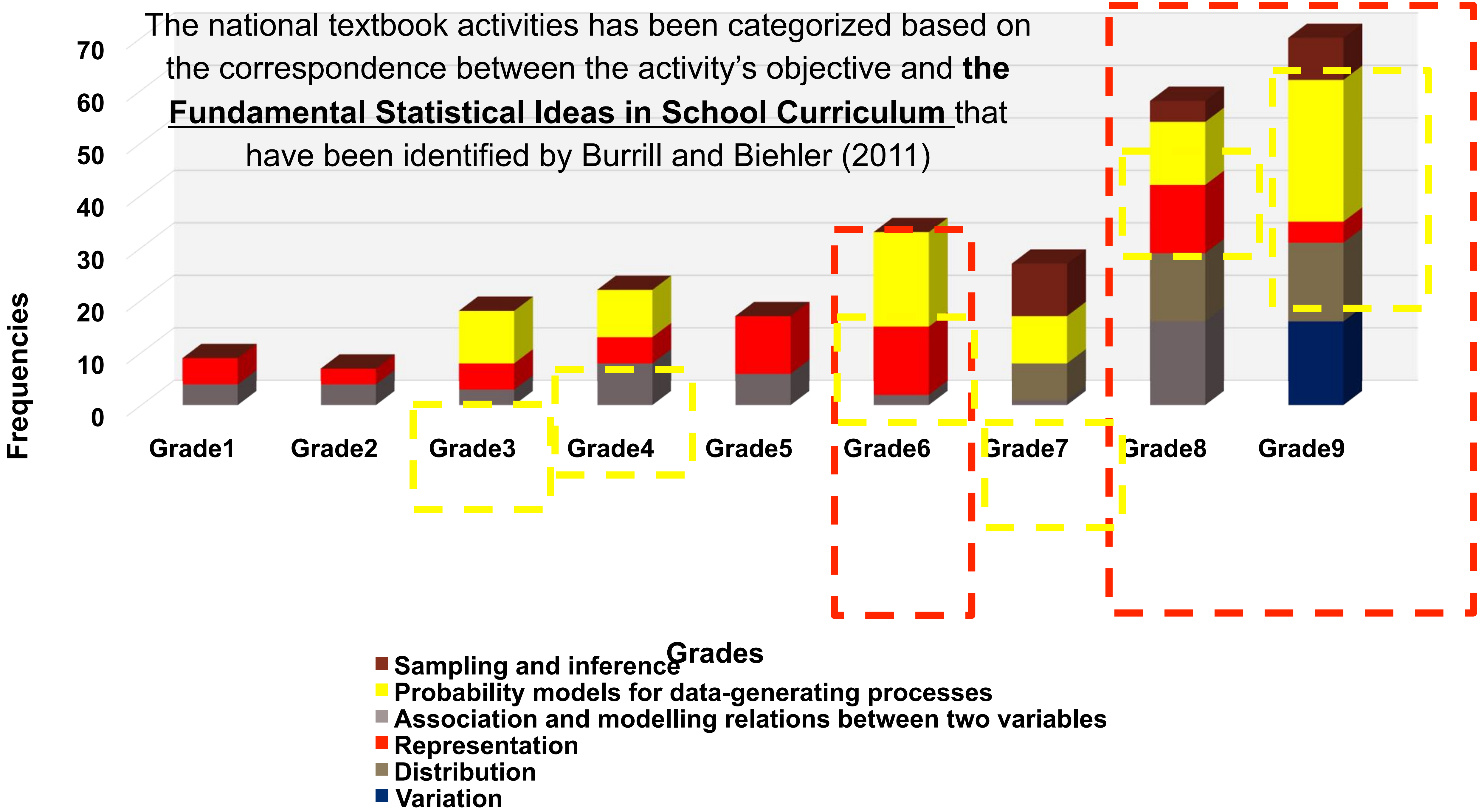


Figure 1. Distributing of the fundamental statistical ideas among elementary school grades

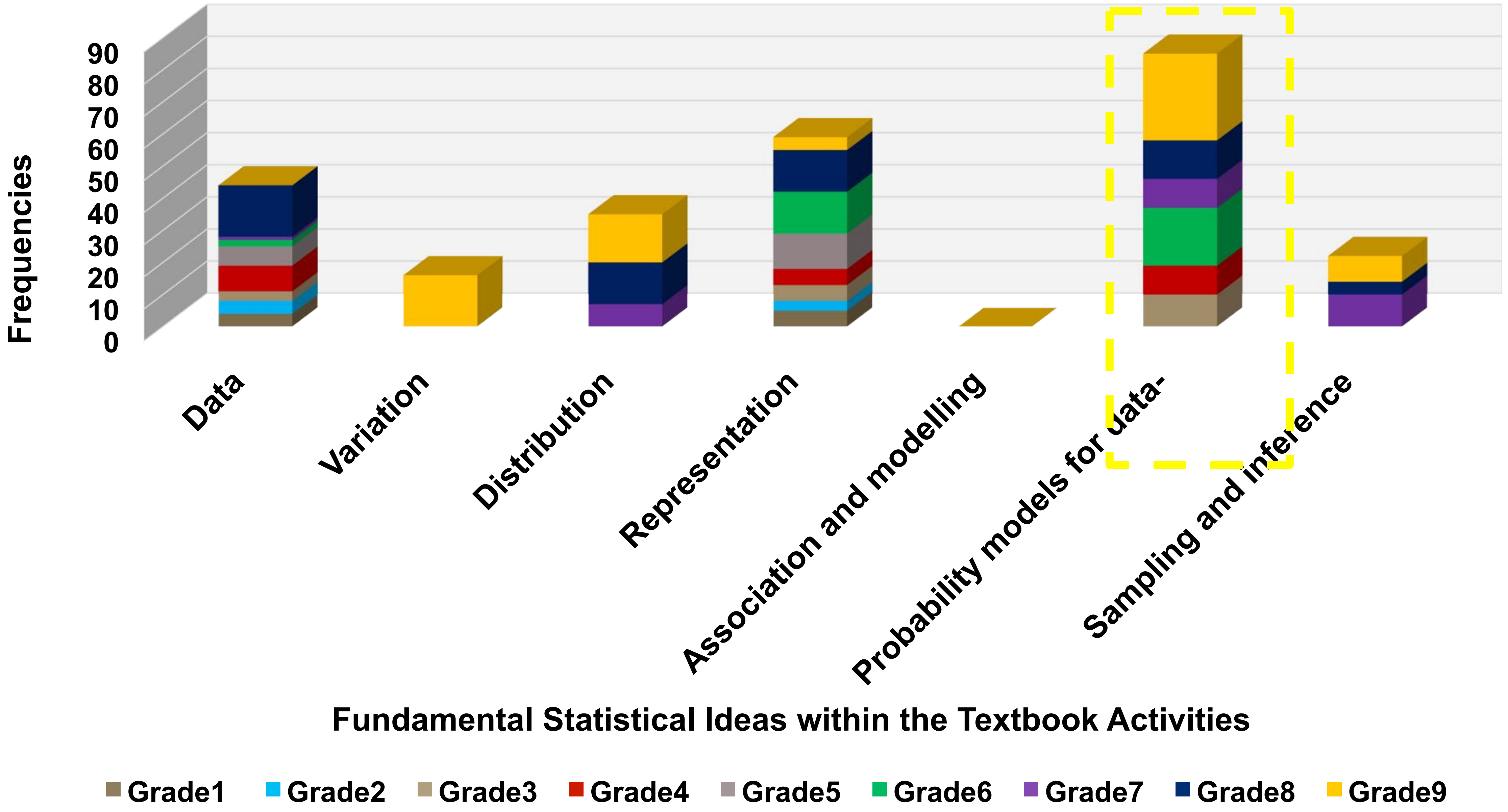


Figure 2. **D**istributing of the Egyptian textbook activities based on their objectives

CHAPTER 3: AVERAGE ACHIEVEMENT IN THE MATHEMATICS CONTENT AREAS

TIMSS2003

Exhibit 3.1: Average Achievement in Mathematics Content Areas

MATHEMATICS Grade 8

Countries	Average Scale Scores for Mathematics Content Areas				
	Number	Algebra	Measurement	Geometry	Data
Egypt	421 (3.0) ▼	408 (3.9) ▼	401 (3.3) ▼	408 (3.6) ▼	393 (3.2) ▼

CHAPTER 3: AVERAGE ACHIEVEMENT IN THE MATHEMATICS CONTENT AND COGNITIVE DOMAINS

Exhibit 3.1 Average Achievement in the Mathematics Content and Cognitive Domains (Continued)

TIMSS2007 Mathematics 8th Grade

Country	Average Scale Scores for Mathematics Content Domains				Average Scale Scores for Mathematics Cognitive Domains		
	Number	Algebra	Geometry	Data and Chance	Knowing	Applying	Reasoning
TIMSS Scale Avg.	500	500	500	500	500	500	500
Egypt	393 (3.1) ▼	409 (3.3) ▼	406 (3.4) ▼	384 (3.1) ▼	392 (3.6) ▼	393 (3.6) ▼	396 (3.4) ▼

Figure3. Grade 8 Egyptian students' achievement in TIMSS 2003 and 2007

Source: https://timss.bc.edu/timss2003i/mathD.html ; https://timss.bc.edu/TIMSS2007/mathreport.html

Textbooks have an important role due to their great influence on the process of teaching and learning (Levicoy, 2014). Further, Robitaille and Travers (1992, p. 706, as cited in Levicoy *et al.*, 2018) cite textbooks as a **"significant factor in determining students' opportunity to learn and their achievement, facilitating the transfer of educative contents in the function of the current curricula guidelines, and constituting a mean to**

❑ Research question

Therefore, it is important to reflect on the textbooks' discourse for identifying the possible opportunities given to students to enhance their probabilistic reasoning. Consequently, preparing them to face daily life situations that contain uncertainty.

From this perspective, the current study aims at **analyzing the probability content as a part of the primary school mathematics curriculum to interpret its function in enhancing students' probabilistic reasoning.**

To what extent does primary school content of probability in Egypt provide opportunities to enhance students' probabilistic reasoning?

❑ Theoretical Perspecti

Probability was conceived from two different perspectives. (1) **A statistical side of probability which is related to the objective mathematical rules that govern random processes.** Complementary to this vision, (2) **An epistemic side views probability as a personal degree of belief, which depends on the information available to the person assigning a probability** (Hacking, 1975). Those two perspectives have been reflected in the works of many authors. Recently, **Batanero *et al.*, (2016) have summarized the main interpretations** of probability

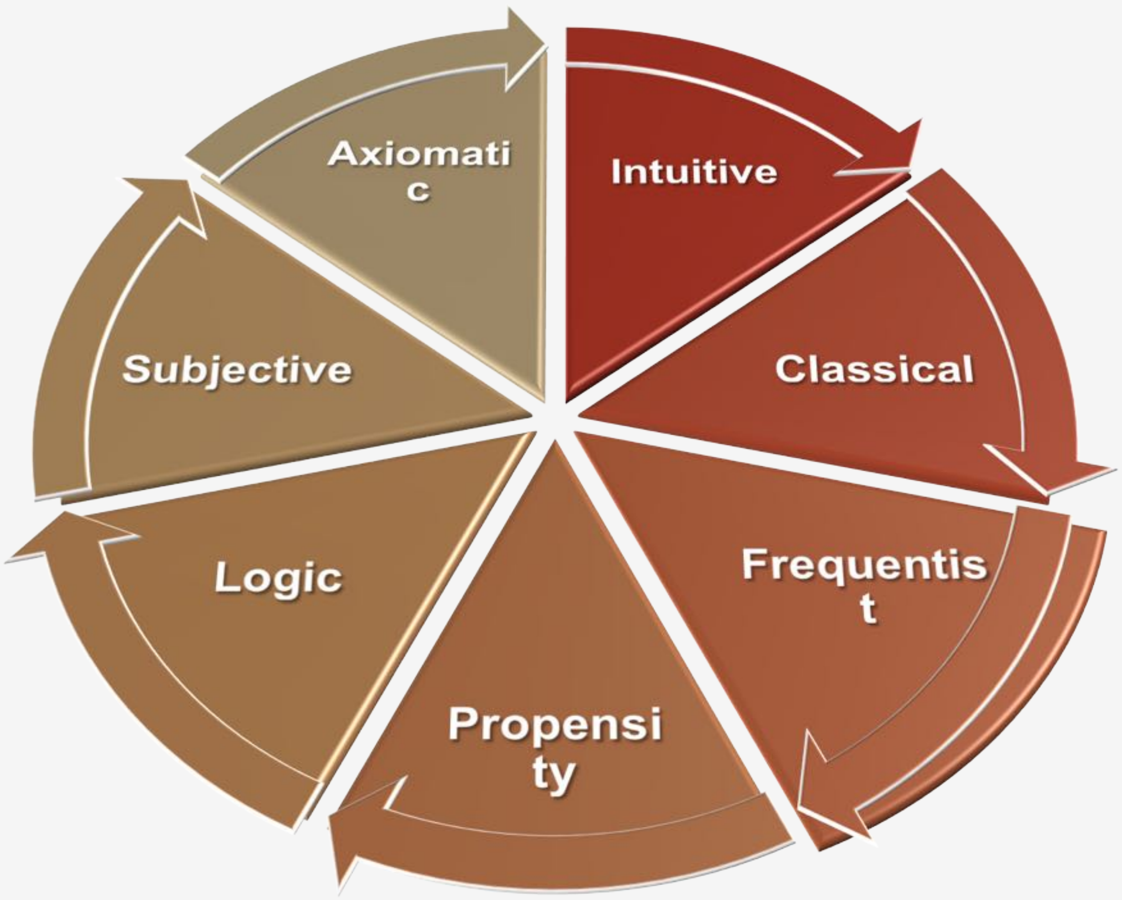
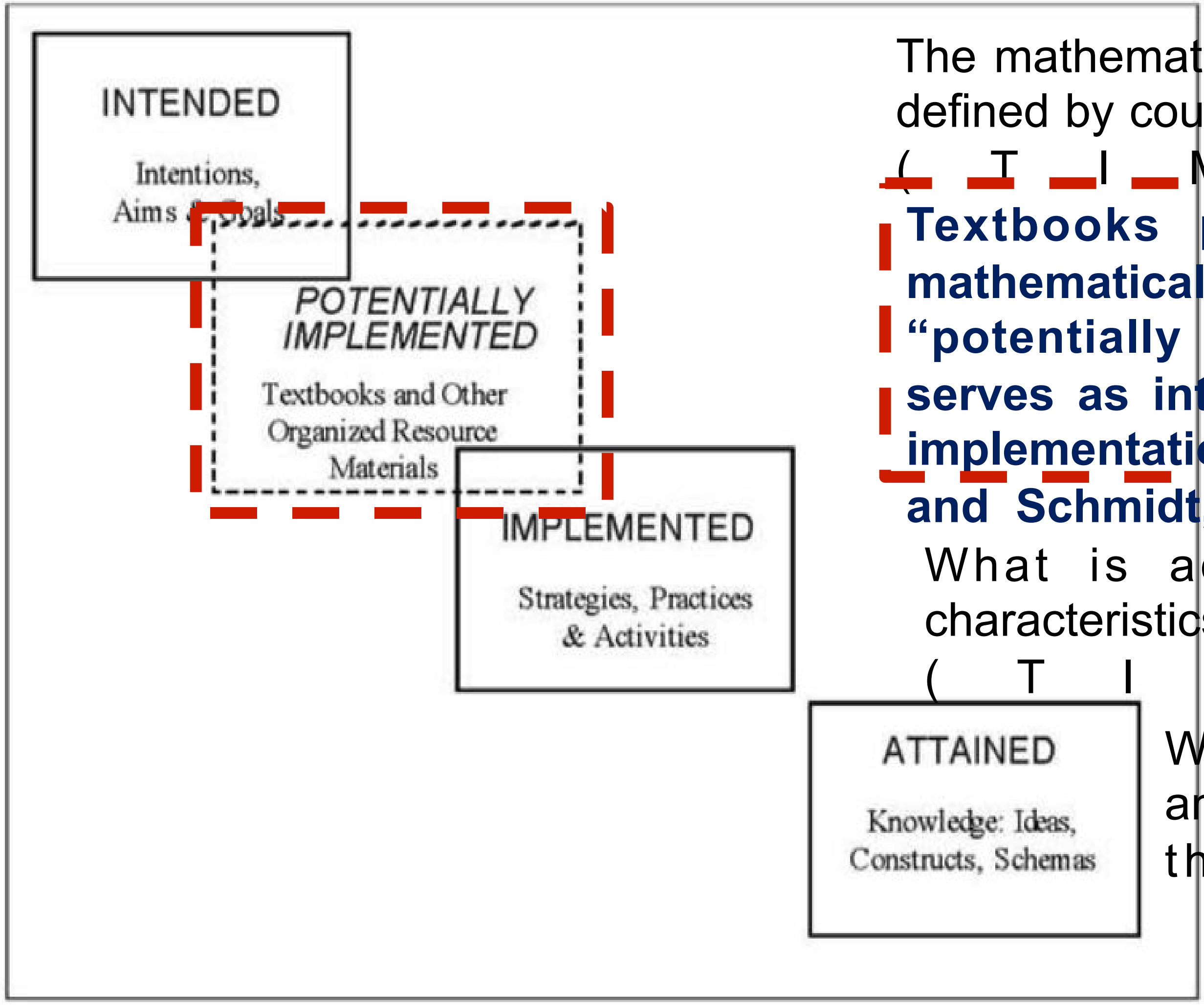


Figure 4 the main interpretation of probability

Source: **Batanero *et al.*, (2016)**

❑ Method

According to TIMSS, Curriculum has been defined through Tri-Partite Model



The mathematics that students are expected to learn as defined by countries' curriculum policies and publications (TIMSS, 2019)

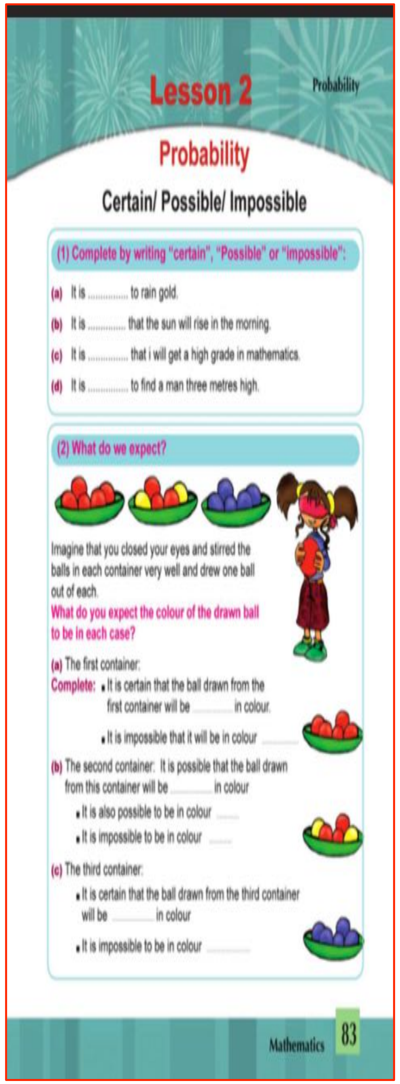
Textbooks provide a more detailed map of mathematical domains and topics. They are the "potentially implementable" curriculum, which serves as intermediaries in turning intentions into implementations ((Schmidt *et al.,* 1997b; Houang and Schmidt, 2008)

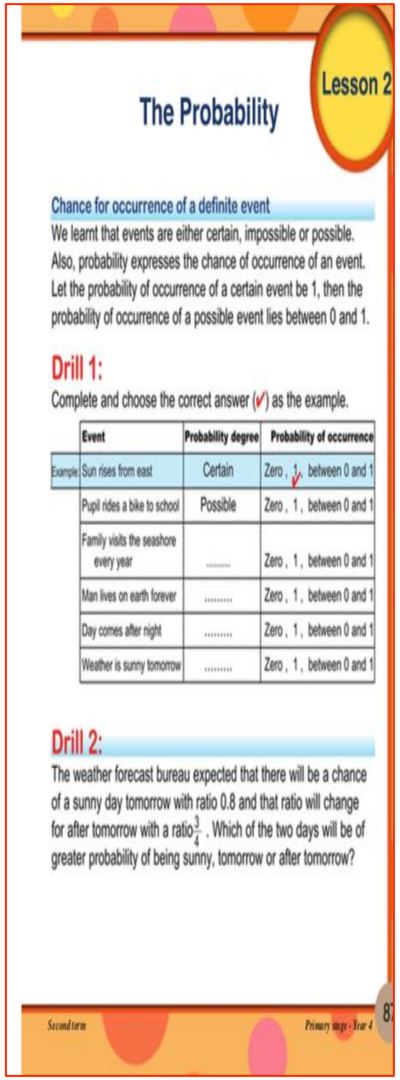
What is actually taught in classrooms, the characteristics of those teaching it, and how it is taught (TIMSS, 2019)

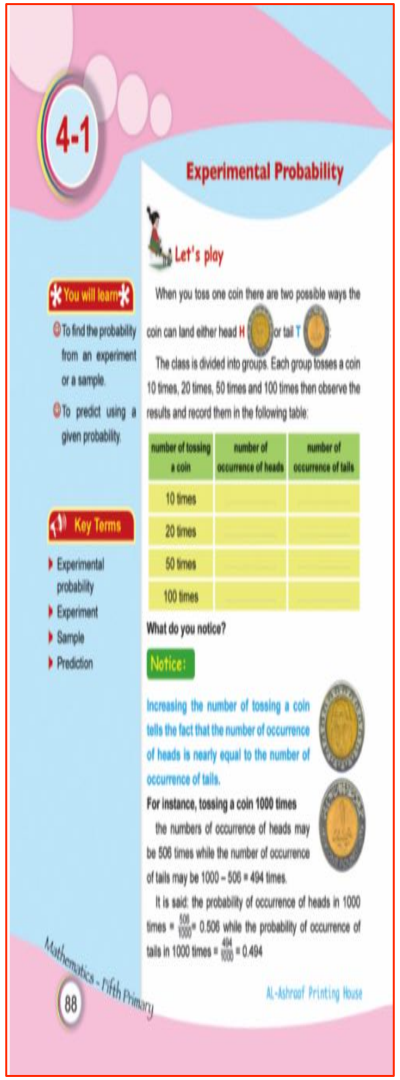
What it is that students have learned and what they think about learning these subjects (TIMSS, 2019)

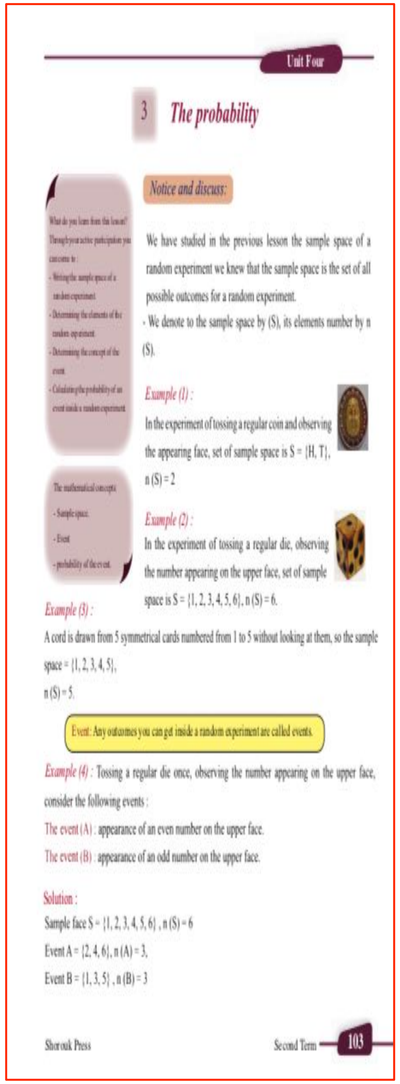
Figure 5. Textbooks, the Potentially Implementable Curriculum.
Source: Schmidt et al., (1997b)

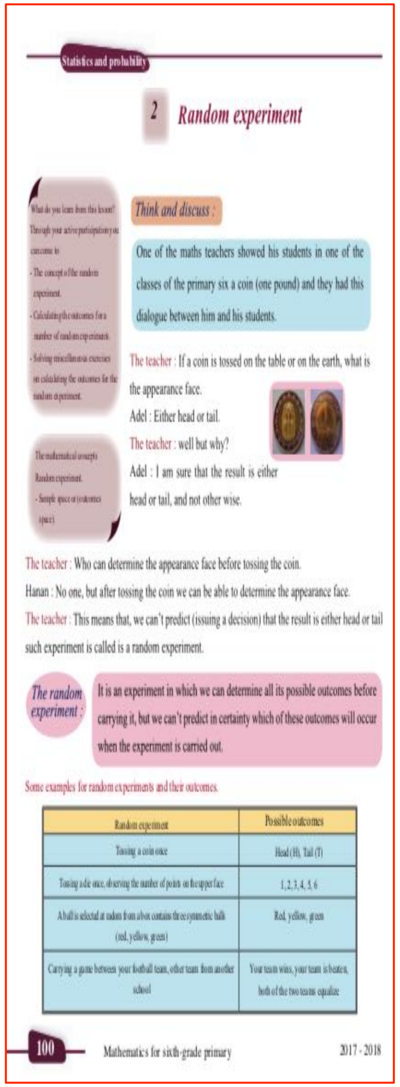
1. Determine primary school content of probability











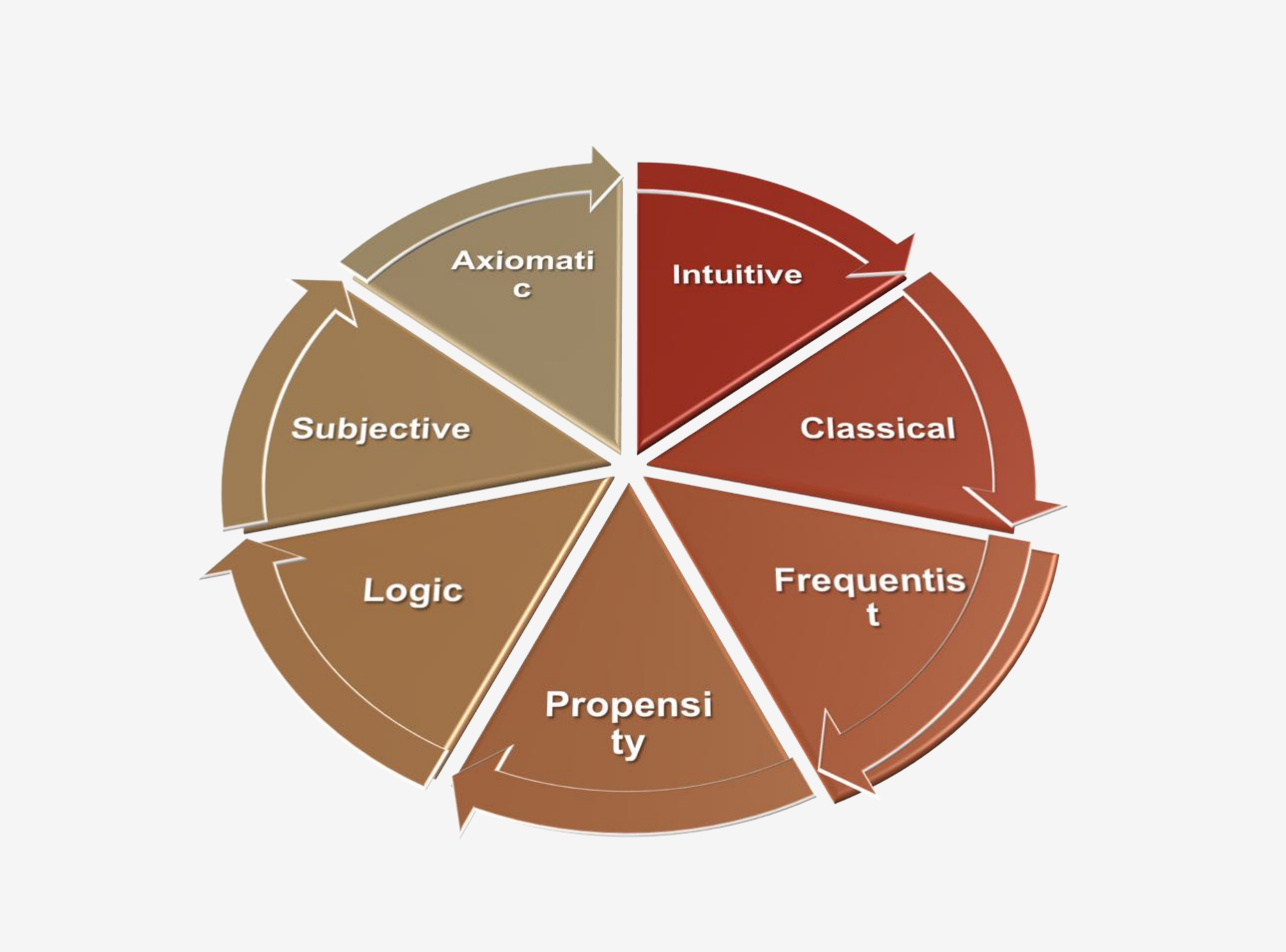
Source: http://elearning1.moe.gov.eg/

2. to analyze textbooks' content of probability, **Onto-Semiotic Approach (OSA)** which is a semiotic and anthropological approach to deal with the meaning of mathematical objects in a personal and in an institutional level, has been employed to identify its primary entities. According to OSA, the primary entities of probability have defined by situations, propositions, procedures, and language (Godino, 2003; Gómez and Contreras, 2014)

Table 1. operational definition of OSA entities

Situation	Propositions	Procedures	Language
What are the probabilistic activities, tasks that has been discussed within the lesson discourse?	What are the properties, theories, relationships that connect the concepts to each other?	What are the suitable algorithms, techniques that can be applied to perform a given situation?	What are the terms, expressions, notations that has been embedded within the lesson discourse to operate a given situation?
e.g., tossing a coin	e.g., relationship between the event and the sample space	e.g., P (H) = n (H)/ n (S)	e.g., H, T, P (A), fairness, randomness

3. Categorizing the deducted primary entities of probability through probability main interpretations (Batanero et al., 2016)



❑ Results

Table 2. Primarily identifies entities of probability content within the school textbook relevant to the **Intuitive Meaning**

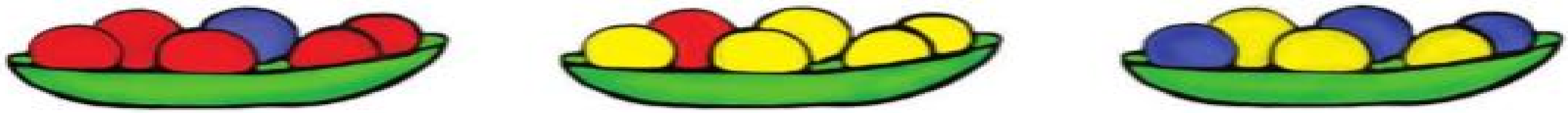
Situations	Propositions	Procedures	Term and embedded concepts
- **Use students' daily life context to grasp certain, possible, and impossible events (3rd G)** - **Discuss the meaning of great and moderate probability (3rd G)** - **Handle students' personal judgments to determine the degree of probability (4th G)**	- Relationship between possible, impossible, certain events and personal expectations (3rd G) - Relationship between types of events and its probability (3rd, 4th G)		- Guess, expect, and predict (3rd: 6th G) - Great, moderate, less, weak and none (3rd : 6th G) - Certain, possible, and impossible event (3rd , 6th G) - Defective Vs functional (5th G) - Success Vs failure (5th G)

Intuitive meaning

Probability is an encapsulation of intuitive views of chance which leads to idea of assigning numbers to uncertain events. Therefore, in that view we use qualitative expressions (e.g., probable and unlikely) to express the degrees of belief in the occurrence of random events.

Guess and expect :

(1) Assume (as we did previously) that someone closed his eyes and stirred the balls in every container very well and then drew one ball from each container. Can you decide the number of the container from which:



(1) (2) (3)

You expect to great extent that the drawn ball will be:

(a) red (container number ....)

(b) yellow (container number ....)

(c) Blue (container number ....)

You expect to a less extent that the drawn ball will be:

(d) blue (container number ....)

(e) red (container number ....)

Table 3. Primarily identifies entities of probability content within the school textbook relevant to the

Classical Meaning

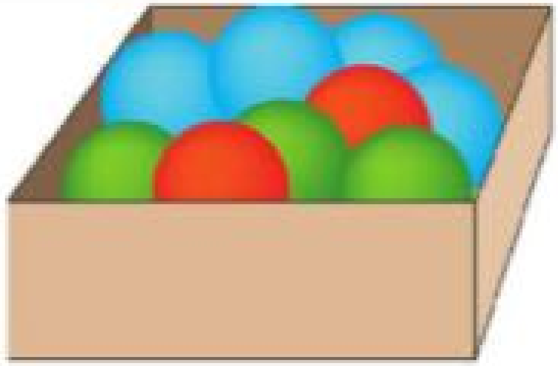
Situations	Propositions	Procedures	Term and embedded concepts
- Introduce and discuss the theoretical meaning of probability P (A) through some random experiments (e.g., tossing a coin, rolling a dice) (4th : 6th G) - Discuss the sample space and assigned probability of some events (5th G). - Explain the meaning of the random experiment (6th G). - Identify the	- Tossing two coins/ dice once is equivalent to tossing one coin/dice two consecutive times (6th G). - Relationship between the sample space and event (A ⊂ S) (6th G). - Relationship between the type of an event and its probability (e.g., if A = ϕ, then n (A)= 0. So, P (A) = 0/n (S) =1; P (S)=1) (6th G). - The probability can be written as a	- Apply the theoretical probability law, P(A) = number of favorable outcomes n (A) / all possible outcomes n (S) (3rd: 6th G) - Determine the probability of impossible, possible, and certain events (3rd G) - Compare among decimals, fractions and percentages (4th, 6th G) - Determine elements of the sample space for one and two stages random experiment (4th: 6th G)	- Assume that (3rd G) - Fair coin, H, T, HH, TT (3rd: 6th G) - Equally likely, Same color, symmetric, identical (4th: 6th G) - Ratios, decimals, and percentages (4th G) - All possible outcomes (4th: 6th G) - Odd, even, prime, divisible by, greater or smaller than or between, and 2-digit number (3rd: 6th G) - Sample space (S) (5th, 6th G) - Theoretical probability (5th, 6th G) - Random experiment (6th G) - Tree diagram (6th G). - S, n (A), n (S), %, ?, P (A), P (?), P (S) (6th G) - inequality P > (6th G)

Classical/ theoretical meaning

Probability is a fraction of the number of favorable cases to a particular event divided by the number of all cases possible under the assumption that all possible events are equiprobable

Drill 5:

A box contains 4 blue balls, 2 red balls, and 3 green balls, all equal in size. If a ball is drawn blindly, complete.



a Probability of drawing a blue ball = $\frac{4}{\dots}$

b Probability of drawing a red ball = $\frac{\dots}{9}$

c Probability of drawing a green ball = $\frac{\dots}{\dots}$

d Probability of drawing a non-blue ball = $1 - \frac{\dots}{\dots}$ = ...

e Probability of drawing a non-red ball = $1 - \frac{\dots}{\dots}$ = ...

Table 4. Primarily identifies entities of probability content within the school textbook relevant to the **Frequentist Meaning**

Situations	Propositions	Procedures	Term and embedded concepts
- Doing a simple random experiment of tossing a coin 10, 20, 50, 100 times (5th G) - Proposing a survey to ask students about preferred sport and language (5th G) - Predicting the favorable cases through knowing the probability of a small sample (5th G) - Inference into the probability	- Relationship between experimental and theoretical probability (e.g., expecting the number of times to get even number when rolling a number cube 250 times) (5th G)	- Applying the experimental probability law (number of outcomes / number of trails) (5th G) - Calculate the expected times of occurrence by knowing the probability of previous trails (5th	- Tossing a regular coin (5th G) - Survey (5th G) - Sample (5th G) - Experimental probability (5th G) - Favorable breakfast, preferred language, and favorite game (5th G)

Frequentist/ experimental meaning

Probability is the hypothetical number towards which the relative frequency tends when a random experiment is repeated infinitely many times (empirical tendency).

Example

The opposite table shows the result of a survey of asking 40 students about their favorite breakfast.

What is the probability of choosing foul and tamaya?

What is the probability of choosing pies?

What is the probability of choosing cheese and dessert?

If the number of student is 400 students. How can you predict about the number of students choosing foul and tamaya?

Breakfast	
Foul and tamayia	20
Pie	4
Cheese and dessert	16

Table 5. Primarily identifies entities of probability content within the school textbook relevant to the

Axiomatic Meaning

Situations	Propositions	Procedures	Term and embedded concepts
- **Discuss the relationships among all possibilities of some random experiments** (4th: 6th G)	- For A ⊂ S, 0 ≤ p (A) ≤ 1) (4th: 6th G) - the sum of probabilities for all possible events = 1 (4th G) - Relationship between the probability of an event and its complementary (e.g., success vs failure, defective vs functional) (4th, 5th G)	- Calculate the probability of a complementary event (4th G) - Calculate the probability of event A union B (4th, 5th G)	- Subset (5th G) - A or B (A ∪ B) (5th G)

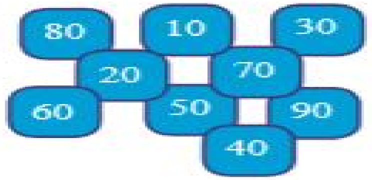
A x i o m a t i c s m e a n i n g

Probability is any function defined from A in the interval of real numbers [0,1] that fulfils the following three axioms: 1. $0 \le P(a) \le 1$, for every $a \in A$; $P(S) = 1$

(a) For a finite sample space S and incompatible or disjoint events A and B, i.e., $A \cap B = \varnothing$, it holds that $P(A \cup B) = P(A) + P(B)$. (b) For an infinite sample space S and a countable collection of pairwise disjoint sets A_i, i = 1,2, ... it holds P

Example (5) :

A box contains 9 symmetric cards each carries a number from the numbers (10 to 90) they are mixed well, then one card is selected at random find the probability of the following events.



1 - The event A, where A is a number that is divisible by 5.

2 - The event B, where B is a number that is divisible by 3.

3 - The event C where C is an odd number.

Solution :

Samplespace is S = {10 , 20 , 30 , 40 , 50 , 60 , 70 , 80 , 90} , n (S) = 9.

- The event A = {10 , 20 , 30 , 40 , 50 , 60 , 70 , 80 , 90} et n (A) = 9

, then $P(A) = \frac{\text{number of elements of the event (A)}}{\text{number of elements of the event (S)}}$

$= \frac{n(A)}{n(S)} = \frac{9}{9} = 1$ (certain event)

- The event B = {30 , 60 , 90} ⊂ S, n (B) = 3

The $P(B) = \frac{\text{number of elements of B}}{\text{number of elements of S}}$

$\frac{3}{9} = \frac{1}{3} = 0.33 = 33\%$

- The event C = φ (Impossible event) then n (C) = 0

Then $P(C) = \frac{n(C)}{n(S)} = \frac{0}{9} = 0$

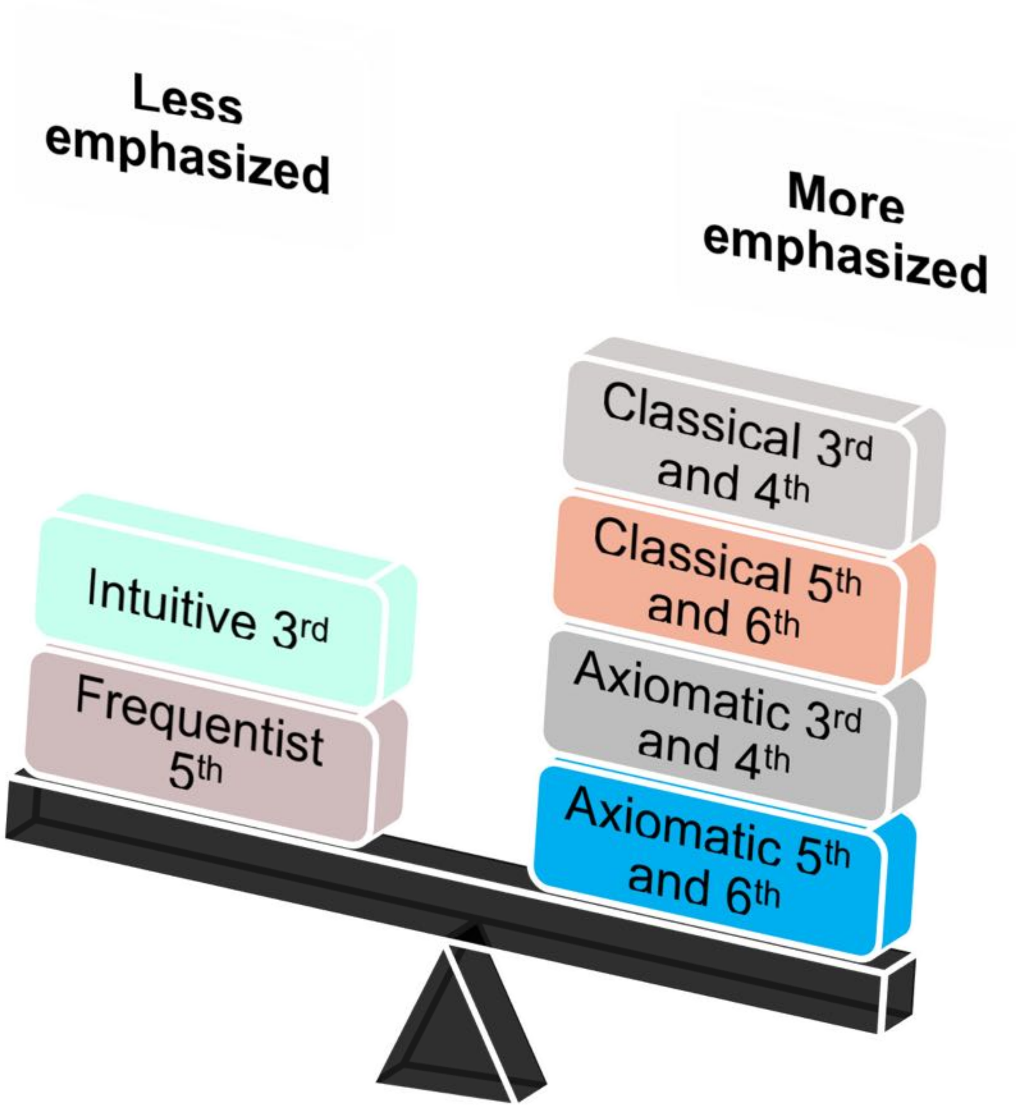
In a box, there are 5 red balls, 3 blue balls and 7 green balls, equal in size. A ball is drawn blindly. Answer the following questions.

a what is the probability that the drawn ball is blue?

b What is the probability that the drawn ball is green?

c What is the probability that the drawn ball is not red?

❑ Discussion and Conclusion



- Using Hacking's explanation to look into the revealed results wherein four interpretations of probability have been discussed through the national textbook **(intuitive, classical, experimental, and axiomatic).** it's clear that most of the textbook's arguments have considered only **the statistical side of probability through emphasizing the mathematical rules.**

- **<u>the subjective meaning</u>** that defines probability as a personal degree of belief and can be updated with new information through Bayes theorem (Batanero, 2005 as cited in Gómez and Miguel, 2014) hasn't been approached and seems to be ignored

- This ignorance can affect **students' probabilistic reasoning**. Wherein in the multi-structural and rational level of probabilistic reasoning, students should recognize the **conditional probability** (Mooney *et al.*, 2014) which is considered a prerequisite for learning the **subjectivist meaning** of probability (Jones *et*

Table 6. key components of prominent probability frameworks (adapted from Mooney et al., (2016)

Study	Probabilistic concepts	Sample	Organization of cognitive levels
Jones et al. (1997)	? Sample space ? Probability of an even ? Probability comparisons ? Conditional probability ? Independence	Grades 3 students in U.S.	Subjective Transitional Informal quantitative Numerical
Tarr and Jones (1997)	? Conditional probability ? Independence	Grades 4-8 students in U.S.	
Watson et al. (1997)	? Chance measurements (simple events, likelihood, comparison of events)	Grades 3,6,9 students in Australia	Ikonic Unistructural (U) Multistructural (M) Relational (R)
Watson and Moritz (2003)	? Fairness	Grades 3,5,6,7,9 students in	

- **Conditional probability reasoning** is a crucial part of statistical literacy, since it helps making accurate decisions or inferences in everyday life (Batanero and Diaz, 2008). Further, Conditional probability and Bayes' theorem are important ingredients of probability and should not be left out of any standard course in probability. The concepts stand at the "border" between the two different theories of probability (White and Guyot, 2018).
- Lack of discussing the **experimental meaning**. Performing probability experiments encourages pupils to develop understandings of probability grounded in real events, as opposed to merely computing answers based on formulae (Andrew, 2009 as cited in Tsakiridou and Vavyla, 2015). As Konold (1995) stated, when teaching probability predominantly uses a theoretic approach rather than a frequentist one, pupils often develop conceptions about probability
- There is **no connection between the four stated interpretations of probability**. For example. In 3rd grade, the textbook discourse doesn't clarify the relationship between one's personal expectation of an event and how to quantify this expectation using theoretical probability.
- **the necessary conditions** for implementing each interpretation of probability has not been treated.

❑ In conclusion

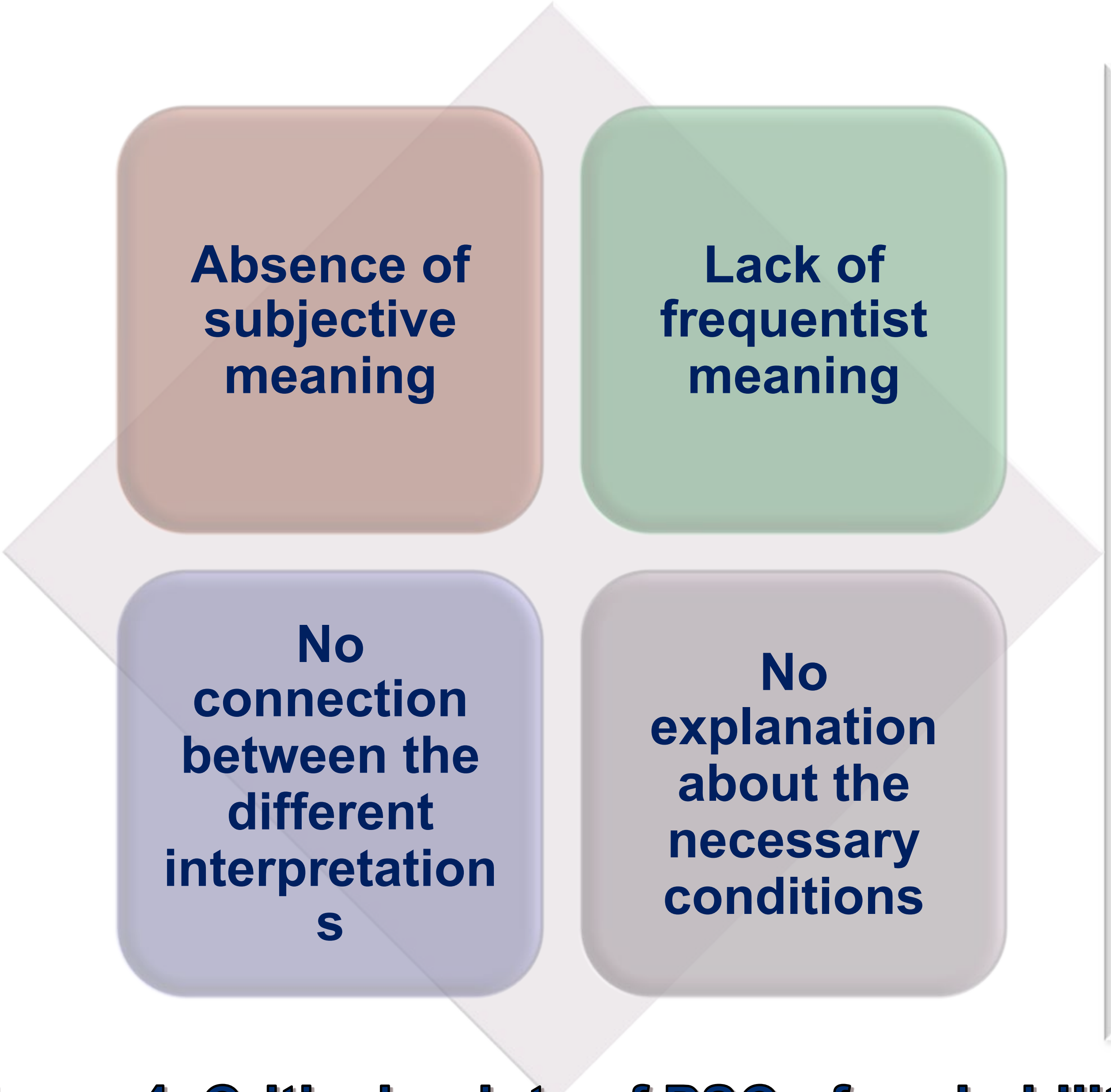


Figure 4. Critical points of PSC of probability

- This study consider an endeavor to shed light on statistics education research (probability in the current study) in the Arabian community. Furthermore, it can also give insights into the context of teacher education as Stylianides and Ball (2004) has declared understanding the content that policymakers recommend students given the opportunity to learn considers one possible approach for discussing teachers' knowledge. Consequently, deducting what teachers would need to know to successfully enact these opportunities in their classrooms.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谢谢
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