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A Study of the Coherence of the Lebanese Math Curriculum at the Intermediate Level

By

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Dedication Page

To my loving parents

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A Study of the Coherence of the Lebanese Math Curriculum at the Intermediate Level

Diana Shatila

Abstract

Curriculum coherence is defined in the literature as the alignment among the three different aspects of the curriculum: the intended, the implemented, and the attained. The aim of this study was to the investigate the alignment of the general objectives of the Lebanese math curriculum (GOMC) with each of: the objectives of the math curriculum at the intermediate level (OMCI), the specific objectives of each of the grade levels in the intermediate level (SOGLI), the national math textbooks (NMT) at each of the latter grade levels, and the official Brevet tests (BT). Various instruments were used to study the latter purpose. Research based criteria were developed for each of GOMC (except for the fifth objective: Valuing mathematics) as basis for evaluating the alignment of the NMT and the BT with the general objectives. The results of the criterion-based evaluation of the tests were used to check the evolution of the official exams throughout the year 2001 till 2013. Moreover, it was used to show whether sessions 1 and 2 BT differ in their degree of alignment with the GOMC. The results showed that the OMCI are aligned with the GOMC. On the other hand, the SOGLI completely neglect the four GOMC, and the three grade level textbooks vary in the their level of alignment with the GOMC; with the grade 9 textbook being the least reflective of the GOMC and the grade 8 textbook being the most reflective (in comparison to the other two textbooks). As for the BT, the results show that throughout the years, the tests are becoming more reflective of the GOMC. However, even in the latest years, two out of the four general objectives are completely neglected. The findings of the study highlighted the importance of revising the Lebanese math curriculum, its textbooks, and assessment tools in terms of their alignment with the general objectives.

Keywords*:* National Curriculum, National Assessment, Math Textbooks, Alignment, Mathematics, Middle School Education, Lebanon

TABLE OF CONTENTS

List of Tables

List of Figures

Glossary of Terms

BT	Brevet Test
GOMC	General Objective of the Math Curriculum
NMT	National Math Textbook
OMCI	Objectives of the Math Curriculum at the Intermediate Level
SOGLI	Specific Objectives at Each Grade Level
TIMSS	Trends in International Mathematics and Science Study

CHAPTER ONE

Introduction

1.1- An Overview of the Role of Curriculum in Education

In educational systems, the curriculum brings order to schooling; it plays an important role in defining and sequencing opportunities for students' learning. The curriculum is "a kind of underlying 'skeleton' that gives characteristic, shape, and direction to instruction in educational systems around the world" (Houang & Schmidt, 2008, p. 2). There are three aspects of curriculum each of which provides a different representation of it: (1) The intended curriculum – guidelines of what students should study and learn, (2) the implemented curriculum – what is actually being taught inside the classroom, and (3) the attained curriculum – the knowledge and skills that students can demonstrate (Mullis et al., 2005). Conformity and balance among the three aspects of curriculum constitute one dimension of the curriculum alignment (La Marca et al.,2000).

Many research works have been conducted on the importance of curriculum alignment. Curriculum alignment is important for (1) the effectiveness of an educational system (Webb 1997), (2) the identification of what students have learned as a result of their schooling (Anderson 2002), (3) the evaluation of educational reforms and frameworks (Herman, Webb, & Zungia, 2007), and (4) the quality of performance of students in national and international tests (Schmidt et al., 2005).

In this paper, the case of the Lebanese intermediate math curriculum will be studied to investigate the alignment of the curriculum.

1.2- An Overview of the Lebanese Intermediate Level Curricula

In the case of Lebanon, the Ministry of Education imposes on schools a unified curriculum plan that is developed by the ECRD (Educational Center for Research and Development). In addition to the centralized curriculum plan, ECRD developed national textbooks for all grade levels. Usually all public schools in Lebanon abide by the national curriculum and textbooks, whereas private schools add to the national curriculum by either adopting other additional curricula, using different textbooks, or implementing different approaches to teaching and learning.

Since Lebanon's independence in 1943, only one attempt for curriculum evaluation and development was seen starting 1997. After the reform that started in 1997, the structure of the educational ladder was modified. It now consists of two stages: the Basic Education and the Secondary Education. The Basic Education consists of three cycles: the First Cycle consists of grades 1, 2, and 3 in the Elementary Level, the Second Cycle consists of grades 4, 5, and 6 also at the Elementary Level, and the Third Cycle consists of grades 7, 8 and 9 at Intermediate Level. At the end of this cycle (grade 9) students should pass the nation-wide examination (Brevet), also referred to as the official exam, to be eligible to enroll in the Secondary Education. There are sessions 1 and sessions 2 of the Brevet tests. If the students missed or failed session 1 or wish to repeat session 1, they have the chance to do session 2. The Secondary Education forms the last cycle of the Lebanese Education ladder. It consists of grades 10, 11, and 12. Also at the end of grade 12, students have to sit again for national examination, and only students who pass the exams will be eligible to pursue their studies at the university level.

The reformed curriculum was first implemented in the academic year 1998 – 1999 for the first grade level of each cycle (1st, 4th, 7th, and 10th grade levels), afterwards it was implemented in the academic year 1999 – 2000 for the second grade level of each cycle (2nd, 5th, 8th, and 11th grade levels), finally it was implemented in the academic year 2000 - 2001 for the third grade level of each cycle (3rd, 6th, 9th, 12th grade levels). In June of the latter academic year, grade 9 and grade 12 students took the official exam for the first time based of the newly applied curriculum.

This study will refer to the official math curriculum document (ECRD,1997) that includes the following components for all cycles:

- Introduction, reflecting the philosophical and pedagogical foundations of the curriculum
- General objectives (for each cycle)
- Specific objectives (for each cycle)
- Scope and sequence of topics to be taught (at each cycle and grade level)

Moreover, the study will also refer to the "details of content" for mathematics. The "details of contents" are texts found in three in different books that include that content and the specific objectives of mathematics at each grade level. The books are designed as follows:

- Book 1: it shows the details of contents of grades 1, 4, 7, and 10 which are the grade levels that represent the 1st year of each cycle.
- Book 2: it shows the details of contents of grades 2, 5, 8, and 11 which are

the grade levels that represent the 2nd year of each cycle.

- Book 3: it shows the details of contents of grades 3, 6, 9, and 12 which are the grade levels that represent the 3rd year of each cycle.

1.3- Problem

An educational program is commonly considered to be successful if students enrolled in this program perform well on national and international tests. TIMSS, Trends in International Mathematics and Science Study, is one well-known study conducted at the international level, where a test is administered to a sample of grade 4 and grade 8 students from various countries around the world. Lebanon participated in TIMSS with eighth graders from different types of schools for three times so far, in the years 2003, 2007, and 2011. In 2003, forty-five countries participated, among which eight Arab countries. In 2007, forty-eight countries participated, among which twelve Arab countries. In 2011, forty-two countries participated, among which twelve Arab countries.

Data about TIMSS 2003, 2007 and 2011 extracted respectively from the International Association for the Evaluation of Educational Achievement (Gonzales et al., 2004, 2009) show the following results with respect to Lebanon:

- The average performance of Lebanon improved from year 2003 to 2007 (from average score of 433 to average score of 449). (Gonzales et al., 2004, 2009). However, in 2011, Lebanon didn’t show any further improvement; its average score was 449.
- Lebanon scored the highest among the Arab countries in the years 2003 and 2007, and the second highest after United Arab Emirates in the year 2011. However, among all participating countries, Lebanon

ranked 31 (out of 45), 28 (out of 48), and 25 (out of 43) in years 2003, 2007, and 2011 respectively.

- Lebanon scored below the average score (500) in all years. In year 2003, Lebanon scored 57 points less than average, while in years 2007 and 2011; Lebanon scored 51 points less than average.
- TIMSS attributes scores for both, contents (number, algebra, and geometry) and cognitive domains (knowing, applying, and reasoning). In terms of Lebanon's score on the cognitive domains, in year 2007, Lebanon's score in the reasoning domain was the lowest (average score of 429 points). The highest score that Lebanon got on a cognitive domain was in the knowing domain (average score of 464 points).

1.3.1- Reflection on the Data from TIMSS 2003 and 2007:

Although Lebanon ranked the highest compared to Arab countries and its performance improved from year 2003 to year 2007, its average score is still below the international test average score. Moreover, since Lebanon's sub-score on the reasoning domain was the least and on the knowing domain was the highest, this may imply that the Lebanese math curriculum focuses on knowledge more than application and reasoning. However, based on the Lebanese national curriculum document issued by the ECRD, the math curriculum has five general objectives: developing mathematical reasoning, solving mathematical problems, establishing connection between mathematics and each of science, scientific thinking, and the surrounding reality, communicating mathematically, and valuing mathematics. So, how can we explain the fact that the first objective of the Lebanese math curriculum is to develop students' mathematical reasoning, yet students in the TIMSS tests scored the least in this domain?

The TIMSS data raises concerns about whether the current Lebanese math program is achieving its intended goals and shows that there is a discrepancy in the Lebanese math curriculum. The latter discrepancy may be identified by checking the alignment of the different aspects of the Lebanese math curriculum. Moreover, knowing that one of the objectives of the Lebanese math curriculum is reasoning, and national tests are supposedly done based on the general objectives, why wasn't the concern that students don't perform well on "reasoning questions" in official exams highlighted? And if Lebanese students are trained to take the national tests at the end of grade 9 (which supposedly include reasoning), why didn't they perform well on the TIMMS on this domain?

1.4- Purpose and Research Questions

The aim of this study is to evaluate the alignment of the general objectives of the Lebanese curriculum (GOMC), the objectives of the math curriculum at the intermediate level (OMCI), the specific objectives of each of the grade levels in the intermediate level (SOGLI), the national math textbooks (NMT) at each of the latter grade levels, and the official math Brevet tests (BT).

The study focuses on four research questions:

1. To what extent are the objectives of the math curriculum at the intermediate level (OMCI), and the specific objectives of each of the grades in the intermediate level (SOGLI) aligned with the general objectives of the Lebanese curriculum (GOMC)?

2. To what extent are the national math textbooks (NMT) reflective of the general objectives of the Lebanese Math curriculum (GOMC)?

3. Are the Brevet tests (BT) aligned with the general objectives of the Lebanese math curriculum (GOMC)?

1.5- Rationale and Significance

The intended curriculum attempts to shape instruction in educational systems through providing guidelines of what students should learn. In other words, the intended curriculum sets the base for the implemented curriculum. In practice, curriculum designers should make sure that the GOMC and the SOGLI are all aligned and gradually serve the goals of the curriculum. Moreover, educators and textbook authors should make sure that the material which they are providing to teachers and students are also aligned with, and reflective of the intended curricula. Finally, assessments too should be reflective of the intended curricula. Alignment is not fully achieved when there are only *some* commonalities among the three components of the curriculum (figure 2.1), rather it is ideally achieved when the three components are unified as one (figure 2.1). Although it is almost impossible to achieve the ideal level of alignment that is represented in figure 2.1, curriculum developers and educators strive to insure the highest level possible of alignment. A program that lacks alignment among its components will have limited effectiveness and could be negatively impacting the students' achievement and progress (Houang & Schmidt, 2008).

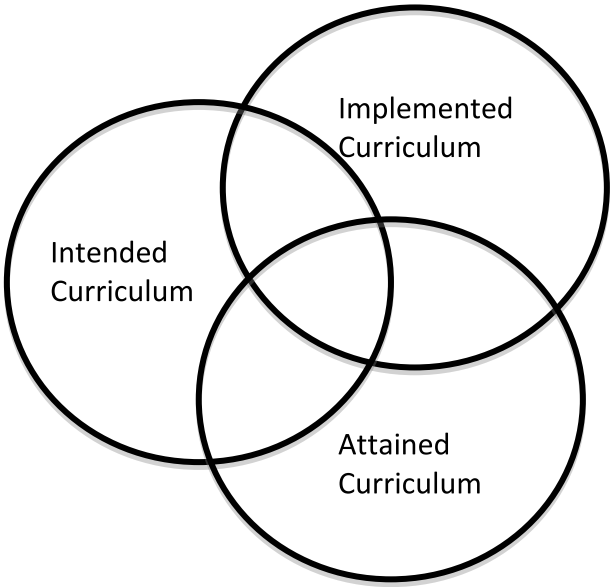


Figure 1.1:

A representation of a non- aligned curriculum.

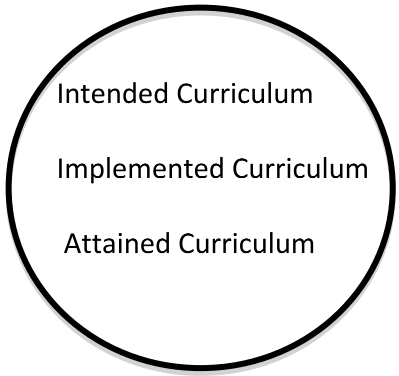


Figure 1.2:

A representation of an ideally aligned curriculum.

This research paper will make a contribution to the Lebanese Math Curriculum in multiple ways. The data collected within this research should provide a picture of the internal alignment of the Lebanese Math curriculum, and the extent to which it is implemented or reflected in the national Math textbooks at the Intermediate Level. Moreover, there will be data collected on the alignment of the BT with the GOMC. From analyzing all the data collected, the researcher will be able to identify the goals of the Math curriculum that are being neglected or underemphasized throughout the curriculum plan, textbooks, and national assessments. Thus, the researcher will be able to come up with a list of recommendations that can be taken into consideration in the next review of the Lebanese math curriculum and textbooks, and in designing national assessments. In addition, this study will contribute to the studies on the Lebanese curriculum which are considered rare. Only a few studies were done on alignment of the Lebanese curriculum. For example, a study conducted by Osta (2007) was done on the Brevet tests under the pre-reform curriculum, and two Master theses were done on Secondary national exams by Sleiman (2002) and Safa (2003) under Osta's supervision to address the alignment and coherence of the Lebanese national tests. Although in this study a slightly different framework is used, it will complete the latter studies and add to them by addressing the alignment of the Brevet (middle-school level) tests.

Chapter II

Review of Literature

In this chapter, a comprehensive body of literature related to the research is presented. In the first section, the philosophy and the aim of math education are discussed, and the implications of the ways to meet the aim of math education are highlighted. The second section defines a curriculum. The third section describes the role of textbooks and discusses different models for assessing textbooks. The fourth section describes the purpose of assessments and gives examples of different international assessments and the purpose of each. In addition, this section describes different models for the alignment between curriculum standards and assessments. The fifth section defines alignment and describes the importance of the alignment within the curriculum.

In summary, this chapter aims to present and reflect on existing research related to the following key terms: math education, curriculum, national textbooks, assessment, and alignment.

2.1- Philosophy and Aim of Math Education

According to the Lebanese national curriculum document, issued by the Educational center for Research and Development (ECRD) (ECRD, 1997), Mathematics is a fundamental part of schooling that offers students the means to explore the world around them in various domains. Mathematics also plays an essential role in the society (ECRD, 1997). With today's technology-driven society, a greater number of vocations are soliciting individuals with high proficiency in mathematics; individuals who can be good decision makers and problem solvers in everyday life. As stated in the Lebanese national curriculum document, the math curriculum should prepare these students who will use mathematics in their vocations and in their life in general (ECRD, 1997).

For decades, there has been a "math war" going on due to the disagreement on the philosophy and aims of math education (Davision & Mitchell, 2008). Mathematics and its philosophy is an area of controversy where the absolutist view argues that mathematical knowledge is absolute, unchangeable, and certain, whereas the fallibilist view questions the absoluteness of mathematical knowledge and argues that it is contextual and affected by the social and historical factors (White-Fredette, 2009). The aim of math education is another area of controversy which will be discussed later in the paper.

Classroom experiences and expectations related to math education are highly affected by the philosophies of math education. The absolutist view mathematics as an objective and purely isolated body of knowledge that is deducted, fixed, universally valid, and ahistorical. This philosophy of math education may be communicated in schools by giving students routine mathematical tasks that focus on computational skills, deductive reasoning, and the application of learnt procedures and rules, and by stressing on speed, accuracy, and close ended tasks that have one fixed right answer (Davision & Mitchell, 2008; White-Fredette, 2009). The fallibilist view also values the role of structure and logic in mathematics; however, it rejects the notion that mathematics is fixed and isolated. On the contrary, the fallibilist view mathematics to be constantly open to revision in terms of its proofs and concepts and to be the outcome of historical and social processes. Consequently, this view acknowledges the history of mathematics, its role in the society, and the importance of contextualizing it. This view is reflected in schools where mathematics education is experienced as investigational, creative, collaborative, enjoyable, historical, cultural, and related to personal and real life situations (Davision & Mitchell, 2008). So, whether believing in absolutist, fallibilist, or a middle ground view between them, the philosophy of math education that schools believe in highly affect classroom experiences.

Controversies in math education have also been reflected in its aims as the aim of math education ranged throughout the years from being strictly related to political and social purposes to being more student centered and related to developing students' interest, awareness, and democratic citizenship through mathematics (Stinson, 2004). In order to determine the aim of math education in the 21st century, it should be determined in light of the aim of education in general. Education serves the individual and the nation as by developing individuals' skills, values, and knowledge, the collective brain power of the nation extends significantly. Since we are currently living in a society with rapid technological developments and scientific accomplishments, and education is highly affected by society, then the aim of education should be reflective of the needs of the society. According to Sowell (2005), the general aim of education is to provide individuals with the intellectual tools needed to analyze situations verbally or numerically and come up with conclusions based on logical reasoning and evidence. In other words, education should develop students' skills and cognitive abilities, and facilitate learning and the communication of knowledge through the use of efficient techniques (such as technology). Moreover, education should prepare students to cope with the changing nature of the world, to reason and solve real life situations, and to discover and experience new things.

In light of the latter aim of education, the aim of math education can be stated in the following terms:

(1) To develop students' understanding of math concepts in context of different disciplines and in context of real life.
(2) To develop students' cognitive abilities and mathematical reasoning and help them become good problem solvers and decision makers.
(3) To facilitate learning and the communication of knowledge through the use of efficient techniques such as technology.
(4) To develop students' abilities to communicate their analysis, reasoning, and conclusions verbally and numerically.

Since the aims of education are reflective of the needs of the society, the aims of education vary from one society to another. Moreover, teachers can have different beliefs related to the aims of math education and since they can directly manipulate classroom experiences and climate, it is important that they fully understand and accept the aims of education (with respect to each of the disciplines) of the society they live in. These aims are usually communicated through curriculum standards or by a national curriculum.

2.1.1- Achieving the Aims of Education

Psychological theories on human behavior and the way data are processed in the human mind had a significant influence on the field of education. The constructivist theory by Jean Piaget, the social learning theory by Albert Bandoura, and the multiple intelligence theory by Gerald Gardner are all examples of those theories that changed the attitudes towards teaching and learning strategies. According to Wiggins& McTighe (2005), while traditionally the focus of the curricula was on teaching rather than learning, and teacher centered rather than student centered, these theories shifted the focus of curricula to be more focused on the students themselves by:

(1) Acknowledging the role of the students in constructing knowledge.
(2) Valuing the process of learning not only its outcome.
(3) Developing the students' sense of curiosity and exploration.
(4) Making connections within the same discipline, across disciplines, or with real life situations clear to students.

Moreover, in light of the psychological theories and the development in science and technology, new perspectives on the structure and implementation of the curricula were developed. New curricula designs recommend the integration of subjects and the contextualizing of learning in real life experiences (Wiggins& McTighe, 2005). One curriculum design that is being implemented in many schools nowadays is called the Understanding By Design (UBD) which focuses on learning and is designed to assure the students' fulfillment of learning outcomes. Therefore, teachers' are urged to prepare interesting lesson plans and activities that are based on the students' needs and abilities and that help students form connections and make sense of the subject in connection to real life. Teachers also have to implement different assessment techniques and constantly reflect and modify their techniques to help their students to achieve to their fullest potential (Sowell,2005). Since teachers play an important role in the classroom, they should be well trained and prepare to provide their students with learning experiences that aim towards achieving the goals of education.

However, in order for the aims of education to be achieved there should be coherence among all the different components of the curriculum. In other words, general objectives, specific objectives, classroom experiences, textbook materials, and assessments should all be designed to be aligned and reflective of the aims of education.

2.2- Curriculum

The term "curriculum" is used and referred to in different ways by different researchers. For some researchers, the curriculum provides a list of content, concepts, and associated teaching tools (Richmond, 1971; Kesidou & Rosemann, 2002), while for others the curriculum includes more than just a list of topics and materials, rather it also specifies the assignments, learning experiences activities, and assessments to be made use of in achieving the curriculum goals (Ross, 2001; Wiggins & McTighe, 2001). Other researchers such as Turner (2003) Van den

Akker (2003) differentiated between the intended and the implemented curriculum (as cited in Osta 2007). They were interested with the curriculum material in addition to its delivery.

The intended curriculum includes mainly the goals, and the general and specific objectives of the curriculum. It communicates what students are expected to develop from the program in general, and what they should achieve at each grade level. The implemented curriculum on the other hand represents the instruction climate and the learning that take place in the classroom. According to Cornbleth (1990) and Grundy (1987), although the implemented curriculum should be reflective of the intended curriculum, sometimes the implemented curriculum tends to vary from the intended curriculum.

2.3- Textbooks

Math textbooks have an important role in the classroom. They promote the vision of specific types of math curricula and often are the primary resource for teachers (Valverde et al., 2002). In other words, curricular knowledge presented in textbooks affects classroom instruction. Usually nations that abide by a national curriculum also publish national textbooks for the different subjects across grade levels. In the case of Lebanon, the ministry of education, more specifically ECRD developed a math textbook series for all grade levels called "Building up Mathematics". Usually all public schools in Lebanon abide by the ECRD textbook, whereas private schools may use a variety of textbooks. For many private schools in Lebanon, ECRD math textbooks are more used starting the intermediate level. Given the crucial role of textbooks, it becomes critical to analyze math textbooks and evaluate whether they reflect the Lebanese intended curriculum. Moreover, until the ECRD math textbooks are reviewed in the near future, it is important for teachers to use the textbooks with a critical eye.

2.3.1- Models for Assessing Textbooks

There are various ways to assess textbooks. One technique used to assess the degree of effectiveness of textbooks is referred to as *textbook analysis*. This technique that was originated at the end of World War I, evaluates the characteristics of textbooks based on a specific set of criteria (Johnsen, 1993). Data from this analysis can determine whether the textbook materials enable the learners to achieve the desired learning outcomes (Mikk, 2000). Different studies may focus on different textbook characteristics and on different criteria. Textbook analysis is done outside the learning situation and can yield qualitative data, quantitative data, or both. However, the most common type of textbook analysis produces quantitative data since the characteristics of the textbook are measured to give an indicator of its quality. Moreover, textbooks can be assessed using *experimental investigations* that take place in learning situations. Examples of these investigations can be using different textbooks in different classes and then comparing students' performance, or asking students questions to determine how their understanding improved after they used a certain textbook or analyzing how students are interacting with the textbook materials. Similar to textbook analysis, experimental investigations also can yield qualitative data, quantitative data, or both, and they are used to evaluate the quality of the textbook (Chambliss and Calfee, 1998). However, when using this technique, researchers should take into consideration the various factors that might be affecting the learning outcomes so that the textbook assessment is valid.

2.4- Assessment

The curriculum also incorporates one important aspect which is the assessment that is associated with it. According to Wiggins et al. (2001) assessment determines " the extent to which the curricular goals are being and have been achieved" (p. 3). According to other researchers, assessment can also be used as a tool to reflect on teaching and learning. According to Hattie (2003), data collected from assessment are most valuable when we:

> Move away from considering achievement data as saying something about the student, and start considering achievement data as saying something about their teaching. If students do not know something, or cannot process the information, this should be clues for teacher action, particularly teaching in a different way. (p. 2)

According to the NCTM (1995), there are four purposes of assessment:

(1) To monitor students' learning and progress

(2) To evaluate and improve instruction

(3) To evaluate students' achievement levels by comparing them to performance criteria

(4) To evaluate the program used based on assessment data and teacher judgments.

More specifically related to this study, assessment in mathematics is defined by the NCTM to be "the process of gathering evidence about a student's knowledge of, ability to use, and disposition toward mathematics and of making inferences from that evidence for a variety of purposes" (1995, p.87). In other words, assessment in mathematics should aim at developing the students' abilities to reason, make inferences, connect ideas, solve problems, and communicate mathematically.

There are also different forms of assessment that vary in their level of standardization and formality, and ultimately in their purpose. One particular type of assessment on which this study will focus is the paper-and-pencil test since it is most used in schools in Lebanon and it is the form of assessment used for the official exams (national tests). Unfortunately, the purpose of national assessments may be misinterpreted as, with their presence, many teachers tend to prepare their students to pass the test by focusing more on the grades rather than the actual learning journey of the students.

In addition, there are several international assessment related to mathematics and other subjects that help participating countries in evaluating their program with respect to other countries and an international standard. Examples of these international assessments are:

(1) The *Program for International Student Assessment* (PISA) which is conducted regularly on a three year basis, administered to 15 year old students, and assesses mathematical literacy, problem solving, reading literacy, and scientific literacy (PISA 2009 Assessment Framework, n.d.).

(2) TIMSS which is conducted regularly on a four year basis, administered to students in grades 4, 8, and 12, and related to math and science. In TIMSS, math assessments target the 3 cognitive domains which are: knowing, applying, and reasoning (Schmidt et al., 2005).

2.4.1- Models for Alignment between Curriculum Standards and Assessments

Multiple studies have been done to determine whether or not assessment is aligned with the goals and objectives of a certain curriculum. From the later studies, many alignment methods were developed. Three important methodologies for assessing alignment are the following:

(1) Webb analysis program (Webb, 2007): this program was initially designed in 1997 and then reviewed in 2007. Webb's program uses four criteria for evaluating assessment alignment in relation to standards. These criteria are: (a) categorical concurrence, which indicates whether or not all standards are measured by the assessment items, (b) depth of knowledge consistency, which evaluates the cognitive demands of assessment items with respect to the standards, (c) range of knowledge correspondence, which indicates whether assessment items have the same span of knowledge as the targeted standards, and (d) balance of representation, which studies whether all objectives are fairly represented in the assessment. In order for assessment alignment to be achieved, an acceptable level (minimum average) is necessary on each of the four criteria.

(2) La Marca Model (La Marca et al., 2000): this model is based on the Webb methodology (1997). It is designed to align assessments to state standards. La Marca model uses five dimensions for analyzing the alignment of assessments. These five dimensions are: (a) content match, (b) depth match, (c) emphasis, (d) performance match, and (e) accessibility. This model is particularly designed for very specific curricula.

(3) Achieve Methodology (Rothman at al., 2002): this method judges the alignment of both the individual test items and the overall assessment tasks.

It is done in two stages: Firstly, each test item is analyzed and compared to the intended outcome that it is designed to assess. Then, the items are analyzed as a whole. The Achieve method gives information about the balance of test items with respect to intended outcomes, and the level of challenge and cognitive demands of the assessment. However, compared to the Webb program, Achieve does not provide clear criteria on the degree of alignment of the items or assessment; rather it provides information about possible changes that can be made as result of the assessment analysis (Martone & Sireci, 2009).

2.5. Coherence and Alignment

2.5.1- Definition of Coherence and Alignment:

The words alignment and coherence are frequently used interchangeably in the literature or used to define each other. For example, according to Herman (2010), "*coherence* involves the close *alignment* of learning goals, instruction, and assessment" (p.4). In other words, curriculum coherence refers to the consistency and balance among the three curriculum aspects (the intended, implemented, and attained curriculum). Moreover, according to Anderson (2002), curriculum alignment refers to strong link between each of the objectives, instructional activities, and assessments. Anderson's definition can also be restated ad the consistency among the three curriculum aspects. One key indicator of curriculum alignment is the assessment of students' learning. According to La Marca et al., curriculum alignment is

> the degree to which assessments yield results that provide accurate information about student performance regarding academic content standards at the desired level of detail to meet the purpose of the alignment system…in a manner that clearly conveys student proficiency as it relates to the content standards. (2000, p. 24)

In other words, poor performance on assessment can suggest lack of alignment between the different aspects of the curriculum. In the case of Lebanon, the TIMSS result discussed in the chapter one, and the results of a study conducted by Osta (2007) on the alignment between the national curriculum and assessment, one can concluded that there is a discrepancy between the three aspects of the curriculum that should be paid more attention to.

2.5.2- Research on Alignment:

A study was conducted by Osta (2007) to analyze the alignment of the BT under the pre-reform curriculum. Osta's study considered three model tests reflecting the analyzed Lebanese math curriculum, and eleven BT. The results of the study showed that the selected eleven brevet tests focus the most on procedural knowledge, then problem solving, and the least on conceptual understanding whereas the model tests focus on conceptual understanding the most. The latter result suggested a lack of alignment of the selected BT with the model tests in terms of mathematical abilities. Moreover, the result of study showed that not all content topics are addressed in the BT although they are included in the curriculum.

Chapter III

Methodology

In this chapter, the research methodology is discussed. The chapter is divided into four sections. In section one, the nature and design of the research are discussed. Section two describes the curriculum sample studied. In section three, the instruments that will be employed and the procedure by which the study will be carried out are described. The limitations of the research design are addressed in the final section.

3.1- Section 1: Nature and Design of the Study

The research approach mainly utilized in this study is a case study approach using mainly qualitative methods. To answer the first research question, the case study approach will include content analysis of the Lebanese Math curriculum plan, as published in the ECRD texts. The content analysis is a strategy used to make logical inferences from a set of collected data (i.e. texts or interviews) (Hsieh & Shannon, 2005). In this study, the aim of the content analysis of the Lebanese math curriculum text is to examine the alignment of the general objectives of the Lebanese math curriculum (GOMC), with the objectives of the math curriculum at the intermediate level (OMCI)(Appendix A), and the specific objectives of each of the grades in the intermediate level(SOGLI) (Appendix B).

To investigate the second research question, the case study will include a quantitative element. The content of the national math textbooks (NMT) will be examined based on different sets of criteria to investigate the extent to which the national Lebanese textbooks are reflective of each of the GOMC (a technique previously referred to as textbook analysis).

In addition, an analysis of Brevet tests (BT) will be conducted to investigate the last research question. The analysis of the BT items will be done using the same sets of criteria used to analyze the NMT. Moreover, each test item will be mapped to its respective general objective to check whether or not the test items of the BT are aligned with the GOMC. Afterwards, the results of all the BT will be compared by calculating the averages of different sets of the results and by representing the averages graphically.

3.2- Section 2: Curriculum Sample

This study will take a sample of the Lebanese Math curriculum plan, which is the math curriculum at the intermediate level. The study will evaluate the extent to which the general objectives of the Lebanese math curriculum are addressed in designing the math curriculum and textbooks at the intermediate level. Consequently, ECRD NMT of grades 7, 8, and 9 (the intermediate level) will be evaluated. In each of the textbooks, 6 chapters are selected, closely examined, and analyzed. The selected chapters from each of the grade 7, 8, and 9 textbooks are from the different content domains of Number Theory, Geometry, Algebra and Statistics.

As for the BT, a sample of 18 tests (sessions 1 and 2) from the years 2001, 2002, 2003, 2006, 2007, 2008, 2011, 2012, and 2013 will be analyzed. The latter sample of test was used to show the evolution of the BT from the year 2001 to 2013 in terms of their alignment with the GOMC.

3.3- Section 3: Instruments and Procedures

A description of the instruments used in this study is provided in this section. One instrument will be used to examine the extent to which there is alignment between the GOMC, the OMCI (Appendix A), and the SOGI (Appendix B). Another instrument will be used to determine the extent to which the GOMC are applied in the NMT at the intermediate level (Tables 2, 4, 5, 6, and 7). The latter instrument will also be used to study the extent to which official exams conducted at the end of the intermediate level are reflective of the GOMC.

3.3.1- Alignment of the Different Levels of Objectives of the Curriculum

When deciding on subject specific content, it is important that curriculum developers select contents that help in fulfilling the general objectives of the curriculum. In other words, starting with the Lebanese Math general objectives, curriculum developers should choose contents that help teachers and students achieve these long-term objectives.

A content analysis will be done to evaluate (1) the alignment of the Intermediate year's math objectives with the GOMC, and (2) the alignment of the specific objectives in each of grades 7, 8, and 9 with the GOMC. So, the tables in Appendix A and B respectively are designed to facilitate the latter analysis. In Appendix A, the OMCI are mapped with the GOMC to evaluate whether all the GOMC are fairly represented by the OMCI. Tables 1, 2, 3 in Appendix B indicate whether the specific objectives at each of grades 7, 8, and 9 respectively are consistent with, and designed to achieve the GOMC.

One way to facilitate the mapping of the OMCI and the SOGLI to the GOMC is by checking for the prevalence of key words that are reflective of the GOMC. These key words/ phrases represent action verbs, adjectives, tools, strategies, or processes related to each of the general objectives.

Some of these key words/ phrases that target the development of the GOMC are listed in table 1:

Table 1

Keywords/ phrases that reflect of each of the general objectives of the Lebanese math curriculum

GOMC	Key words/ phrases
Mathematical Reasoning	Analyze, deduce, induce, formulate, observe, abstract, synthesize, interpret, prove, generalize, falsify, , etc.
Solving Mathematical Problems	Understand the problem, identify relevant information, devise a plan, break down a complex problem to simpler parts, choose a strategy (a model, table, diagram, etc.), apply your plan/ strategy, recheck or evaluate your solution, classify, quantify, construct, apply, verify, manipulate, etc.
Establishing connections between mathematics and each of science, scientific thinking, and the surrounding reality	Authentic, real life, reflect, prior knowledge, society, scientific skills (generalize, synthesize, analyze…),etc.
Communicate mathematically	Interpret, explain, different forms of representations, lines of reasoning, mathematical language, present, write, read, in groups, in pairs, etc.
Valuing mathematics	Appreciate, construct, connect, manipulate, challenging, in groups, in pairs, model, games, etc.

It is important to understand that this list is incomplete because it is impossible to state all terms/ phrases that may apply to each of the general objectives. Moreover, some terms or phrases can be indicators of more than one objective so it is important to look at the context of the terms/ phrases to check which objective it reflects. Having said that, this table will NOT be used as an instrument per se rather it is only referred to by the researcher when the researcher is unable to decide which general objective(s) best reflect a certain more specific objective.

3.3.2– Alignment of ECRD Math Textbooks with the General Objectives of the Lebanese Math Curriculum

In this subsection, the selected chapters from the ECRD math textbooks of grades 7, 8, and 9 will be evaluated in terms of their alignment with the four general objectives of the Lebanese math curriculum. More specifically, each item in the chapters that addresses the student and asks him/her to provide a response will be analyzed. The latter items will be referred to in the study as "student items". They can be in the form of a statement or a question. Before starting the analysis, the total number of student items in each of the chapters will be counted; afterwards, each student item is examined based on research based criteria. Since there are four different GOMC that can be analyzed through textbooks, four different sets of criteria are respectively used to evaluate each of the student items in each of the selected chapters of the NMT. It is important to note that within each criterion of the selected general objective, a student item can only be classified to be reflective of only one behavior or category. So, although a student item may reflect more than one of the behaviors or categories listed in a certain general objective, the researcher will choose the 'best fit' behavior or category within a criterion. In order for the classification not to be subjected to personal interpretation, and to increase the validity and reliability of the study, the classification will be performed separately by two researchers based on the definition of each classification in the criteria. Afterwards results will be compared and in case of any disagreement, the two researchers will discuss their points of views until an agreement is reached.

3.3.2.1– General Objective 1: Solving Mathematical Problems

The Lebanese math program aims at engaging students with problem solving experiences. There are different levels of problem solving; students should be engaged with all of the levels. According to the Lebanese national curriculum document, students need to be engaged with authentic problem solving and they should be exposed to challenging problems that require them to use various mathematical strategies. Moreover, students should be exposed to situations that require taking decisions, manipulating data, and performing various levels of problem-solving skills (ECRD, 1997).

Problem solving activities can be classified as three types: routine problems, non- routine problems, and grey-area problems (Kolovou et al., 2009). Routine problems are problems that don't require students to develop new ways to solve a problem, rather they can solve it by replicating or reciting previously learned strategies step-by-step. Routine problems can be one-step, or two-step problems. The typical challenge in these problems is working through multiple steps. The purpose of routine problems is to help students apply a math concept, strategy, or operation. Examples of routine problems are problems that require solving an equation or substituting values to find the area of a triangle. On the other hand, non-routine problems require students to come up with new way to get the answer. In non-routine problems, there is no straightforward answer, and students should be independent, creative, think out of the box, and use higher-order thinking. So, if a student knows the formula or technique for solving a problem, the problem is considered to be a routine problem. Grey-area problems represent the category of problems that is between routine and non-routine problems. These problems are not straightforward yet not so novel to students. In this study, gray area problems are those problems that can be solved in multiple steps and problems that trigger students' strategic thinking and problem solving skills. Problem solving is not about solving routine problems, it is rather about solving open ended problems that require creativity, judgment, and independence. Therefore, in order for students to develop different levels of problem solving skills ranging from classifying, applying or quantifying to manipulating information, taking decisions or discovering mathematical methods, they need to be exposed to routine, grey-area, and non-routine problems.

Based on the latter classification of problem solving types, table 2 represents the tool used to record the number of routine, non-routine, and grey area student items in the selected chapters of the ECRD math textbooks for grades 7, 8, and 9.

Table 2

The percentage of routine, non-routine, and grey-area student items in the selected chapters of the ECRD math textbooks for grades 7, 8, and 9

Grade level textbook	Chapter Number	Evaluating Problem Solving in the Chapters		
		Routine	Non-routine	Grey-area
Grade 7 textbook	Chapter 1			
	Chapter 2			
	Chapter 3			
	Chapter 4			
	Chapter 5			
	Chapter 6			
Global percentage				
Grade 8 textbook	Chapter 1			
	Chapter 2			
	Chapter 3			
	Chapter 4			
	Chapter 5			
	Chapter 6			
Global percentage				
Grade 9 textbook	Chapter 1			
	Chapter 2			
	Chapter 3			
	Chapter 4			
	Chapter 5			
	Chapter 6			
Global percentage				

Each student item in the selected chapters of the three grade levels will be classified as routine, non-routine, or grey-area item. Afterwards, the percentages of each routine, non-routine, or grey-area items in each chapter of the selected chapter will be determined (considering the total to be the total number of student items in the selected chapter of the textbook).

3.3.2.2– General Objective 2: Mathematical Reasoning

One main objective of math education is to develop students' mathematical reasoning. This objective is merely achieved by engaging students with cognitively demanding experiences (Henningsen & Stein, 1997). In order to evaluate the degree to which Lebanese math textbooks aim at developing students' mathematical reasoning, this study will adopt the TIMMS 2011 description of the reasoning domain as the criteria for evaluating the textbook materials. According to the TIMSS 2011 framework, reasoning involves the students' ability to exhibit certain behaviors such as the ability to (1) analyze, (2) generalize/ specialize, (3) synthesize/ integrate, (4) justify, and (5) solve non-routine problems. However, students can't develop the latter abilities without being exposed to materials that can trigger and develop them. Table 3 presents a description of each of the five behaviors as presented in the TIMSS 2011 framework.

Table 3

Description of each of the five behaviors that reflect mathematical reasoning as presented in the TIMSS 2011 framework

Behaviors that reflect reasoning	Description
Analyze	- Determine and describe relationships between objects or variables in mathematical situations. - Make valid inferences from a set of data.
Generalize/ Specialize	Generalize mathematical results by restating them in a more widely applicable term.
Synthesize/ Integrate	- Make a link between math ideas. - Make connections between different representations or between ideas/ elements of knowledge. - Combine mathematical ideas, concepts, and procedures to come up with a result, and combining different results to come up with a new result.
Justify	Provide a justification by referring to a known mathematical property or result.
Solve non-routine problems	Solve complex or unfamiliar mathematical problems.

Therefore, in order to evaluate the Lebanese math textbooks for reasoning, all student items in the selected chapters will be analyzed to check whether or not they allow students to exhibit any of the five behaviors that reflect reasoning. Table 4 will be used to document the percentage of student items that engage students with any of the five behaviors of reasoning (considering the total to be the total of student items in the selected chapter of the selected textbook).

Table 4

The percentage of student items in the selected chapters of the ECRD math textbooks that reflect reasoning based on the TIMSS 2011 framework.

		Evaluating Textbook Materials for Reasoning Based on the TIMSS 2011 Framework				
Grade Level Textbook	Chapter Number	Analysis	Generalizations/ specialization	Inferences or synthesizing	Justifications	Non-routine problems
Grade 7 textbook	Chapter 1 Chapter 2 Chapter 3 Chapter 4 Chapter 5 Chapter 6					
Global percentage						
Grade 8 textbook	Chapter 1 Chapter 2 Chapter 3 Chapter 4 Chapter 5 Chapter 6					
Global percentage						
Grade 9 textbook	Chapter 1 Chapter 2 Chapter 3 Chapter 4 Chapter 5 Chapter 6					
Global percentage						

The percentage of non-routine student items found in the selected chapters will be obtained from the data previously collected in table 2. In The TIMSS 2011 framework, the percentage of the math assessment items that target the reasoning domain is 25% for eight grades. This percentage may also imply that approximately 25% of the material that students are exposed to should reflect reasoning. So, through the data collected in this section, we will be able to see if the percentage of textbook material that reflects reasoning encompasses approximately 25% of the overall textbook material.

3.3.2.3– General Objective 3: Establishing Connection between Mathematics and each of science and the surrounding reality

According to the ECRD (1997) document, the third GOMC is:

> "Modern society has a greater need for highly qualified workers and researchers in all areas. The mathematics curriculum responds to these demands by offering students an opportunity of practicing the scientific approach, developing the scientific spirit, improving skills in research, establishing relations between mathematics and the surrounding reality in all dimensions and valuing the role of mathematics in technological, economical, and cultural development" (p. 289).

Unlike the other general objectives, the third GOMC is not specific to only one main objective, rather it has two main sub-objectives which are (1) to develop the connection of mathematics with sciences and scientific thinking, and (2) to establish connections between mathematics and the surrounding reality. Therefore, in order to evaluate whether or not the math textbooks reflects the 3rd general objective of the Lebanese curriculum, two different sets of criteria for each of the two sub-objectives are developed.

Firstly, one objective of the Lebanese math curriculum is to establish a connection between mathematics and other subject areas such as science (ECRD, 1997). The connection between math and sciences is mainly highlighted due to the rapid development of the science and technology sectors in today's society and often students who are capable of going into a scientific or a technical field may find it difficult to continue in these fields because of their lack of competency in mathematics. Therefore, it is important to provide students with opportunities to explore the connection between math and science. One way to show the integration between math and science is by exposing students to materials that provide scientific content in context of real life and involve methods and processes related to mathematics. The scientific content can be related to any of the three fields of science which are physics, biology and/or chemistry. So, in this study all student items that involve a situation related to any field of science (physics, biology and chemistry) will be represented in table 5.

Table 5

The percentage of student items with or without scientific content in the selected chapters of the ECRD math textbooks for grades 7, 8, and 9

	Evaluating BT for Their Connection to Science	
Selected BT	With	Without
2001 Brevet Test (session 1)		
2001 Brevet Test (*session 2*)		
2002 Brevet Test (session 1)		
2002 Brevet Test (*session 2*)		
2003 Brevet Test (session 1)		
2003 Brevet Test (*session 2*)		
Global Percentage		
2006 Brevet Test (session 1)		
2006 Brevet Test (*session 2*)		
2007 Brevet Test (session 1)		
2007 Brevet Test (*session 2*)		
2008 Brevet Test (session 1)		
2008 Brevet Test (*session 2*)		
Global Percentage		
2011 Brevet Test (session 1)		
2011 Brevet Test (*session 2*)		
2012 Brevet Test (session 1)		
2012 Brevet Test (*session 2*)		
2013 Brevet Test (session 1)		
2013 Brevet Test (*session 2*)		
Global Percentage		

Secondly, the Lebanese math curriculum aims at encouraging students to make connections with real life situations. However, this skill is not naturally acquired; students should be exposed to tasks that are authentic and relevant to their lives in order to be able to make sense of mathematics in real life context. Skovsmose (2002) distinguishes between three different types of exercises:

(1) Purely mathematical; which are tasks that are not embedded in any context.
(2) Semi-realistic; which are tasks that are embedded in context; however students can't relate them to their daily lives. In other words, reality in these items is constructed rather than observed.
(3) Real-life exercises; which are tasks that are relevant to students' lives and within their realm of experiences.

Therefore, in order to evaluate the Lebanese math textbooks for its role in developing students' ability to relate mathematics to real-life situations, all student items in the selected chapters of the textbooks will be analyzed based on Skovsmose's three types of tasks. Table 6 will be used to document the percentage of student items for each of the three types (considering the total to be the total number of student items in the selected chapter of the textbook).

Table 6

The percentage of purely mathematical, semi-real, and real-life student items in the selected chapters of the ECRD math textbooks for grades 7, 8, and 9

Selected BT	Criteria for Evaluating BTs for Their Degree of Realism		
	Purely Mathematical	Semi-Real	Real-life
2001 Brevet Test (session 1)			
2001 Brevet Test (*session 2*)			
2002 Brevet Test (session 1)			
2002 Brevet Test (*session 2*)			
2003 Brevet Test (session 1)			
2003 Brevet Test (*session 2*)			
Global percentage			
2006 Brevet Test (session 1)			
2006 Brevet Test (*session 2*)			
2007 Brevet Test (session 1)			
2007 Brevet Test (*session 2*)			
2008 Brevet Test (session 1)			
2008 Brevet Test (*session 2*)			
Global percentage			
2011 Brevet Test (session 1)			
2011 Brevet Test (*session 2*)			
2012 Brevet Test (session 1)			
2012 Brevet Test (*session 2*)			
2013 Brevet Test (session 1)			
2013 Brevet Test (*session 2*)			
Global percentage			

3.3.2.4– General Objective 4: Communicate Mathematically

Mathematical communication is one of the essential GOMC. According to the Lebanese national curriculum document, students should be able to communicate mathematically by being able to (1) read, understand, or interpret mathematical texts (2) use various forms of representations (charts, tables, diagrams, drawing, equation, etc.), and (3) use correct mathematical language in expressing information. Tasks for developing communication in mathematics are likely to be investigations, real life problems, word problems that can be solved in different ways, word problems that require data collection and representation, or any task that requires students to exhibit any of the three behaviors listed previously. In this study, the percentage of student items that reflect the three behaviors related to communication in mathematics that are listed in the ECRD document of the math curriculum will be calculated to evaluate the extent to which students are exposed to material that allow them to develop their communication skills in mathematics (table 7). In this table too, the percentages of each of the three behaviors related to communication in mathematics in each chapter of the selected chapter will be determined considering the total to be the total number of student items in the selected chapter of the textbook.

Table 7

The percentage of student items in the selected chapters of the ECRD math textbooks that reflect communication in mathematics

Grade Level Textbook	Chapter Number	Evaluating Textbook Material for Their Level of Communication		
		Read, understand, or interpret mathematical texts	Using various forms of representations	Using of correct mathematical language in expressing information
Grade 7 textbook	Chapter 1			
	Chapter 2			
	Chapter 3			
	Chapter 4			
	Chapter 5			
	Chapter 6			
Global percentage				
Grade 8 textbook	Chapter 1			
	Chapter 2			
	Chapter 3			
	Chapter 4			
	Chapter 5			
	Chapter 6			
Global percentage				
Grade 9 textbook	Chapter 1			
	Chapter 2			
	Chapter 3			
	Chapter 4			
	Chapter 5			
	Chapter 6			
Global percentage				

3.3.3– Alignment of the Brevet Tests with the General Objectives of the Lebanese Math Curriculum

The BT for the respective years 2001, 2002, 2003, 2006, 2007, 2008, 2011, 2012, and 2013 will be analyzed based on the criteria listed previously for each of the four GOMC. The analysis method of BT will be similar to that of the NMT. Each test item will be evaluated based on the sets of criteria designed for each of the four general objectives. A test item is a part of the test that requires the student to provide a response for which he/she will be given a grade. A test item can be written in the form of a *question* (e.g. What is the area of triangle ABC?) or an *imperative sentence* (e.g. Find the measure of segment AB) (Osta, 2007). Moreover, each test item will be evaluated based on the criteria of the respective general objective and the percentage of test items that correspond to each of the categories of the four general objectives will be determined. The results of the analysis of each of the eighteen tests will be then compared to each other to check whether there has been any development in designing official tests over the nine years. The comparison will take place in the following aspects:

- The brevet tests of the years 2001-2003 will be compared to the tests of the years 2006-2008, and both will then be compared to the tests of the years 2011-2013. In this way, we can see whether or not the degree of alignment of the BT has evolved over the years. In order to fulfill the latter objective, after the results for each of the BT are collected and changed to percentages, the average results for each 3 years (sessions 1 and 2) for each of the four GOMC will be calculated.
- We will study whether there is significant difference between sessions 1 and 2 of the BT regarding their alignment with the Lebanese curriculum. In order to do so, the average results for session 1 for each year of each of the four general objectives and the average results for session 2 for all the years for each of the four general objectives are compared.

Chapter IV

Findings of the Study

In this chapter, the findings of the study are presented. The chapter is divided into four sections. In section one, the result of mapping the objectives of the math curriculum at the intermediate level (OMCI) with the general objectives of the Mathematics curriculum (GOMC) are presented. Section two presents the result of mapping the specific objectives of each of the grades in the intermediate level (SOGLI) with the general objectives of the Mathematics curriculum. In section three, the result of the analysis of the grades 7, 8, and 9 national math textbooks (NMT) based on the degree of alignment with each of the general objectives of the Lebanese math curriculum is presented. The results of the analysis of the brevet tests (BT) are presented in the last section.

4.1- The results of mapping the objectives of the math curriculum at the intermediate level (OMCI) with the general objectives of the Mathematics curriculum (GOMC):

The mapping of OMCI with the GOMC shows that overall most of the GOMC are reflected in the objectives of the intermediate level (Appendix A). However, some objectives are more highlighted than others. The general objective that is highlighted the most at the Intermediate level is "developing reasoning" while the one that is least reflected is "establishing connection between mathematics and each of science and the surrounding reality". The other two general objectives related to developing problem solving skills and communication skills are almost equally reflected in the intermediate objectives. From the results of the mapping, we can see that only three objectives at the intermediate level can be linked to establishing connection between math and real life. The following objectives are:

1. Find connections between the real world and mathematical models.
2. Analyze a situation and deduce the relevant elements.
3. Find the approximate value of a result.

More specifically, only the first objective has a clear link between math and real life whereas the other two objectives are more general *and may or may not* end up being objectives for linking math to reality. For example, in relation to the objective: "Find the approximate value of a result", usually in most real life situations students should make sense of the result in connection to the real life situation and should find "the approximate value of the result" that makes sense in the situation at hand. However, this objective can be approached from a purely mathematically way and thus can have no importance in helping students establish a connection between math and reality.

In conclusion, one can say that overall, the GOMC are fairly represented at the intermediate level in different capacities with "establishing a connection between mathematics and each of science and the surrounding reality" being the least represented. Moreover, it was noticed that is not enough to check the alignment of the intermediate objectives because they are too general and subject to personal interpretation and analysis. Therefore, it is necessary to look at the SOGLI of the intermediate level to have a better and more precise view on the alignment of the Lebanese math curriculum.

4.2- The alignment of the specific objectives at each grade in the intermediate level (SOGLI) with the general objectives of the Lebanese curriculum (GOMC):

Tables 1,2, and 3 in Appendix B respectively show the mapping of the specific objectives at each of grades 7, 8 and 9 of the intermediate level with the GOMC. The results of the mapping show that:

- **In grade 7:**
    - Almost three quarter of the grade 7 specific objectives start with verbs such as "knowing" and "using" that reflect lower order skills and demands.
    - Not a single specific objective was related to the general objective "establishing connection between mathematics and each of science and the surrounding reality".

- Moreover, out of 128 specific objectives, only two objectives are designed to develop students' problem solving skills. For example, in most cases, the objectives specify what strategies should be used by the students and include mostly mathematical concepts at the knowledge level.
- As for the general objective, communication in mathematics, eleven specific objectives can be linked to this general objective. In other words, 8.59% of the grade 7 specific objectives address the fourth GOMC. Out of these eleven objectives, two objectives aim at defining terms which is a form of communication in mathematics, but much higher skills in communication are required.
- Finally, regarding the general objective "developing mathematical reasoning", nine specific objectives can be linked to this objectives thus reflecting 7.03 % of the total specific objectives.

- **In grade 8**: The results of the mapping of the grade 8 specific objectives with the GOMC are more or less similar to those of grade 7.
  - The general objective "establishing connection between mathematics and each of science and the surrounding reality" was once again forgotten and not reflected at all in the specific objectives. However, next to the specific objective "Solve problems involving inversely proportional magnitudes", a comment was included stating the following: "The situations we consider should come from various disciplines: physics, kinematics, economics, etc." Thus one can say that at least in the field of proportions

the specific objectives are encouraging the development of the latter general objective.

    - The general objective "solving mathematical problems" is also barely reflected as there are only 2 specific objectives out of 139 that aim at developing students' problem solving skills.
    - The percentage of specific objectives that are reflective of the general objective "developing mathematical reasoning" is 7.19%. However, some objectives *may or may not* end up targeting reasoning depending on the task to which they are incorporated. For example, the specific objective, "use the correct operations to reduce a compound fraction to a simple fraction", can require synthesis if the task is complex and involves several steps, however if the compound fraction is simple then it might not require any reasoning; it will be direct application.
    - As for developing communication in mathematics, 9.35% of the grade 8 specific objectives aim at developing different skills related to communication in mathematics, ranging from using various representations to describing the steps of constructing different solids.

- **In grade 9**:
    - The general objective "establishing connection between mathematics and each of science and the surrounding reality" is not reflected at all in the grade 9 specific objectives, as in those of grades 7 and 8.
    - Only 3 out of 148 specific objectives aim at developing students' problem solving skills where most of the rest of the objectives target lower order skills such as direct application of a formula or a method.

- As for the general objective related to mathematical reasoning, 10.81% of the specific objectives target different reasoning skills. However, it is important to note that for some objectives, such as "reduce an expression of the form $\frac{P(x)}{Q(x)}$ where P(x) and Q(x) are polynomials in x"; it *may or may not* require reasoning depending on the complexity of the expression.
- The perentage of the grade 9 specific objectives that are designed in alignment with the general objective "developing communication in mathematics" is 7.43%.

- **Overall**: It can be clearly seen that the lack of alignment of the different parts of the curriculum starts showing at this level (specific objectives) as there is one general objective that is completely neglected in the specific objectives, and the rest of the general objectives are barely represented. A glance of the table that shows the mapping of the general objectives with the objectives of the intermediate level and those that show the mapping of the GOMC with the SOGLI directly reflects a difference in the degree of alignment as the number of "x" marks drastically decreases in the latter tables.

4.3- The alignment of the national math textbooks (NMT) with the general objectives of the Lebanese Math curriculum (GOMC):

To study the alignment of the NMT with the GOMC, six chapters from each of three grade levels at the intermediate level were selected. Each of the six chapters reflected the different domains of mathematics; more specifically:

- In grade 7 textbook:
    - Chapter 1: Number

- Chapter 2: Geometry
- Chapter 3: Algebra
- Chapter 4: Geometry
- Chapter 5: Algebra
- Chapter 6: Statistics

- In grade 8 textbook:
  - Chapter 1: Number
  - Chapter 2: Geometry
  - Chapter 3: Geometry
  - Chapter 4: Geometry
  - Chapter 5: Algebra
  - Chapter 6: Statistics
- In grade 9 textbook:
  - Chapter 1: Geometry
  - Chapter 2: Algebra
  - Chapter 3: Algebra
  - Chapter 4: Number
  - Chapter 5:Geometry
  - Chapter 6: Statistics

The first step of analysis was identifying the total number of student items in each of the selected chapters for grades 7, 8, and 9 NMT (Table 8). A student item is considered to be any form of a statement or a question that requires a response from the student. Student items are taken from the following sections in the NMT: (1) Exercises, (2) Problems, and (3) Just for Fun. Afterwards, each of the student items was analyzed based on four different criteria to evaluate the degree to which the selected chapters are representative of each of the four GOMC. Afterwards all the data was converted to percentages to create a basis for comparison since different chapters have different total numbers of student items.

A demonstration of how student items were calculated is shown below by taking number 7 of page 73 from the grade 8 *Building Up Mathematics* textbook as an example:

In a plane, consider a system x'Ox, y'Oy.
Given the line (D) of equation y=2x – 1, the point A of coordinates (0, 5).

a) *Plot the points A and B ← 2 student items (since it is equivalent to: Plot the point A and Plot the point B)*
b) *Show that A belongs to (D) ← 1 student item*
c) *Construct the line (D) ← 1 student item*
d) *Calculate the coordinates of I the midpoint of [AB] ← 1 student item*
e) *Let H be the orthogonal projection of A on the y-axis. Using the graph, determine the lengths of AH and BH. Deduce the length of AB. ← 3 student items*

Table 8

The total number of student items in the selected chapters of the math textbooks for each of grades 7, 8, and 9

Chapter Number	The Number of Items in the NMT		
	Grade 7 Textbook	Grade 8 Textbook	Grade 9 Textbook
Chapter 1	218	53	263
Chapter 2	158	84	136
Chapter 3	152	88	92
Chapter 4	94	150	180
Chapter 5	183	141	361
Chapter 6	91	56	58
Total Student Items	896	572	1,090

4.3.1- General Objective 1: Solving Mathematical Problems

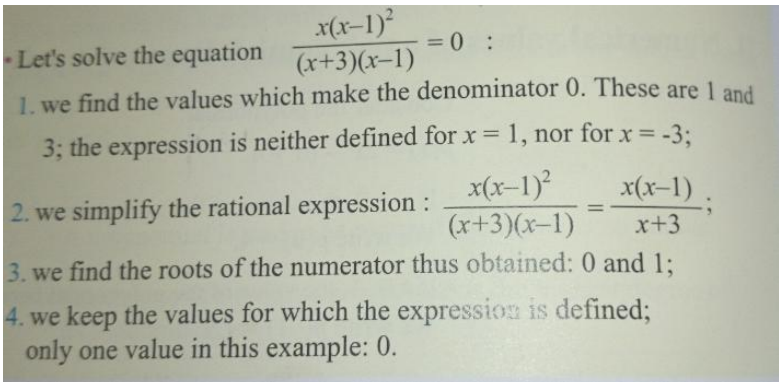
Routine problems are problems that can be solved by applying previously learned strategies step-by-step. Non- routine problems are unfamiliar problems that require students to come up with new strategies or new ways of thinking to come up with an answer. Grey-area problems are those that don’t have a straight forward answer but aren’t so novel to the students at the same time.

Every chapter of the NMT includes a couple of pages that provide students with rules and demonstrations on how to solve certain tasks in steps. So every student item that is similar to those tasks is considered a routine task because students are only following the steps provided by the authors of the book without being independent thinkers.

An example of each of a routine, non-routine and grey-area problem is given below to demonstrate how the classification of the student items occurred:

- Routine: grade 9 textbook. Chapter 11:

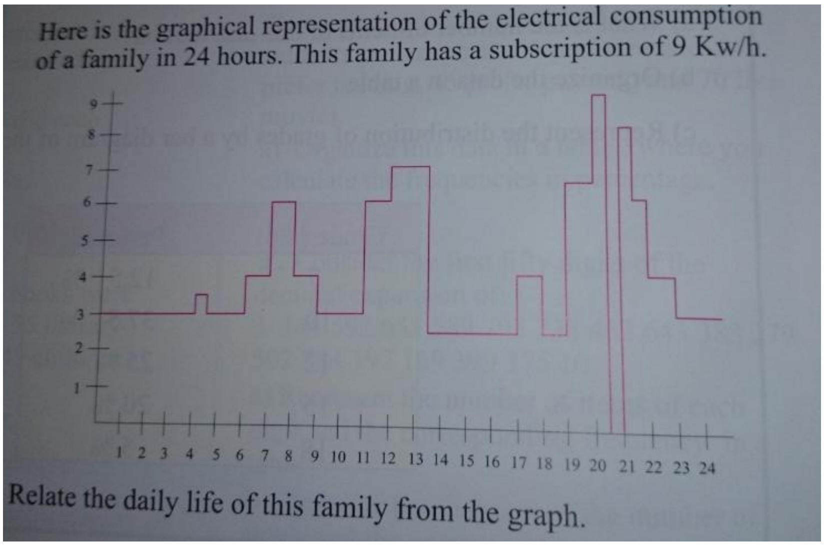
  At the beginning of the lesson the following demonstration was given to students (page 126):



- Let's solve the equation $\frac{x(x-1)^2}{(x+3)(x-1)} = 0$:
  1. we find the values which make the denominator 0. These are 1 and 3; the expression is neither defined for $x = 1$, nor for $x = -3$;
  2. we simplify the rational expression : $\frac{x(x-1)^2}{(x+3)(x-1)} = \frac{x(x-1)}{x+3}$;
  3. we find the roots of the numerator thus obtained: 0 and 1;
  4. we keep the values for which the expression is defined; only one value in this example: 0.

Since this demonstration was given at the beginning of the chapter, then all student items that are similar to that given in the demonstration are considered routine items, including student item on page 130, number 16 a) which is : *Solve the following equation:* $\frac{2x+1}{x+1} = 0$

- Non routine: grade 7 textbook page 66, "Just for Fun":



This student item is considered to be non routine because this type of graph is not familiar to them and they can't read it as a regular line graph. So, they are required to be creative and independent thinkers to describe family activities that would lead to this graph.

- Grey area: Grade 8 textbook page 35: " Just for Fun"

> A frog wants to climb a stairway of 13 steps. It can jump one, two, or three steps. How many ways can it climb it?

This student item is considered a grey-area student item because it requires a little bit of thinking yet it is not completely novel to students.

Table 9 shows the percentage of routine, non-routine, and grey-area student items in the selected chapters of the ECRD NMT for grades 7, 8, and 9.

Table 9

The percentage of routine, non-routine, and grey-area student items in the selected chapters of the ECRD math textbooks for grades 7, 8, and 9

Grade level textbook	Chapter Number	Evaluating Problem Solving in the Chapters		
		Routine	Non-routine	Grey-area
Grade 7 textbook	Chapter 1	212 (97.248%)	4 (1.835%)	2 (0.917%)
	Chapter 2	152 (96.203%)	1 (0.633%)	5 (3.165%)
	Chapter 3	142 (93.421%)	2 (1.316%)	8 (5.263%)
	Chapter 4	82 (87.234%)	5 (5.319%)	7 (7.447%)
	Chapter 5	167 (91.257%)	9 (4.918%)	7 (3.825%)
	Chapter 6	88 (96.703%)	2 (2.198%)	1 (1.099%)
Global percentage		94.085%	2.567%	3.348%
Grade 8 textbook	Chapter 1	46 (86.792 %)	1 (2.857 %)	6 (11.321 %)
	Chapter 2	82 (97.619 %)	1 (1.190 %)	1 (1.190 %)
	Chapter 3	85 (96.591 %)	1 (1.136 %)	2 (2.273 %)
	Chapter 4	135 (90 %)	3 (2 %)	12 (8 %)
	Chapter 5	131 (92.908 %)	0 (0 %)	10 (7.092 %)
	Chapter 6	53 (94.643 %)	1 (1.786 %)	2 (3.571 %)
Global percentage		93.007%	1.224 %	5.769%
Grade 9 textbook	Chapter 1	252 (95.817%)	1 (0.380 %)	10 (3.80 %)
	Chapter 2	125 (91.912 %)	1 (0.735 %)	10 (7.353 %)
	Chapter 3	77 (83.696 %)	3 (3.361 %)	12 (13.043 %)
	Chapter 4	165 (91.667 %)	4 (2.222 %)	11 (6.111 %)
	Chapter 5	352 (97.507 %)	4 (1.108 %)	5 (1.385 %)
	Chapter 6	55 (94.828 %)	1 (1.724 %)	2 (3.449 %)
Global percentage		94.128 %	1.284%	4.587%

From table 9, we can notice that the analyzed chapters of the intermediate math textbooks do not reflect a balance between routine, non-routine, and grey-area student items. On the contrary, out of the 18 chapters selected the least percentage of routine student items found was 83.696% while it reached a maximum of 97.619%, and for the non-routine items their percentage ranged from 0% to 5.319% maximum. As for the grey-area student items, the maximum percentage found in the selected chapters was 13.043%. It can also be noticed from the table that there is no significant difference in the percentages of routine, non-routine, and grey-area problems among the three different grade level textbooks since the global percentages per grade level are very close to each other.

4.3.2- General Objective 2: Mathematical Reasoning

According to TIMSS 2011 framework (Mullis et al., 2009) there are five behaviors that reflect reasoning which are (1) analysis, (2)making generalizations/ specifications, (2) synthesizing, (3) justifying, and (4) solving non – routine problems. So, in order for textbook material to be designed towards developing students' reasoning, student items should require students to demonstrate the latter behaviors to provide a response.

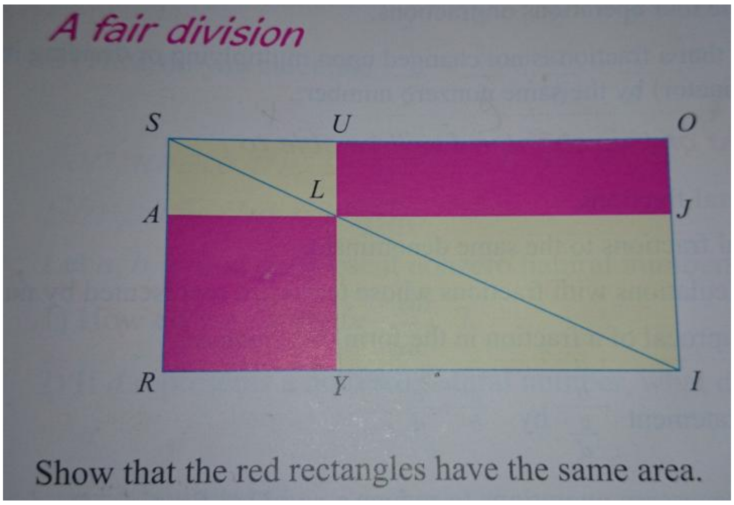
Examples of student items extracted from the three NMT are provided to demonstrate how they were linked to the different behaviors of reasoning:

- **Analyze and generalize**: grade 9 textbook page 45, activity 2.

  1) *Choose a value 'a' different than 0, and draw the line y=ax in a system of axes x'Ox, y'Oy.*
  2) *In the same system, draw the line of equation y=* $-\frac{1}{a}x$.
  3) *What relation exists between the lines just drawn? ←Analysis*
  4) *Verify the result with your classmates.*
  5) *Can you formulate a general rule? ← generalization*

Part 3) requires analysis because it requires students to determine a relationship between the two lines drawn in the figure. Whereas part 5) requires generalization because it requires students to generalize the mathematical results they got in part 3 by restating them in more widely applicable terms.

- **Synthesize**: grade 8 textbook, page 59, " Just for Fun"



This student item requires synthesis because it requires students to make links between math ideas and to perform and combine several steps in order to come up with the result.

- **Justify**: grade 8 textbook, page 58, number 2, part b:

  Construct another rectangle PURE in which the diagonals are perpendicular. What is the nature of PURE? Justify your answer.

In part b) students should provide a justification by referring to known mathematical properties (properties of a rectangle and properties of a square).

Table 10

The percentage of student items in the selected chapters of the ECRD math textbooks that reflect reasoning based on the TIMSS 2011 framework

Grade Level Textbook	Chapter Number	Evaluating Textbook Materials for Reasoning Based on the TIMSS 2011 Framework				
		Analysis	Generalizations/ specialization	Inferences or synthesizing	Justifications	Non-routine problems
Grade 7 textbook	Chapter 1	16 (7.34%)	0 (0%)	0 (0%)	3 (1.376%)	4 (1.835%)
	Chapter 2	10 (6.33%)	0 (0%)	19 (12.025%)	4 (2.532%)	1 (0.633%)
	Chapter 3	8 (5.263%)	0 (0%)	23 (15.132%)	0(0%)	2 (1.316%)
	Chapter 4	14 (14.894%)	0 (0%)	33 (35.106%)	2 (2.128%)	5 (5.319%)
	Chapter 5	8 (4.372%)	0 (0%)	39 (21.311%)	5 (2.732%)	9 (4.818%)
	Chapter 6	18 (19.78%)	0 (0%)	3 (3.297%)	0 (0%)	2 (2.198%)
Global percentage		8.258 %	0%	13.058%	1.562%	2.567%
Grade 8 textbook	Chapter 1	6 (11.321%)	0 (0%)	14 (26.415%)	0 (0%)	1 (2.857%)
	Chapter 2	5 (5.952%)	0 (0%)	13 (15.476%)	2 (2.381%)	1 (1.190%)
	Chapter 3	13 (14.773)	1 (1.136%)	16 (18.182%)	6 (6.682%)	1 (1.136%)
	Chapter 4	21 (14%)	0 (0%)	29 (19.333%)	0 (0%)	3 (2%)
	Chapter 5	31 (21.986%)	0 (0%)	12 (8.511%)	1 (0.709%)	0 (0%)
	Chapter 6	9 (16.071%)	1 (1.786%)	6 (10.714%)	0 (0%)	1 (1.786%)
Global percentage		14.860%	0.35%	15.734%	1.573%	1.224%
Grade 9 textbook	Chapter 1	17 (6.464%)	1 (0.38%)	12 (4.563%)	13 (4.943%)	1 (0.38%)
	Chapter 2	18 (13.235%)	0 (0%)	1 (0.735%)	4 (2.941%)	1 (0.735%)
	Chapter 3	11 (11.957%)	0 (0%)	15 (16.304%)	0 (0%)	3 (3.261%)
	Chapter 4	29 (16.111%)	0 (0%)	23 (12.778%)	1 (0.556%)	4 (2.222%)
	Chapter 5	11 (3.047%)	1 (0.277%)	11 (3.047%)	5 (1.385%)	4 (1.108%)
	Chapter 6	4 (6.9 %)	0 (0%)	3 (5.172%)	0 (0%)	1 (1.724 %)
Global percentage		8.257%	0.183%	5.963%	2.111%	1.284%

Table 10 shows the following observations:

- There aren’t any student items in the selected chapters of grade 7 textbook that require students to make generalizations. So, one aspect of reasoning is completely neglected. In grades 8 and 9 textbooks it can also be considered to be neglected since the global percentages of its occurrence in each of the textbooks are 0.35% and 0.183% respectively.
- In both grades 7 and 8, the student items that require synthesis are more than those that require the other behaviors of reasoning. Whereas for grade 9, student items that require analysis have the highest percentage. Having said that, it is important to note that the global percentage of student items that require analysis is 8.57% in grade 9.
- There is no significant difference in the percentage of student items that require justification among the three grade levels. It is also noticed that in each of the three textbooks, the chapters on Statistics don't require student to present any justification.
- As for the degree to which each grade level reflects reasoning, it can be noticed that the grade level textbook that has the highest percentage of student items that reflect reasoning is the grade 8 textbook with a total of 33.741%. Next is grade 7 with a total of 25.45%, then grade 9 with 17.798%.

4.3.3- General Objective 3: Establishing Connection between Mathematics and each of science and the surrounding reality.

4.3.3.1- Connection between mathematics and science:

In this study, we considered that a student item is designed to help students establish relationship between mathematics and science if it involves scientific content from any field of science (Physics, Chemistry, or Biology).

The following is an example of a student item that shows a connection between math and science. The student item is extracted from the Grade 9 math textbook, page 51, number 17:

> *A motor vehicle between Tripoli and Beirut, at a distance of 20 Km from Tripoli, starts towards Beirut at an average speed of 75Km/h.*
>
> a) *Write a relation to calculate, at a time* t, *the distance* d *of the vehicle from Tripoli*.

This student item shows a connection between math and science since students are required to use their knowledge of the concept and formula of speed (Physics) in order to be able to provide a response.

Table 11

The percentage of student items that are with or without scientific content in the selected chapters of the ECRD math textbooks for grades 7, 8, and 9

Grade Level Textbook	Chapter Number	Evaluating Textbook Material for Their Connection with Science	
		With	Without
Grade 7 textbook	Chapter 1	6 (2.752%)	212 (97.248%)
	Chapter 2	0 (0%)	158 (100%)
	Chapter 3	0 (0%)	152 (100%)
	Chapter 4	0 (0%)	94 (100%)
	Chapter 5	0 (0%)	183 (100%)
	Chapter 6	1 (1.099%)	90 (98.901%)
Global percentage		0.781%	99.219 %
Grade 8 textbook	Chapter 1	0 (0%)	53 (100%)
	Chapter 2	0 (0%)	84 (100%)
	Chapter 3	0 (0%)	88 (100%)
	Chapter 4	0 (0%)	150 (100%)
	Chapter 5	2 (1.418 %)	139 (98.582%)
	Chapter 6	0 (0%)	56 (100%)
Global percentage		0.4%	99.65%
Grade 9 textbook	Chapter 1	5 (1.901 %)	258 (98.099%)
	Chapter 2	0 (0%)	136 (100%)
	Chapter 3	0 (0%)	92 (100%)
	Chapter 4	0 (0%)	180 (100%)
	Chapter 5	0 (0%)	361(100%)
	Chapter 6	0 (0%)	58 (100%)
Global percentage		0.458 %	99.541%

In table 11, it can be clearly noticed that the sub objective "establishing connection between mathematics and science" has been clearly neglected when designing the textbook since out of the 18 selected chapters from the grades 7, 8, and textbooks, only 4 chapters include items that involve science content. Moreover, among these 4 chapters, the maximum percentage of student's items that connect mathematics to science is 2.752%.

4.3.3.2- Connection between mathematics and the surrounding reality:

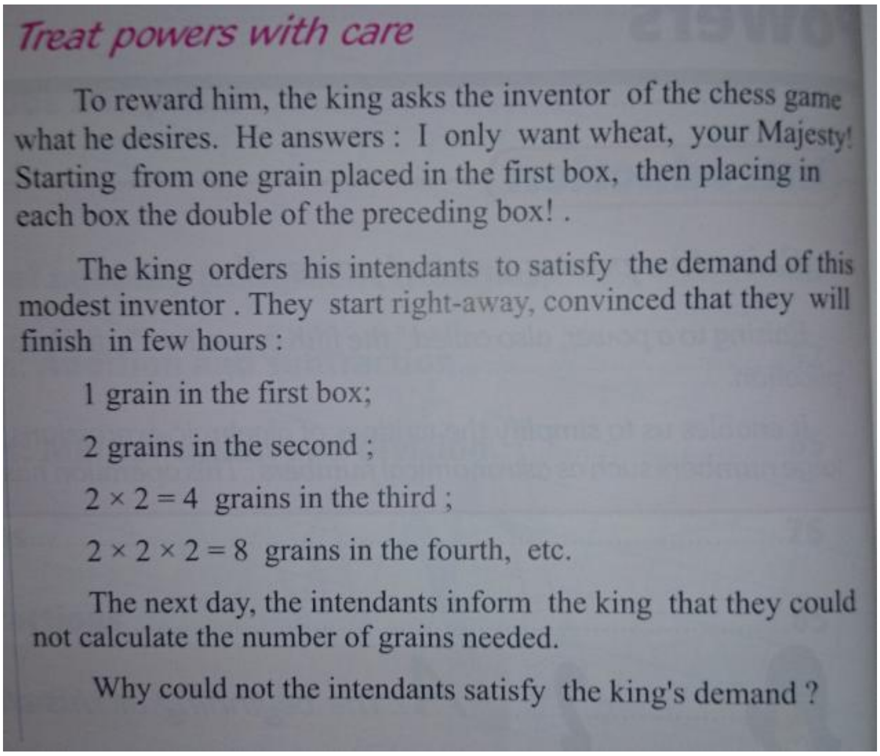
To check whether or not textbook material is designed to meet the general objective of the Lebanese curriculum that is related to establishing a connection between mathematics and the surrounding reality, student items in each of the selected chapters of the grades 7, 8, and 9 textbooks were classified as (1) purely mathematical – student items with no context, (2) semi- realistic – student items designed in a constructed reality that is not relevant to students' lives, and (3) real life student items that are within the realm of experiences of the students.
An example of each of the types is given below to demonstrate how the classification of the student items occurred:

1. Purely mathematical student item: Grade 9 textbook – page 84 – number 9:

   Solve the following inequality: $5(x-3)>3(x-10)$

This is an example of a purely mathematical student item because it is not embedded in any context.

2. Semi-real- student item: grade 7 textbook – page 21 – Just for Fun



Treat powers with care

To reward him, the king asks the inventor of the chess game what he desires. He answers : I only want wheat, your Majesty! Starting from one grain placed in the first box, then placing in each box the double of the preceding box! .

The king orders his intendants to satisfy the demand of this modest inventor . They start right-away, convinced that they will finish in few hours :

1 grain in the first box;

2 grains in the second ;

$2 \times 2 = 4$ grains in the third ;

$2 \times 2 \times 2 = 8$ grains in the fourth, etc.

The next day, the intendants inform the king that they could not calculate the number of grains needed.

Why could not the intendants satisfy the king's demand ?

This student item is considered semi-real because the context is not real to students. It is obvious that the story is not relevant to students' every-day life.

3. Real life student item: Grade 8 textbook – page 176 – number 4

> *Mom poured a mug of milk and one of chocolate for her children, Nada and Rami. The kids decided to mix their mugs by pouring them into the third.*
> *Assuming that the three mugs have the same height of 10 cm, and each of the first two mugs has a diameter of 7 cm, what should be the diameter of the third mug if the poured liquid did not over flow?*

This student item is classified as real life student item because students can investigate it to find the response, or they can visualize the situation because we've all had experience where we had to mix things into a bigger bowl and asked ourselves it would fit or not.

Table 12

The percentage of purely mathematical, semi-real, and real-life student items in the selected chapters of the ECRD math textbooks for grades 7, 8, and 9

Grade Level Textbook	Chapter Number	Evaluating Textbook Material for Their Degree of Realism		
		Purely Mathematical	Semi-Real	Real-life
Grade 7 textbook	Chapter 1	202 (92. 661%)	8 (3.67%)	8 (3.67%)
	Chapter 2	158 (100%)	0 (0%)	0 (0%)
	Chapter 3	144 (94.737%)	8 (5.263%)	0 (0%)
	Chapter 4	91 (96.809%)	3 (3.319%)	0 (0%)
	Chapter 5	161 (87.978%)	13 (7. 104%)	9 (4.918%)
	Chapter 6	38 (41.758%)	45 (49.451%)	8 (8.791%)
Global percentage		88.616%	8.593%	2.790 %
Grade 8 textbook	Chapter 1	44 (83.019%)	6 (11.321%)	2 (3.774%)
	Chapter 2	84 (100%)	0 (0%)	0 (0%)
	Chapter 3	88 (100%)	0 (0%)	0 (0%)
	Chapter 4	148 (98.667%)	3 (2%)	0 (0%)
	Chapter 5	133 (94.326%)	6 (4.255%)	2 (1.418%)
	Chapter 6	25 (44.643%)	31 (55.357%)	0 (0%)
Global percentage		91.258%	8.042 %	0.699%
Grade 9 textbook	Chapter 1	242 (92.015%)	17 (6.464%)	4 (1.521%)
	Chapter 2	107 (78.676%)	19(13.971%)	0 (0%)
	Chapter 3	89 (96.74%)	3 (3.261%)	0 (0%)
	Chapter 4	180 (100%)	0 (0%)	0 (0%)
	Chapter 5	357 (98.892%)	4 (1.108%)	0 (0%)
	Chapter 6	23 (39.655%)	33(56.9%)	2 (3.448%)
Global percentage		91.56 %	6.972%	0.550%

Table 12 shows the following observations:

- The global percentages of items that are real life are 2.790%, 0.699%, and 0.55% for grades 7, 8, and 9 textbooks respectively. The latter results show that as the grade level is higher, the percentage of real life items decreases. In addition, the global percentage of semi-real items decreases from grade 7 to grade 9 by 1.621% whereas the global percentage of items that are purely mathematical increased from 88.616% in grade 7 textbook to 91.56% in the grade 9 textbook.
- In each of grades 7 and 8 NMT, the discipline that includes the least percentage of purely mathematical student items is statistics. Next are number theory, algebra, and finally geometry; having the highest percentage of student items that are purely mathematical. Moreover, it is important to note that, in grades 7 and 8 textbook, three out of the four selected chapters from the discipline of Geometry are 100% purely mathematical. In grade 9 textbook, the discipline that includes the least percentage of purely mathematical items is also statistics. Next is algebra, geometry, and finally number theory.
- Therefore, it is important to note that without the chapters of statistics, the global percentage of items that are purely mathematical would have been much higher in each of the grade level textbooks.

4.3.4- General Objective 4: Communicate Mathematically

In order to evaluate the NMT based on the degree to which they are designed to achieve the general objective related to developing students' communication skills in mathematics, the percentage of student items in each of the three textbooks of the intermediate level that reflect each of the following aspects of communication in mathematics was calculated:

- Read, understand, or interpret mathematical texts.
- Use various forms of representations (charts, tables, diagrams, drawing, equation, etc.).
- Use correct mathematical language in expressing information.

The following student items from the three textbooks are given to demonstrate an example of each of the three communication skills:

- **Read, understand, or interpret mathematical texts:** from grade 7 textbook:

  If you ask a chemist why wood or charcoal do not burn except at a high temperature, he will answer that the combination of carbon with oxygen takes place, in fact, at all temperatures; however, at low temperatures, this process is very slow, and for this reason, it escapes observation. The law that defines the speed of chemical reactions states that for each fall of 10^o, the speed of the reaction diminishes by half.
  Assume that if the temperature of the flame is equal to 600^o, one gram of wood burns per second. How much time would it take one gram of wood to burn at temperature 20^o?

This student item is one that requires students to "read, understand, or interpret mathematical texts" since there is a lot of information that is included in the text. So they need to read, understand and interpret in order to identify relevant and irrelevant information that they should use to find the answer.

- **Use various forms of representations**: from grade 9 textbook, page 87, number 8, parts f) and g).

Part f) Determine the values of x for which we have
$$\frac{2}{3}x + 4 \leq x + 2 \leq 2x$$
Part g) How can you obtain these results graphically?

Part g) is an example of a student item that requires students to use various forms of representations since it requires the student to get the answer of part f) again but using a different form of representation.

- **Use correct mathematical language in expressing information:**

  from grade 8 textbook, page 31, preparatory activity:

  What is a prime number?

  - *From grade 8 textbook, page 43, number 10, part c:*

    What property is satisfied by points A, I, and J? Prove this property.

The two examples from the grade 8 textbook both require students to express information or to express their reasoning. Although, one requires higher communication skills than the other, they are both classified under the umbrella of "using mathematical language in expressing information"

Table 13

The percentage of student items in the selected chapters of the ECRD math textbooks that reflect communication in mathematics

Grade Level Textbook	Chapter Number	Evaluating Textbook Material for Their Level of Communication		
		Read, understand, or interpret mathematical texts	Using various forms of representations	Using of correct mathematical language in expressing information
Grade 7 textbook	Chapter 1	2 (0.917%)	0 (0%)	4 (1.835%)
	Chapter 2	1 (0.633%)	0 (0%)	38 (24.051%)
	Chapter 3	7 (4.605%)	0 (0%)	2 (1.316%)
	Chapter 4	13 (13.83%)	0 (0%)	32 (34.043%)
	Chapter 5	15 (8.197 %)	0 (0%)	8 (4.372%)
	Chapter 6	0 (0%)	18 (19.78%)	2 (2.198%)
Global percentage		4.24%	2.001%	9.598 %
Grade 8 textbook	Chapter 1	5 (9.434%)	0 (0%)	4 (7.547%)
	Chapter 2	0 (0%)	0 (0%)	15 (17.857%)
	Chapter 3	0 (0%)	0 (0%)	37 (42.045%)
	Chapter 4	3 (2%)	0 (0%)	4 (2.667%)
	Chapter 5	7 (4.965%)	56 (39.716%)	2 (1.418%)
	Chapter 6	2 (3.571%)	22 (39.286%)	5 (8.929%)
Global percentage		2.972%	13.636%	11.713%
Grade 9 textbook	Chapter 1	7 (2.662%)	0 (0%)	16 (6.084%)
	Chapter 2	7 (5.147%)	14 (10.294%)	11(8.088%)
	Chapter 3	2 (2.174%)	11 (11.957%)	2 (2.174%)
	Chapter 4	2 (1.111%)	1 (0.556%)	79 (43.889%)
	Chapter 5	0 (0%)	0 (0%)	58 (16.067%)
	Chapter 6	1 (1.724%)	23 (39.655%)	2 (3.448%)
Global percentage		1.743%	4.495%	15.413%

The following information can be extracted from the table 13,

- The global percentages of student items that require students to read, understand, or interpret mathematical texts in the grade 7 , 8, and 9 textbooks are 4.24%, 2.972%, and 1.743% respectively, thus showing a low percentage of items addressing this communication skill. It also shows that the selected chapters of the grade 7 textbooks exhibit more of this skill in comparison with those of grades 8 and 9 textbooks. Moreover, in the grades 7 and 9 textbooks, the chapters on Algebra include the highest percentage of student items that require reading, understanding, and interpreting mathematical texts, then comes geometry, number theory, and finally statistics. As for the grade 8 textbook, the distribution of this skill among the domains is different as it is the highest in algebra, then geometry, number theory, and finally statistics.

- Moreover, 1 out of 6 chapters, 2 out of 6 chapters, and 4 out of 6 chapters from the grade 7, 8, and 9 textbooks respectively involve student items that require the use of various forms of representations. The global percentages of this skill in grades 7, 8, and 9 are 2.001%, 13.636%, and 4.95% respectively, thus showing that this skill gets the highest percentage in grade 8 textbook, then in grade 9 textbook, and the least percentage in grade 7 textbook. In addition, it can be noticed that in three grade levels, the student items that require students to use various forms of representations are mainly evident in the chapters of statistics but are completely absent in chapters on geometry.
- In grades 7 and 8 textbooks, the selected chapters related to geometry include the highest percentage of student items that require students to use correct mathematical language in expressing information. Whereas in grade 9, the chapters on geometry include the second highest percentage of items that reflect this communication skill (the first being Number theory). As for the other domains no pattern is found across grade level NMT. Moreover, it can be noticed that the global percentage of student items that require the use of correct mathematical language in expressing information in each of grade 7, 8, and 9 are 9.598%, 11.713%, and 15.413% respectively thus

showing that as the grade level becomes higher, the percentage of students items that require expressing information becomes higher.

- In total, if we calculate the percentage of items that reflect each of the three different communication skills out of the total number of items for each grade level we get the following results:
  - 15.848% of the student items in the selected chapters of the grade 7 textbook aim at developing students' communication in mathematics.
  - 28.32% of the student items in the selected chapters of the grade 8 textbook aim at developing students' communication in mathematics.
  - 21.651% of the student items in the selected chapters of the grade 9 textbook aim at developing students' communication in mathematics.

  Therefore, one can deduce that the grade 8 textbook is the most reflective of the general objective "developing students' communication in mathematic". Next is the grade 9 textbook, then the grade 7 textbook with least percentage of student items that require students to communicate mathematically.

4.4- The alignment of the Brevet tests (BT) with the general objectives of the Lebanese math curriculum (GOMC):

Eighteen Brevet test for the respective years 2001, 2002, 2003, 2006, 2007, 2008, 2011, 2012, and 2013 (sessions 1 and sessions 2) were analyzed the same way the textbooks were analyzed; the total number of student items in each test is identified (table 14), afterwards, each test item was evaluated based on the sets of criteria designed for each of the four general objectives. The comparison of the BT will take place according to the following aspects:

- The brevet tests of the years 2001-2003 will be compared to the tests of the years 2006-2008, and both will then be compared to the tests of the years 2011-2013 for each of the criteria reflecting the four general objectives of the Lebanese math curriculum. These comparisons aim at studying the evolution of the Brevet tests, as pertains to the general objectives, since the creation of the 1997 reformed curriculum.
- A comparison between all session 1 and 2 tests of the 9 selected years. (Table 15 shows the total number of items in session 1 and session 2 BT tests in the different sets of years)

Table 14

The total number of student items in the selected BT

Selected BT	The Number of Items in the BT
2001 Brevet Test (session 1)	45
2001 Brevet Test (*session 2*)	36
2002 Brevet Test (session 1)	39
2002 Brevet Test (*session 2*)	31
2003 Brevet Test (session 1)	35
2003 Brevet Test (*session 2*)	38
Total Student Items	224
2006 Brevet Test (session 1)	43
2006 Brevet Test (*session 2*)	33
2007 Brevet Test (session 1)	45
2007 Brevet Test (*session 2*)	47
2008 Brevet Test (session 1)	48
2008 Brevet Test (*session 2*)	58
Total Student Items	274
2011 Brevet Test (session 1)	58
2011 Brevet Test (*session 2*)	40
2012 Brevet Test (session 1)	55
2012 Brevet Test (*session 2*)	38
2013 Brevet Test (session 1)	46
2013 Brevet Test (*session 2*)	48
Total Student Items	285

Table 15

The total number of items in session 1 and session 2 BT in the different sets of years

Selected BT	The Number of Items in Sessions 1 and 2 in the BT
Session 1 2001-2003 tests	119
Session 1 2006- 2008 tests	136
Session 1 2011 -2013	159
Total Student Items	414
Session 2 2001-2003 tests	105
Session 2 2006-2008 tests	138
Session 2 2011-2013 tests	126
Total Student Items	369

4.4.1- General Objective 1: Solving Mathematical Problems

Table 16

The percentage of routine, non-routine, and grey-area student items in the selected Brevet tests

Selected BT	Criteria for Evaluating Problem Solving in the BT		
	Routine	Non-routine	Grey-area
2001 Brevet Test (session 1)	45 (100%)	0 (0%)	0 (0%)
2001 Brevet Test (*session 2*)	36 (100 %)	0 (0%)	0 (0%)
2002 Brevet Test (session 1)	38 (97.436 %)	0 (0%)	1 (2.564%)
2002 Brevet Test (*session 2*)	31 (100%)	0 (0%)	0 (0%)
2003 Brevet Test (session 1)	34 (97.143 %)	0 (0%)	1(2.857 %)
2003 Brevet Test (*session 2*)	36 (94.737 %)	0 (0%)	2 (5.263 %)
Global percentage	98.214%	0%	1.786%
2006 Brevet Test (session 1)	42 (97.674 %)	0 (0%)	1 (2.326%)
2006 Brevet Test (*session 2*)	33 (100 %)	0 (0%)	0 (0%)
2007 Brevet Test (session 1)	(44) 93.617 %	0 (0%)	(3) 6.382%
2007 Brevet Test (*session 2*)	47 (100%)	0 (0%)	0 (0%)
2008 Brevet Test (session 1)	48 (100%)	0 (0%)	0 (0%)
2008 Brevet Test (*session 2*)	58 (100%)	0 (0%)	0 (0%)
Global percentage	98.540 %	0 %	1.46%
2011 Brevet Test (session 1)	56 (96.552 %)	0 (0%)	2 (3.448%)
2011 Brevet Test (*session 2*)	40 (100%)	0 (0%)	0 (0%)
2012 Brevet Test (session 1)	55 (100%)	0 (0%)	0 (0%)
2012 Brevet Test (*session 2*)	36 (94.737%)	0 (0%)	2 (5.263%)
2013 Brevet Test (session 1)	46 (100 %)	0 (0%)	0 (0%)
2013 Brevet Test (*session 2*)	47 (97.917 %)	0 (0%)	(1) 2.083%
Global percentage	98.246%	0%	1.754%

From table 16, it is noticed that the Brevet tests do not reflect a balanced distribution between routine, non routine and grey area problems. On the contrary, there is a complete absence of non-routine problems throughout the eighteen selected brevet tests. In other words, all student items included in the Brevet tests are also found in the ECRD textbooks that students use throughout their school year. Therefore, none of the student items are completely novel to students to be considered non routine. It is also remarkable to note that 10 out of 18 selected brevet test are purely mathematical thus suggesting a lack of alignment between the brevet tests and the general objective of the Lebanese math curriculum that is related to developing students' problem solving skills.

As for the occurrences of grey area problems, the maximum percentage of student items found in a brevet test is 6.382%, also suggesting a discrepancy in the distribution of the three types of problems. However, it is important to note that within the sample chosen, it was found that there was a repetition of exercises among different assessments. For example:

Considering 2006 Brevet test- session 2:

- Number I: is the same as in 2003 Brevet test – session 1
- Numbers II and III: are the same as in 2002 Brevet test – session 1
- Number IV: is the same as in 2001 Brevet test- session 2
- Number V: is the same as number V in Brevet session 1 except for part 5

This can create a problem since teachers use previous Brevet tests in class as basis for preparing students to their Brevet test. So, even if the exercise was to be considered "grey area" it is actually "routine" because students have been already exposed to it several times during their school year.

Moreover, it can be noticed that in the set of years 2001-2003, the percentage of items that are routine have decreased from 2001 to 2003 in both of session 1 and session 2 tests. Consequently, the percentage of grey-area problems increased in both of session 1 and session 2 tests. In the session 1 tests of set of years 2006-2008, the percentage of items that are routine decreased from the year 2006 to 2007 then increased in 2008 to reach 100%; consequently the percentage of grey-area student items has increased from 2006 to 2007 and then decreased in 2008 to reach 0%. On the other hand, routine items get 100% of the total items and grey area problems get 0% of the total items in session 2 tests of the latter years. In the session 1 BT of the set of years 2011-2013, the percentage of items that are routine increases from 96.552% in 2011 to 100% in 2012 and 2013; consequently, the percentage of items that are grey items decreased from 3.448% in 2011 to 0% in the years 2012 and 2013. However, in session 2 tests of the latter years, the percentage of routine items decreased from 100% in 2011 to 94.737% in 2012, and then increased again in 2012 to 97.917%, therefore inducing an opposite pattern for the percentage of grey-area problems along the latter years.

Comparing 2001-2003 tests, 2006-2008 tests, and 2011 to 2013 tests:

From table 16, it can be noticed that there is no significant changes in the percentage of routine, non-routine, and grey-area problems along the different BT from year 2001 to 2013 suggesting that the level of alignment of the brevet test with the general objective related to reasoning has not evolved throughout the years.

Comparing Globally Session 1 Brevet tests to session 2 Brevet tests:

Table 17

The percentage of routine, non-routine, and grey-area student items in session 1 and session 2 Brevet tests

	Session 1 Tests			Session 2 tests		
Different sets of years ↓	Routine student items	Non-routine student items	Grey-area student items	Routine student items	Non-routine student items	Grey-area student items
2001-2003	98.319%	0%	1.681%	98.095%	0%	1.905%
2006-2008	98.529%	0%	1.471%	100%	0%	0%
2011-2013	98.742%	0%	1.258%	97.619%	0%	2.381%
Global percentage	**97.608%**	**0%**	**2.392%**	**98.645%**	**0%**	**1.355%**

From table 17, it can be noticed that there is no difference between the global percentages of sessions 1 and 2 as the global percentage of routine items in both sessions is ranges approximately between 98% and 99%. It can also be noticed that all the session 2 BT from year 2006-2008 include 100% routine items, showing complete negligence of one of the GOMC.

4.4.2- General Objective 2: Mathematical Reasoning

Table 18

The percentage of student items in the selected brevet tests that reflect reasoning based on the TIMSS 2011 framework

Selected Brevet Tests	Criteria for Evaluating BTs for Reasoning Based on the TIMSS 2011 Framework				
	Analysis	Generalizations/ specialization	Inferences or synthesizing	Justifications	Non-routine problems
2001 Brevet Test (session 1)	4 (8.889%)	0 (0%)	2(4.444%)	0 (0%)	0 (0%)
2001 Brevet Test (*session 2*)	4 (11.111) %	0 (0 %)	1 (2.778 %)	2 (5.556 %)	0 (0%)
2002 Brevet Test (session 1)	7 (17.949%)	0 (0%)	3 (7.692%)	1 (2.564%)	0 (0%)
2002 Brevet Test (*session 2*)	2 (6.452 %)	0 (0%)	3 (9.677%)	2 (6.453%)	0 (0%)
2003 Brevet Test (session 1)	4 (11.429%)	0 (0%)	1 (2.857%)	0 (0%)	0 (0%)
2003 Brevet Test (*session 2*)	6 (15.79%)	0 (0%)	1 (2.632%)	2 (5.263%)	0 (0%)
Global percentage	12.053%	0%	4.911%	3.125%	0%
2006 Brevet Test (session 1)	7 (16.28 %)	0 (0%)	1 (2.326%)	5 (11.628%)	0 (0%)
2006 Brevet Test (*session 2*)	4 (12.121%)	0 (0%)	3 (9.091%)	0 (0%)	0 (0%)
2007 Brevet Test (session 1)	11 (24.44 %)	(0) 0%	3 (6.667%)	1 (2.222%)	0 (0%)
2007 Brevet Test (*session 2*)	14 (29.787%)	(0) 0%	3 (6.383%)	2 (4.255%)	0 (0%)
2008 Brevet Test (session 1)	16(33.333%)	(0) 0%	4 (8.333%)	(0) 0%	0 (0%)
2008 Brevet Test (*session 2*)	20 (34.483%)	(0) 0%	1 (1.724%)	(0) 0%	0 (0%)
Global percentage	26.277%	0%	5.474%	2.92%	0%
2011 Brevet Test (session 1)	12 (20.69%)	0 (0%)	5 (8.621%)	7 (12.069%)	0 (0%)
2011 Brevet Test (*session 2*)	6 (15%)	0 (0%)	8 (20%)	1 (2.5%)	0 (0%)
2012 Brevet Test (session 1)	6 (10.909%)	0 (0%)	8 (14.545%)	10 (18.182%)	0 (0%)
2012 Brevet Test (*session 2*)	8 (21.053%)	0 (0%)	7 (18.421%)	2 (5.263%)	0 (0%)
2013 Brevet Test (session 1)	10 (21.739%)	0 (0%)	2 (4.348%)	0 (0%)	0 (0%)
2013 Brevet Test (*session 2*)	13 (27.083%)	0 (0%)	1 (2.083%	0 (0%)	0 (0%)
Global percentage	19.298%	0%	10.877%	7.018%	0%

- Table 18 shows the following observations:
  - The reasoning skill that is most reflected throughout all the BTs is "analyzing" as it gets the highest percentage of items in 15 out of 18 of the selected BT. As to "synthesizing", it gets the highest percentage of items in 3 out of 18 of the selected BT, and the second highest percentage in the rest of the tests.
  - Moreover, 7 out of the 18 selected BT do not include any test items that require justification and none of the selected tests require the student to solve non-routine problems. However, all of the selected tests include both synthesis and analysis.
  - In the session 1 tests of the set of years 2001-2003, the percentage of items that require "analysis" has increased from 2001 to 2002 and then decreased in 2003. The opposite pattern is found in session 2 tests of the latter years. In the sets of years 2006-2008, both session 1 and session 2 tests show an increase in the percentage of items that reflect analysis throughout the years. An increase in the latter reasoning skill is also evident in session 2 tests of the years 2011-2013, where the percentage of items that require analysis has increased from 15% in 2011 to 27.83% in 2013. As for session 1 tests of the years 2011-2013, the percentage of items that require analysis has decreased from 2011 to 2012 and then increased in 2013.
  - In both session 1 and session 2 of the years 2001-2003, the percentage of items that require synthesis has increased from 2001 to 2002 and then decreased in 2003. In the session 1 BT of the set of years 2006-2008, the percentage of items that require synthesis has increased from 2.326% in

2006 to 8.333% in 2008. However, in session 2 of the latter years the opposite pattern is evident as the percentage of items that require synthesis decreased from 9.091% in 2006 to 1.724% in 2008. As for the session 1 and 2 of the set of years 2011-2013, the percentage of items that require reasoning has decreased from 2011 to 2013.

- In addition, there is a constant decrease and increase in the percentage of items that require justifications throughout the years from 2001 to 2013.Moreover, throughout all the years the least number of items that require justification is 0% whereas the highest is 18.182%.

Comparing 2001-2003 tests, 2006-2008 tests, and 2011-2013tests:

- In comparison among the three sets of years, the 2006-2008 brevet tests include the highest percentage of test items that require synthesis which is 26.277%. Next are the 2011-2013 brevet tests with 19.298%, and then comes the 2001-2003 tests which include 12.053% of test items that require reasoning.
- There is no significant difference in the percentage of test items that require justification between the two sets of years 2001-2003 and 2006 -2008 (approximately 3%). However, the percentage of test items that require justification in the 2011-2013 brevet tests is higher than those in the previous sets of years (approximately 7%).
- The percentage of items that require synthesis has increased throughout the years as the global distribution among the years is 4.911%, 5.474, and 10.877% for the 2001-2003, 2006-2008, and 2011-2013 tests respectively. However, student items that require analysis get the highest percentage in the

years 2006-2008 (26.277%), then in 2011-2013 (19.298%), and the least being in the years 2001-2003 (12.053%).

- As for the degree to which each grade level reflects reasoning, it can be noticed that the highest percentage of reasoning is found in the 2011-2013 test with 37.193% of reasoning, then in 2006-2008 brevet test with 34. 672%. Finally, the lowest share goes to the 2001-2003 tests with 20.089%, thus showing that the percentage of reasoning has increased throughout the years.

Comparing Globally Session 1 Brevet tests to session 2 Brevet tests:

Table 19

The percentage of student items in session 1 and session 2 BT that reflect reasoning based on the TIMSS 2011 framework

Different groups of years ↓	Total Reasoning	
	Session 1 Tests	Session 2 tests
2001-2003	18.487%	21.905%
2006-2008	35.294%	34.058%
2011-2013	37.735%	36.508%
Global percentage	**31.401%**	**31.436%**

It can be noticed from table 19 the following:

- There is no significant difference in the distribution of reasoning among session 1 and session 2 tests along the different sets of years as the global percentage of reasoning for sessions 1 and 2 is approximately 31%.
- In both sessions 1 and 2, there is a remarkable increase of the percentage of reasoning over the years.

4.4.3- General Objective 3: Establishing Connection between Mathematics and each of science and the surrounding reality

4.4.3.1- Connection between mathematics and science:

Table 20

The percentage of student items with or without scientific content in the selected BT

Selected BT	Evaluating BT for Their Connection to Science	
	With	Without
2001 Brevet Test (session 1)	0 (0%)	45 (100%)
2001 Brevet Test (*session 2*)	0 (0%)	36 (100%)
2002 Brevet Test (session 1)	0 (0%)	39 (100%)
2002 Brevet Test (*session 2*)	0 (0%)	31 (100%)
2003 Brevet Test (session 1)	0 (0%)	35 (100%)
2003 Brevet Test (*session 2*)	0 (0%)	38 (100 %)
Global Percentage	0%	100%
2006 Brevet Test (session 1)	0 (0%)	43 (100%)
2006 Brevet Test (*session 2*)	0 (0%)	33 (100%)
2007 Brevet Test (session 1)	0 (0%)	45 (100%)
2007 Brevet Test (*session 2*)	0 (0%)	47 (100%)
2008 Brevet Test (session 1)	(0) 0%	48 (100%)
2008 Brevet Test (*session 2*)	0 (0%)	58(100%)
Global Percentage	0%	100%
2011 Brevet Test (session 1)	0 (0%)	58 (100%)
2011 Brevet Test (*session 2*)	0 (0%)	40 (100%)
2012 Brevet Test (session 1)	0 (0%)	55 (100%)
2012 Brevet Test (*session 2*)	0 (0%)	38 (100%)
2013 Brevet Test (session 1)	0 (0%)	46(100%)
2013 Brevet Test (*session 2*)	0 (0%)	48 (100%)
Global Percentage	0%	100%

As it can be noticed from table 20, the general objective "establishing connection between mathematics and the surrounding reality" is completely neglected throughout all the selected 18 Brevet tests.

4.4.3.2- Connection between mathematics and the surrounding reality:

Table 21

The percentage of purely mathematical, semi-real, and real-life student items in the selected Brevet tests

Selected BT	Criteria for Evaluating BTs for Their Degree of Realism		
	Purely Mathematical	Semi-Real	Real-life
2001 Brevet Test (session 1)	40 (88.889 %)	3 (6.667 %)	2(4.444 %)
2001 Brevet Test (*session 2*)	33 (91.667) %	0 (0%)	3 (8.333 %)
2002 Brevet Test (session 1)	39 (100%)	0 (0%)	0 (0%)
2002 Brevet Test (*session 2*)	27 (87.097%)	4 (12.903%)	0 (0%)
2003 Brevet Test (session 1)	34 (97.143%)	1 (2.857%)	0 (0%)
2003 Brevet Test (*session 2*)	35 (92.105%)	0 (0%)	3 (7.895%)
Global percentage	92.857%	3.571%	3.571%
2006 Brevet Test (session 1)	42 (97.674%)	1 (2.326%)	0 (0%)
2006 Brevet Test (*session 2*)	29 (87.879%)	0 (0%)	4 (12.121%)
2007 Brevet Test (session 1)	42 (93.333%)	3 (6.667%)	0 (0%)
2007 Brevet Test (*session 2*)	44 (93.617%)	3 (6.383%)	(0) 0%
2008 Brevet Test (session 1)	44 (91.667%)	4 (8.333%)	(0) 0%
2008 Brevet Test (*session 2*)	52 (89.655%)	2 (3.448%)	4 (6.897%)
Global percentage	92.335%	4.745%	2.92%
2011 Brevet Test (session 1)	49 (84.483%)	9 (15.517%)	0 (0%)
2011 Brevet Test (*session 2*)	34 (85%)	0 (0%)	6 (15%)
2012 Brevet Test (session 1)	53 (96.364%)	2 (3.366%)	0 (0%)
2012 Brevet Test (*session 2*)	30 (78.947%)	8 (21.053%)	0 (0%)
2013 Brevet Test (session 1)	44 (95.652%)	2 (4.348%)	0 (0%)
2013 Brevet Test (*session 2*)	48 (100%)	0 (0%)	0 (0%)
Global percentage	90.526%	7.368%	2.105%

Table 21 shows the following observations:

- Throughout the years, the percentage of purely mathematical items has kept on increasing and decreasing for both of sessions 1 and 2 of the BT. Moreover, the least percentage of purely mathematical items found in the selected BT is 78.947% whereas the highest is 100%.

- In addition, 2 out of the 18 selected tests don't include any semi-real nor real life student items. Moreover, 12 out of the 18 selected chapters don't include any real life student items, and for those that include real life items, their percentage ranges between 4.444% and 15%.
- In the session 1 and session 2 BT of the years 2001-2003 real life items are neglected in 3 out of the 6 tests whereas in the other 3 tests its occurrence ranges from 4.444% to 8.333%. In session 1 tests of the years 2006-2008, real life student items are completely neglected. In addition, in session 2 of the year 2007, real life student items are also neglected, whereas is session 2 BT real life student items get 12.121% and 6.897% of the total student items in the years 2006 and 2008 respectively. In all of session 1 and session 2 tests of the years 2011-2013, real life student items are also completely neglected except for the 2011 session 2 brevet tests where it gets 15% of the total student items.

Comparing 2001-2003 tests, 2006-2008 tests, and 2011-2013 tests:

Table 21 shows the following observations:

- The percentage of purely mathematical student items has slightly decreased throughout the years as the difference in the global percentage of purely mathematical items between the 2001 to 2003 tests and those of 2011 to 2013 is 2.331%.
- The percentage of real life items has also decreased throughout the years from 3.571% in 2001 to 2003 BTs to 2.105% in 2011 to 2013 BTs.

- On the other hand, the percentage of semi-real life items has increased over the years from 3.571% to 4.745% to 7.368% in 2001 to 2003, 2006 to 2008, and 2011 to 2013 test respectively.

Comparing Globally Session 1 Brevet tests to session 2 Brevet tests:

Table 22

The percentage of purely mathematical, semi-real, and real-life student items in session 1 and session 2 Brevet tests

Different sets of years ↓	Session Tests			Session 2 tests		
	Purely Mathematical	Semi-Real	Real-life	Purely Mathematical	Semi-Real	Real-life
2001-2003	94.958%	3.361 %	1.681%	90.476%	3.81%	5.714%
2006 -2008	94.118 %	5.882 %	0%	90.58%	3.623 %	5.797%
2011-2013	91.824 %	8.176 %	0%	88.889%	6.359 %	4.762 %
Global percentage	**93.478%**	**6.039 %**	**0.483 %**	**89.973%**	**4.607%**	**5.420 %**

Table 22 shows the following observations:

- Real life test items are completely absent from the 2006 to 2008 and the 2011 to 2013 session 1 tests thus affecting the global percentage of real life items in session 1 tests. Consequently, it can be noticed that the global percentage of real life items is less in session 1 tests than in session 2 tests with a difference of approximately 5%.
- In comparison, the global percentage of purely mathematical test student items is higher in the session 1 Brevet tests (93.478%) than in session 2 Brevet tests (89.973%). Moreover, semi real life items get a higher

percentage in session 1 Brevet tests than in session 2 Brevet tests with a difference of 1.432%.

4.4.4- General Objective 4: Communicate Mathematically

Table 23

The percentage of student items in the selected BT that reflect communication in mathematics

Selected BT	Criteria for Evaluating BTs for Their Level of Communication: Read, understand, or interpret mathematical texts	Use various forms of representations	Use of correct mathematical language in expressing information
2001 Brevet Test (session 1)	0 (0%)	0 (0%)	7(15.556 %)
2001 Brevet Test (*session 2*)	0 (0%)	0 (0%)	6 (16.667%)
2002 Brevet Test (session 1)	0 (0%)	0 (0%)	6 (15.385%)
2002 Brevet Test (*session 2*)	0 (0%)	1 (3.226%)	8 (25.806%)
2003 Brevet Test (session 1)	0 (0%)	0 (0%)	3 (8.571%)
2003 Brevet Test (*session 2*)	0 (0%)	0 (0%)	10 (26.316%)
Global percentage	0 (0%)	0.446%	17.857%
2006 Brevet Test (session 1)	0 (0%)	0 (0%)	16 (37.209%)
2006 Brevet Test (*session 2*)	0 (0%)	2 (6.061%)	8 (24.242%)
2007 Brevet Test (session 1)	1 (2.222%)	0 (0%)	12 (26.667%)
2007 Brevet Test (*session 2*)	4 (8. 511%)	(0) 0%	13 (27.68%)
2008 Brevet Test (session 1)	(0) 0%	1 (2.083%)	8 (16.667%)
2008 Brevet Test (*session 2*)	4 (6.897%)	(0) 0%	7 (12.069%)
Global percentage	3.285%	1.095%	23.358%
2011 Brevet Test (session 1)	3 (5.172%)	0 (0%)	10 (17.241%)
2011 Brevet Test (*session 2*)	5 (12.5%)	0 (0%)	12 (30%)
2012 Brevet Test (session 1)	3 (5.455%)	0 (0%)	21 (38.182%)
2012 Brevet Test (*session 2*)	9 (23.684%)	0 (0%)	11 (28.947%)
2013 Brevet Test (session 1)	0 (0%)	0 (0%)	11 (23.913%)
2013 Brevet Test (*session 2*)	0 (0%)	0 (0%)	13 (27.083%)
Global percentage	7.018%	0%	27.368%

Table 23 shows the following observations:

- Out of the eighteen selected BT, eleven tests don't include any student items that require reading, understanding or interpreting mathematical texts. For the seven tests left, there is an imbalance in the percentages of items that involve this skill as they range from to 2.22% to 23.684%.
- The communication skill "using various representations" is also neglected as 15 out 18 of the selected BTs don't include any student items that reflect this skill. Moreover, even if it was found, its maximum percentage is 6.061% of the total test items.
- The communication skill "expressing information in a mathematical way" is the most represented among the different communication skills as it is found in all the selected BTs. The percentage of these items that require expressing information ranges from 8.571% to 30% in the selected tests.
- In the set of years 2001-2003, the percentage of items that require students to read, understand, or interpret mathematical text is 0% over the years. The same results are evident also in the BT of the year 2006. After the year 2006, the percentage of the latter skills started increasing and decreasing throughout the years until it reached its highest level in session 2 of the 2012 BT. Unfortunately, it decreased back to 0% in the year 2013.
- As for the communication skill related to the use of various forms representations, it was almost neglected in the set of years 2001-2003 as only the session 2 BT of the year 2002 includes one student item that reflects this skill whereas the rest of the tests in this set of year completely neglects the latter skill. In the 2006-2008 set of years similar results are found as this skill is neglected in all of the session 1 and session 2 tests except for 2006 session

2 and 2008 BT. However, even in the latter tests, the skill of using various representations is barely reflected as it gets 6.061% and 2.083% of the total test items respectively. As for the years 2011-2013, this communication skill is completely neglected in all the BT. So, overall, the skill of using various representations was more or less neglected throughout all the selected years.

- It can be noticed that percentage of items that require students to express information decreased from 2001 to 2003 (sessions 1) from 15.556% to 8.571%, however an opposite pattern is found in the session 2 tests of the latter years as they increased from 16.667% in 2001 to 26.316% in 2003. As for the years 2006- 2008, the percentage of items that require expressing information in session 1 tests decreased over the years whereas the percentage of items of this skill in session 2 decreased from 2006 to 2007 but then increased in 2008. As for session 1 tests of the set of years 2011-2013, the percentage of items that reflect this communication skill increased then decreased the following year. For example percentage of items that require students to express information is 17.241% in 2011, it increased to 38.182% in 2012, and then decreased to 23.92% in 2013. As for the session 2 tests of the latter years, the percentage of this skill decreased from 2011 to 2013.

Comparing 2001-2003 tests, 2006-2008 tests, and 2011 to 2013 tests:

- Throughout the years it can be noticed that there is an increase in the global percentage of test items that require reading and interpreting texts as they increased from 0% to 3.285 to 7.018% in the years 2001to 2003, 2006 to 2008, and 2011-2013 respectively.

- A completely opposite pattern is noticed for the communication skill related to using various representations as the percentage of its occurrence in the tests has decreased throughout the years to reach 0% in the years 2011-2013.
- As for the communication skill "expressing information in a mathematical way", the global percentage items that require this skill increased throughout the years. In years 2001 to 2003 it is 17.857%, in 2006 to 2008 it is 23.358%, and finally in the years 2011 to2013 with 27.368%.

Comparing Globally Session 1 Brevet tests to session 2 Brevet tests:

Table 24

The percentage of student items in session 1 and session 2 Brevet tests that reflect communication in mathematics

	Total Test Items that Reflect Communication	
Different sets of ↓ years	Session 1 Tests	Session 2 tests
2001 to 2003	13.445 %	23.81 %
2006 to 2008	27.941 %	27.536 %
2011 to 2013	30.189 %	39.683 %
Global percentage	**24.638%**	**30.623 %**

Table 24 shows the following observations:

Overall, communication in mathematics gets a higher global percentage in sessions 2 than in session 1 tests where the percentage difference is 5.985%.

The latter difference is mainly evident in BTs of the years 2001 to 2003 and those of 2011-2013. However, in the years 2006-2008 no remarkable difference is observed between sessions 1 and 2 as they both include approximately 28% of items that reflect communication in mathematics.

4.5- Summary of the Findings:

The findings of this study show that in the OMCI, the general objective "developing reasoning" is highlighted the most whereas the general objective "establishing connection between mathematics and the surrounding reality" is highlighted the least. The other two general objectives are almost equally highlighted. At the level of the SOGLI, none of the objectives are fairly reflected. In the NMT, the majority of items are routine and only a small percentage of the tests items are non routine, real life situations, or show connection with science. The grades 7 and 8 textbooks include a fair percentage of student items that require reasoning and communication; however the latter two skills are only partially reflected as not all the skills embedded in them are included in the NMT. On the other hand, the grade 9 textbook shows a discrepancy in the representation of all of the four GOMC. As for the BT, it is evident that there is a slight improvement over the years as the percentage of items that reflect reasoning and communication has increased throughout the years. However, the BT as the NMT, include more procedural items that require direct application than those are non routine, real life situations, or show connection with science.

Chapter 5

Conclusions and Recommendations

5.1- Introduction

The purpose of this study was to evaluate the alignment of the General objectives of the Lebanese math curriculum (GOMC), the objectives of the math curriculum at the intermediate level (OMCI), the specific objectives at each grade level of the Intermediate level (SOGLI), the NMT at each of grade 7,8, and 9, and the official brevet tests (BT). The framework used to ensure the latter evaluation is based mainly on techniques of content analysis that involve qualitative and quantitative data collection and analysis methods.

The qualitative part is mainly the mapping of the GOMC with the OMCI or with those of the SOGLI. It also involves the evaluation of each student item in NMT and BTs based on the research based criteria designed for every GOMC.

The quantitative part involves the use of simple statistics such as averages and percentages to unify the basis of the analysis within different chapters and tests and to come up with conclusions related to the alignment of NMT and BTs with the GOMC, moreover to check the evolution in the alignment of the BTs over the years and to compare session 1 and session 2 BTs in terms of their alignment with the GOMC.

Care has been taken when evaluating student items based on a set of criteria, as a student item may involve more than one of the skills listed in the criteria. So, a student item was classified under the best fit skill that is reflected in it. In order for the classification not to be subjected to personal interpretation, and in order to increase its validity and reliability, the classification was performed separately by two researchers based on the definition of each classification in the criteria and then compared. In case of any disagreement, the two researchers discussed their points of views until an agreement was reached.

The tables that are used to classify students items based on the criteria designed for the four GOMC provide information on the percentages of student items in textbooks and BTs that address each of the four GOMC. The data in the tables are entered in the form of frequencies and percentages of student items within each criterion of the four general objectives. These data allow comparing different textbooks of the Intermediate level, different domains of mathematics within each textbook, session 1 and session 2 brevet math tests over the years, and session 1 and session 2 tests to each other.

The framework used to analyze the GOMC, the OMCI, the SOGLI, and the BTs was put in action to analyze the alignment of the Lebanese math curriculum. The result of the study would help educators understand the points of weakness of the curriculum where alignment is least evident. Such results will serve as a guide to improve the Lebanese math curriculum, its textbook, and assessment tools in terms of alignment.

5.2- Conclusions

The results of the analysis of the different components of the study that are obtained from the implementation of the methodological framework used are summarized as follows in relation to the three research questions of the study:

5.2.1- **Research question 1:** To what extent are the objectives of the math curriculum at the intermediate level (OMCI), and the specific objectives of each of the grades in the intermediate level (SOGLI) aligned with the general objectives of the Lebanese curriculum (GOMC)?

- The OMCI show an acceptable level of alignment with most of the GOMC as the general objective "developing reasoning" is highlighted the most whereas the general objective "establishing connection between mathematics and the surrounding reality" is highlighted the least. The remaining two general objectives are almost equally reflected.
- At the level of the SOGLI, signs of lack of alignment of the curriculum start showing as the number of specific objectives that reflect each of the four GOMC becomes very low. There is even one objective, "establishing connection between mathematics and each of science and the surrounding reality", that is completely neglected in each of grades 7, 8, and 9 specific objectives. As for the remaining three general objectives:
    - The percentages of specific objectives that reflect reasoning in grades 7, 8, and 9 are 7.03%, 7.19%, and 10.81% respectively. Thus showing that as the grade level gets higher, the percentage of specific objectives that reflects reasoning gets higher.
    - The percentage of specific objectives that reflect "communication in mathematics" is the highest in grade 8 with 9.35%, then in grade 7 with 8.59, and the lowest in grade 9 with 7.43%.

- The number of specific objectives that reflect "problem solving" does not exceed three specific objectives out of the total number of specific objectives in each of the three grade levels.

5.2.2- **Research question 2:** To what extent are the national math textbooks (NMT) reflective of the general objectives of the Lebanese Math curriculum (GOMC)?

- **<u>Grade 7 textbook</u>:**

  - <u>General objective 1</u>: Solving Mathematical Problems:

    - There is no balance in the percentage of routine, non-routine, and grey-area problems as the global percentage of routine items is 94.085% whereas the percentage of non-routine items and grey-area items together is 5.915%. Moreover, out of the 5.915%, only 2.567% are real life items. This imbalance in the distribution of the three types of problems suggests a lack of alignment between the grade 7 textbook and the general objective "solving mathematical problems".

  - <u>General objective 2</u>: Mathematical Reasoning:

    - In the selected chapters of the grade 7 textbook, the total percentage of student items that reflect reasoning is 25.45%. As stated earlier in the "Methodology" section, if reasoning encompasses approximately 25%

of the overall textbook material then the textbook is considered to be aligned with the general objective Mathematical reasoning (percentage taken from the TIMSS 2011 framework). Since reasoning gets 25.45% of the grade 7 textbook then the textbook is considered to be aligned with the general objective "mathematical reasoning". However, among the five behaviors that reflect reasoning, one of them (making generalizations) is completely neglected and two other behaviors (making justifications and solving non-routine problems) are barely reflected. So, only two out of the five behaviors that reflect reasoning (synthesis and analysis) are fairly represented in the grade 7 textbook. In other words, the grade 7 NMT is partially (not fully) aligned with the general objective "mathematical reasoning".

- General objective 3: Establishing connection between mathematics and each of science and the surrounding reality:

    - It is evident that there weren't intentions of designing student items that connect math to science as 99.219% of the student items don't involve any scientific content. Moreover, 88.616% of the student items are purely mathematical and out of the rest student items, only 2.790% are real life. The dominance of the purely mathematical problems and the very low percentage of real life items and of items with a scientific content all suggest a lack of alignment between the grade 7 textbook and the general objective "establishing connection between mathematics and each of science and the surrounding reality".

- General objective 4: Communicate mathematically:

  - This general objective gets 15.848% of the selected chapters of the grade 7 textbook. The latter percentage includes the student items that reflect any of the three communication skills. Moreover, it can be noticed from the results of the data analysis that one communication skill (the use of correct mathematical languages in expressing information) dominates the other two communication skills that are not are not fairly represented in the grade 7 textbook. All the later results show that the grade 7 textbook is not reflective of the fourth GOMC.

- **Grade 8 textbook:**

  - General objective 1: Solving Mathematical Problems:

    - There is no balance in the percentage of routine, non-routine, and grey-area problems in the grade 8 textbook as the global percentage of routine items is 93.007% of the total student items whereas the sum of the percentages of both non-routine items and grey area items is 6.993 %. Moreover, out of the 6.993%, only 1.224% are real life items. This imbalance in the distribution of the three types of problems shows that the student items in grade 8 textbook are not aligned with the general objective "solving mathematical problems".

- General objective 2: Mathematical Reasoning:

  - In the selected chapters of the grade 8 textbook, the total percentage of student items that reflect reasoning is 33.741%. Since we are considering the TIMSS framework as basis for judging the alignment of the textbook chapter with this general objective, then we may conclude that the grade 8 textbook is aligned with the GOMC that is related to reasoning. However, among the five behaviors that reflect reasoning, three out of the five behaviors (justifying, generalizing, and solving non-routine problems) are neglected as their occurrence ranges from 0.35% to 1.573% So, when it comes to this general objective, it is being partially reflected in the grade 8 textbook as only 2 out of the 5 behaviors (synthesis and analysis) that reflect reasoning are fairly represented.

- General objective 3: Establishing connection between mathematics and each of science and the surrounding reality:

  - A percentage of 99.65% of the total test items in the grade 8 textbooks don't involve any link between mathematics and science. Moreover, 91.258% of the student items are purely mathematical and out of the rest student items, only 0.699% are real life. The lack of occurrence of student items that involve scientific content or a connection between math and real life reflect a lack of alignment between the grade 8 textbook and the general objective "establishing connection between mathematics and each of science and the surrounding reality".

- <u>General objective 4</u>: Communicate mathematically:

  - A percentage of 28.32% of the grade 8 math textbook requires students to communicate mathematically. This percentage shows that the grade 8 textbook is reflective of the general objective related to communication in mathematics. However, one out of the three communication skills is not fairly reflected thus showing a partial alignment of the grade 8 textbook with the fourth GOMC.

- **<u>Grade 9 textbook</u>:**

  - <u>General objective 1</u>: Solving Mathematical Problems:

    - There is no balance in the percentage of routine, non-routine, and grey-area problems as the percentage of routine items is 94.128% of the total student items whereas the sum of the percentage of non-routine items and grey-area items is 5.871%. Moreover, out of the 5.871%, only 1.284% are real life items. This imbalance in the distribution of the three types of problems suggests a lack of alignment between the grade 9 textbook materials and the general objective "solving mathematical problems".

- General objective 2: Mathematical Reasoning:

  - In the selected chapters of the grade 9 textbook, the total percentage of student items that reflect reasoning is 17.798%. Since the latter percentage is less than the 25%, then the selected chapters of the grade 9 textbook are not considered to be aligned with the general objective "mathematical reasoning". In addition, among the five behaviors that reflect reasoning, three out of the five behaviors that reflect reasoning (making justifications, making generalizations, and solving non-routine problems) are neglected as their occurrence ranges from 0.183% to 2.111%. So, also among the items that require reasoning, only two out of the five behaviors that reflect reasoning (analysis and synthesis) are fairly represented. Consequently, the grade 9 textbook is partially aligned with the general objective related to reasoning.

- General objective 3: Establishing connection between mathematics and each of science and the surrounding reality:

  - No attention was given, while developing the textbooks, for designing student items that connect math to science as 99.541% of the student items don’t involve any scientific content. Moreover, 91.56% of the student items are purely mathematical and out of the remaining student items, only 0.55% are real life. The dominance of the purely mathematical problems and the very low percentage of real life items and of items with a scientific content show that the grade 9 textbook failed to reflect the third GOMC.

- General objective 4: Communicate mathematically:

  - This general objective gets 21.651% of the selected chapters of the grade 9 textbook. The latter percentage is not enough to consider the grade 9 textbook to be reflective of the fourth GOMC. Moreover, among the items that require students to communicate mathematically, 1 of the 3 skills of communication (use correct mathematical language in expressing information) dominates the other two skills in its prevalence.

- **Grades 7,8, and 9 textbooks:**

  - General objective 1: Solving Mathematical Problems:

    - In the three grade-level textbooks, the student items in the selected chapters show a discrepancy in the distribution of routine, non-routine, and grey-area problems. This discrepancy shows that the textbooks at the intermediate level are not aligned with the general objective "solving mathematical problems".

- General objective 2: Mathematical Reasoning:

  - The results of the analysis of the grades 7, 8, and 9 textbooks show that the grades 7 and 8 textbooks are aligned with general objective "mathematical reasoning" whereas the grade 9 textbook is not reflective of it as the total percentage of students items that reflect reasoning is 7.202% less than the acceptable level of reasoning that should be included in the textbook (which is 25%). In addition, in the three textbooks, among the items that require reasoning, only 2 out of the 5 behaviors that reflect reasoning are fairly represented (synthesis and analysis) thus even in the cases of the grades 7 and 8 textbooks, the items are partially aligned with the general objective "mathematical reasoning".

- General objective 3: Establishing connection between mathematics and each of science and the surrounding reality:

  - The three textbooks of the intermediate level fail to reflect this general objective as barely any student items are designed to show connection between math and science or between math and the surrounding reality.

- General objective 4: Communicate mathematically:
  - This general objective is not fully represented in the three math textbooks of the intermediate level as in each textbook at least one of the three communication skills is neglected. However, in grade 8 textbook,

the total percentage of items that reflect communication is more or less acceptable, thus reflecting partial alignment of the latter textbook with the 4th GOMC.

- A summary of the latter results is provided in the following table:

Table 25

The alignment of the grades 7, 8, and 9 textbooks with the general objectives of the Lebanese math curriculum

	General Objectives of the Lebanese Math Curriculum			
	Objective 1: Develop mathematical reasoning	**Objective 2:** Solving mathematical problems.	**Objective 3:** Establishing a connection between mathematics and each of science and the surrounding reality.	**Objective 4:** Communicate mathematically
Grade 7 textbook	√	⊘	⊘	⊘
Grade 8 textbook	√	⊘	⊘	√
Grade 9 textbook	⊘	⊘	⊘	⊘

⊘ Not aligned
√ Partially aligned

5.2.3- **Research question 3:** Are the Brevet official exams aligned with the general objectives of the Lebanese math curriculum (GOMC)?

- General objective 1: Solving Mathematical Problems:

    - ***Comparing 2001-2003 tests, 2006-2008 tests, and 2011-2013tests:***

    - The analysis of the brevet tests shows that in each of the three sets of years, non- routine items are neglected since approximately 98% of the total student items in each set of years are strictly routine items.
  - ***Comparing Globally Session 1 Brevet tests to session 2 Brevet tests:***
    - Similar results are deduced from comparing session 1 brevet tests to those of session 2.

- <u>General objective 2</u>: Mathematical Reasoning:

  - ***Comparing 2001-2003 tests, 2006-2008 tests, and 2011-2013tests:***

    - The analysis of the brevet tests over the selected years shows that in each of the three sets of years, 2 out of the 5 behaviors that reflect reasoning (making generalizations and solving non routine problems) are completely neglected. Moreover, among the other three behaviors that reflect reasoning; "synthesis" is the skill that is most highlighted, and then comes "analyzing", then "justifying".
    - There is a noticeable increase in the global percentage of items that reflect reasoning over the years as it increased from 20.089% in the years 2001-2003 to 37.193% in the years 2011-2013.
    - Due to the latter results, tests of the years 2001-2003 are considered not aligned with the general objective related to reasoning because the total percentage of items that reflect reasoning is less than 25%. However, tests of the years 2006-2008 and 2011-2013 are considered partially aligned with the general objective

"mathematical reasoning" because in both sets of years reasoning takes more than 25% of the total student items; however, 2 out of the 5 behaviors that reflect reasoning (making generalizations and solving non routine problems) are completely neglected.

- ***Comparing Globally Session 1 Brevet tests to session 2 Brevet tests:***

  - There is almost no global difference between session 1 and session 2 brevet tests as the global percentage of items that reflect reasoning is approximately 31.4% in both sessions. Moreover, it can be noticed that the difference in the percentage of items that reflect reasoning between session 1 and session 2 decreased with time.
  - In both session 1 and session 2 tests the percentage of items that reflect reasoning increased throughout the years.

- General objective 3: Establishing connection between mathematics and each of science and the surrounding reality:
  - ***Comparing 2001-2003 tests, 2006-2008 tests, and 2011-2013tests:***
    - This general objective is divided into two sub-objectives: (1) Establishing connection between mathematics and science, and (2) establishing connection between mathematics and the surrounding reality. The first sub-objective is totally neglected as none of the selected brevet tests included any student item that shows a connection between math and science. As for the second sub-objective, it is also not well reflected in any of the sets of years of the BTs as the majority of

student items are purely mathematical (approximately between 91% and 93%) whereas real life items get a maximum of 3.571% of the total student items.

- The percentage of purely mathematical student items has shown a slight decrease over the different sets of years. From the years 2001-2003 to 2011- 2013 the percentage of items that are purely mathematical dropped by 2.331%. Unfortunately, the percentage of items that are real life also decreased throughout the years by approximately 1.5%. However, the percentage of items that are semi real increased throughout the years by approximately 4%.

- ***Comparing Globally Session 1 Brevet tests to session 2 Brevet tests:***

  - It is evident that in each set of years, the percentage of items that are purely mathematical is higher in session 1 than in session 2. Moreover, for some reason, in session 1 tests the percentage of items that are real life is very low (if at all present) whereas in session 2 tests it is higher by approximately 4% to 6%. However, in both cases, it is still evident that there is no alignment between the selected brevet tests and the general objective "establishing connection between mathematics and each of science and the surrounding reality".

- General objective 4: Communicate mathematically:

  - ***Comparing 2001-2003 tests, 2006-2008 tests, and 2011-2013tests:***

- The percentage of items that require students to communicate mathematically has kept on increasing throughout the different sets of years. Considering the global percentage of items that show communication in mathematics, the tests of the years 2001- 2003 and those of 2011-2013, show a lack of representation of this general objective, whereas the tests of the years 2006-2008 are considered to be reflective of this general objective. However, in each of the latter sets of years, there is a discrepancy in the distribution of items that require the use of the three different communication skills as one skill (use correct mathematical language in expressing information) is mainly highlighted whereas as the two other skills (reading, understanding, or interpreting mathematical texts and using different representations), are either not reflected or barely reflected. This discrepancy leads to partial alignment of the 2006-2008 tests with the general objective related to communication in mathematics.

- ***Comparing Globally Session 1 Brevet tests to session 2 Brevet tests:***

  - It is evident from comparing session 1 tests to session 2 tests that the percentage of items that require communication is higher in session 2 tests (30.623%) than in session 1 tests (24.638%). The biggest difference between the sessions is seen in the years 2011-2013 as session 2 tests include approximately 9.5% more items that require communication than session 1 tests.

5.2.4- The alignment of the different components of the curriculum taken in this study:

Table 26

The alignment of different components of the Lebanese math curriculum

Different components of the curriculum	General Objectives of the Lebanese Math Curriculum			
	Objective 1: Develop mathematical reasoning	**Objective 2:** Solving mathematical problems.	**Objective 3:** Establishing a connection between mathematics and each of science and the surrounding reality.	**Objective 4:** Communicate mathematically
Objectives at the intermediate level	✔	✔	√	✔
Grade 7 specific objectives	⊘	⊘	⊘	⊘
Grade 8 specific objectives	⊘	⊘	⊘	⊘
Grade 9 specific objectives	⊘	⊘	⊘	⊘
Grade 7 textbook	√	⊘	⊘	⊘
Grade 8 textbook	√	⊘	⊘	√
Grade 9 textbook	⊘	⊘	⊘	⊘
2001 -2003 brevet tests	⊘	⊘	⊘	⊘
2006 -2008 brevet tests	√	⊘	⊘	√
2011 -2013 brevet tests	√	⊘	⊘	√

⊘ Not aligned
√ Partially aligned
✔ Aligned

The results in table 26 show that out of all the components of the curriculum that were studied, the OMCI are the only ones that can be considered to be aligned with the GOMC. At the level of the SOGLI, it can be noticed that there is no alignment with the general objectives as if they were designed based on a completely different set of general objectives. Moreover, the grades 7, 8, and 9 textbooks also show a lack of alignment with the GOMC as the grade 9 textbook is not aligned with any of the GOMC, the grade 7 textbook is partially aligned with only one general objective (reasoning), and the grade 8 textbook is partially aligned with two general objectives (reasoning and communication). So, general objective 2 and general objective 3 are not reflected at all in the grades 7, 8, and 9 textbooks. As for the brevet tests, the 2001-2003 brevet tests are not aligned with any of the four general objectives of the Lebanese curriculum whereas 2006-2008 tests and 2011-2013 tests are partially aligned with two out of the four general objectives (reasoning and communication) thus showing a slight improvement in the design of the tests with time.

5.3- Discussion of the results:

The latter results lead to following conclusions:

- The SOGLI are not designed to align with on the GOMC nor the OMCI.
- The NMT of the grade levels are more reflective of the SOGLI than they are of the GOMC or OMCI as the grade 9 textbook is also not aligned with any of the GOMC and the other two grade level textbooks are only partially aligned with two of the GOMC. It is interesting to note that rather than highlighting the reasoning and communication skills as the grade level becomes higher, the percentage of items that show the latter skills decreased from grade 8 to grade 9.
- Throughout the years, it can be noticed the BTs are becoming more reflective of the GOMC (in the years 2006- 2008 and 2011-2013 compared to 2001-2003). This should be considered a positive thing; however, if the tests are

more reflective of the general objectives related to reasoning and communication, how is it fair for the students to take these tests when the grade 9 textbook is not reflective of these objectives?

5.4- Connection to Literature

As discussed in the literature, mathematics and its philosophy are an area of controversy between the fallibist and the absolutist perspectives. The absolutists view mathematics as an objective and purely isolated body of knowledge that is deducted and fixed and whose content may be communicated in schools by giving students routine mathematical tasks that focus on computational skills, deductive reasoning, and the application of learnt procedures and rules (Davision & Mitchell, 2008; White-Fredette, 2009). The fallibilist view also values the role of structure and logic in mathematics; however, it rejects the notion that mathematics is fixed and isolated. On the contrary, it acknowledges the history of mathematics, its role in the society, and the importance of contextualizing it. This view is reflected in schools where mathematics education is experienced as investigational, creative, collaborative, enjoyable, historical, cultural, and related to personal and real life situations (Davision & Mitchell, 2008). The philosophy of the Lebanese Math curriculum, its GOMC, and OMCI are stated in the introduction of the ECRD document to be directed toward fallibilism. However, the SOGLI, NMT, and BT are more directed toward the absolutist view. So, two opposing perspectives of mathematics and its learning are manifested within the same curriculum!

In addition, the components of the math curriculum taken in this study were each compared to the general aim of math education that is deduced from Sowell's view of the general aim of education in the 21st century. The results are demonstrated in the following table:

Table 27

Mapping the different components of the Lebanese math curriculum taken in this study to Sowell's aim of math education

Aims of Math Education	OMCI	SOGLI	NMT	Global 2001-2013
1- To develop students' understanding of math concepts in context of different disciplines and in context of real life.	√	⊘	⊘	⊘
2- To develop students' cognitive abilities and mathematical reasoning	✓	⊘	√	√
and				
help them become good problem solvers and decision makers.	✓	⊘	⊘	⊘
3- To facilitate learning and the communication of knowledge through the use of efficient techniques such as technology.	NA	NA	NA	NA
4- To develop students' abilities to communicate their analysis, reasoning, and conclusions verbally and numerically.	✓	⊘	√	√

⊘ Not reflective of
√ Partially reflective of
✓ Reflective of
NA Not Applicable

The latter four points summarize the aims of math education in the 21st century. The third point is not reflected in this study as it is not highlighted in the GOMC in any of the other curriculum components, though it was slightly mentioned in the Introduction to the Lebanese math curriculum. As for the other three, they are compared in table 27 to each of the OMCI, SOGLI, NMT, and 2001-2013 BT (globally). For the NMT and the BT, the decision of whether they are reflective of the aim of math education or not was taken globally not for each grade level or for the BT of each set of years. So, if the aim of math education is reflected in one out of the three textbooks, it is considered to be partially reflected in the NMT in general. Similarly, if the aim of math education is reflected in one set of years, it is considered to be partially reflected in the 2001-2013 BT. As for the second aim in the list, two entries are given in the table-cell as the latter aim resembles two distinct general objectives (the 1st and 2nd GOMC). It can be deduced from table 27 that the different components of the Lebanese math curriculum reflect the aims of math education at different degrees; the OMCI are the most reflective of the aims of math education of the 21st century whereas the SOGLI completely fail to reflect the latter aims. As for the NMT and the BT they are partially reflective of the fourth aim and of the first section of the second aim of the list. So in general, the Lebanese math curriculum fails to reflect the aims of math education of the 21st century beyond the levels of the GOMC and the OMCI.

An educational program is commonly considered to be successful if students enrolled in this program perform well on national and international tests. Lebanon participated in TIMSS 2003, 2007, and 2011. In each of those years, 8th graders enrolled in the Lebanese program scored below the international average. Moreover, the TIMSS tests are based on three domains: Knowing, Applying, and Reasoning. The Lebanese 8th graders performed the lowest on the domain of “reasoning”, despite the fact that one of the general objectives of the Lebanese math curriculum is to develop students’ reasoning. The latter results can be explained through the results of this study as they showed that the grade 7 and grade 8 textbooks include more than 25% of items that reflect reasoning yet they only highlight two out of the five behaviors that reflect reasoning (synthesis and analysis). In other words, in both grades 7 and grade 8 some reasoning skills are totally neglected while they are included in the TIMSS tests. This may be a reason for which Lebanese students didn’t perform well on the domain of reasoning in the TIMSS tests.

A study conducted by Osta (2007) was conducted to analyze the Brevet tests under the pre-reform curriculum. The results of the latter study showed that the selected eleven brevet tests focus the most on procedural knowledge, then problem solving, and the least on conceptual understanding. In relation to this study the results of Osta's study can be rephrased to the following:

> The majority of the student items of the BT are routine items (require direct application- procedural), whereas a smaller percentage requires students to solve non routine problems, real life situations, or any complex problems that require students to reason and communicate their reasoning clearly.

Similar results are found in this study as the percentage of routine items in the selected BT dominates that of the non routine items. Moreover, the BT of the years 2001- 2003 particularly, were not reflective of the general objectives related to reasoning, problem solving, communication, or establishing connection between math and different fields. Thus the focus was on procedural knowledge, thus reflecting the fact that, even after the curriculum reform, the Brevet Tests remained focused around procedural knowledge just as they were before the reform, as Osta's study showed.

Although in this study a slightly different framework is used, it completes Osta's study and adds to it by showing what improved and what stayed the same over the years.

5.5- Recommendations:

Since the results of the study showed a lack of alignment of various components of the curriculum it is recommended to revise all the components of the curriculum while taking into consideration the GOMC that are neglected. Even the GOMC should be revised over time due to social, economic, and technological changes; however, alignment with the GOMC, whether modified or not, should always be established to ensure the success of the program. Hopefully, (1) if the curriculum developers, textbook authors, and assessment designers modify the current written curriculum, and (2) teachers and administrators become aware of the importance of alignment and receive training sessions on the new curriculum foundation and the general objectives, students will perform better on the assessments and will develop based on the criteria suggested in the GOMC.

5.6- Limitation of the Study:

The main limitation of this study is that it is a case study. Since it is a case study that is done on a limited curriculum sample, it may not be generalized to the whole curriculum. In other words, what might apply to the intermediate level might not apply to the Elementary and Secondary levels. Moreover, data analyzed can be subject to bias or subjective interpretation. To decrease the effect of the latter limitation, and increase the validity and reliability of the study, two educators worked together on collecting and analyzing qualitative data.

5.7- Recommended further study:

The following are questions asked for future research to investigate answers for:

- Since the grade 9 textbook is not aligned with the general objective "Mathematical reasoning", did the students perform well on BT of the years 2006-2008 and 2011-2013? (Knowing that these tests are partially aligned with the general objective related to reasoning) Or did the students who took the BT on the latter years perform weaker than those who took the BT in 2001-2003?
- What induced the slight development of BT over the years? Was it random? Or was it induced by necessity of establishing brevet tests that are more aligned with the GOMC? Or was it the result of an increasing awareness of and belief in the value of GOMC?
- Do teachers design their classroom activities and instructions keeping in mind the GOMC? Or do they refer only to the specific objectives and NMT?
- It was noticed during the analysis of the BT that some content topics, such as space geometry, were never addressed, so to which extent are the post-reform BT aligned with the content specified in the math curriculum?
- Knowing that many teachers consider previously done BT as mini-curriculum that they teach in their classroom as a preparation for the end-of-year BT; does that mean that the student experiences in the classroom are also not aligned with the GOMC?

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APPENDICES

Appendix A

The Instrument Used for the Mapping the Objectives at the Intermediate Level with the General Objectives of the Lebanese Math Curriculum

Ministry of National Education, Youth and Sports & National Center of Educational Research and Development (1997). *Mathematics curricula. In General Education curricula and their objectives. Decree no 10227* (pp. 287-327). Lebanon: Ministry of National Education, Youth and Sports & National Center of Educational Research and Development.

Table 1

The mapping of the objectives at the intermediate level with the general objectives of the Lebanese math curriculum

The Objectives at the Intermediate Level		**General Objectives of the Lebanese Math Curriculum**			
		Objective 1: Mathematical reasoning	**Objective 2:** Solving mathematical problems	**Objective 3:** Establish connections between mathematics and each of science and the surrounding reality	**Objective 4:** Communicating mathematically
Mathematical Reasoning	Find connections between the real world and mathematical models	X		X	
	Induce the general term of a sequence of results duly constructed	X			X
	Distinguish between a general statement and particular one.	X			
	Carry out simple proofs	X			X
	Recognize a false proof	X			
Problem Solving	Analyze a situation and deduce the relevant elements	X	X	X	
	Look for necessary information to clarify an incomplete given		X		
	Construct a mathematical model associated with a situation	X	X		
	Choose a strategy to find the solution		X		
	Decompose a problem into simpler tasks, and combine necessary facts to reach a conclusion	X	X		
Communication	Read, understand and use mathematical notation and language				X
	Present their work orally or in writing, with clarity and rigor, with particular care to writing a proof				X
Spatial	Construct geometric figures based on given	X	X		
	Represent solid figures		X		X
	Prove and apply the properties of plane figures	X			X
	Perform transformations on figures				
Numerical	Find and use relations among numbers	X			
	Extend computational techniques to literal expressions.	X			
	Find the approximate value of a result.			X	

Measurem ent	Measure areas and volume				
Statistics	Make representations of statistics and read them.				X
	Calculate the mean of a statistical distribution				

Appendix B

The Instrument Used for the Mapping the Specific Objectives of Each Grade Level at the Intermediate Level with the General Objectives of the Lebanese Math Curriculum

Table 1

Retrieved from:

Ministry of National Education, Youth and Sports & National Center of EducationalResearch and Development (1997). *Curriculum of Mathematics. Decree no10227. Details of the contents of the first year of each cycle.* Lebanon: Ministry of National Education, Youth and Sports & National Center of Educational Research and Development.

Table 2:

Retrieved from:

Ministry of National Education, Youth and Sports & National Center of EducationalResearch and Development (1997). *Curriculum of Mathematics. Decree no10227. Details of the contents of the second year of each cycle.* Lebanon: Ministry of National Education, Youth and Sports & National Center of Educational Research and Development.

Table 3:

Retrieved from:

Ministry of National Education, Youth and Sports & National Center of EducationalResearch and Development (1997). *Curriculum of Mathematics. Decree no10227. Details of the contents of the third year of each cycle.* Lebanon: Ministry of National Education, Youth and Sports & National Center of Educational Research and Development.

Table 1

The mapping of the grade 7 specific objectives to the general objectives of the Lebanese math curriculum.

The Specific Objectives at grade 7 of the Intermediate Level			General Objectives of the Lebanese Math Curriculum			
			Objective 1: Develop mathematical reasoning	**Objective 2:** Solving mathematical problems.	**Objective 3:** Establishing a connection between mathematics and each of science and the surrounding reality.	**Objective 4:** Communicate mathematically
Arithmetic and Algebra						
1.Natural Integers	1.1. Prime numbers	1. Recognizing a prime number.				
		• Recognizing if a given integer is prime or not by formulating and using heuristic methods.	X	X		
		• Applying the method of the sieve of Eratosthenes to calculate all the prime numbers less than 100.				
		• Memorizing the first prime numbers 2,3,5,7,11,13,17,19,23,29, etc.				
		• Knowing and using the algorithm of successive division.				
	1.2. Decomposition of an integer into prime factors.	1. Decomposing a natural integer into prime factors.				
		2. Using the decomposition into prime factors to find the G.C.F and the L.C.M of two natural integers.				
		• Finding the power k of a prime divisor p of a natural integer n and writing n in the form p^k x q.				
		• Practicing the writing of an integer in the form of a product of its prime factors by using the writing in the form of a product of powers.				
		• Practicing the algorithms of calculating the G.C.F and L.C.M				

		of two integers, based on the decomposition into prime factors.				
2. Fractions	2.1. Reducing fractions.	1. Reducing fractions by several methods.		X		
		• Knowing the meaning of terms: irreducible, reduced, to reduce, and to simplify.				
		• Using the property 1= $\frac{a}{a}$ for every non zero natural integer a.				
		• Calculating the reduced form of a fraction by using the GCF of its two terms.				
		• Calculating the reduced form of a fraction by decomposing its terms into prime factors and by simplifying.				
		• Calculating the reduced form of a fraction by applying successive divisions.				
3. Decimals	3.1. Decimal writing of a fraction.	1. Recognizing a non-decimal fraction.				
		2. Writing a fraction in a decimal form.				
		• Writing a decimal fraction in the form of a decimal number.				
		• Defining and recognizing a non- decimal fraction.		X		
		• Knowing that a non- decimal fraction can be written in the form of a number with a point, in which the decimal part is unlimited and periodic.				
		• Knowing that every decimal is a fraction but there are fractions that are not decimal numbers.				
		• Writing a decimal number in the form of a sum of several decimal fractions where the denominators are in order of 10, 100, 1000, …				
4. Operations	4.1 Subtraction and multiplication of integers.	1. Mastering the addition and the subtraction of integers.				
		2. Multiplying integers by applying the rules of signs.				
		• Using in calculations, the rule of addition of two integers of the same sign.				

		• Using in calculations, the rule of addition of two integers of opposite signs.				
		• Knowing the opposite if an integer and using it to transform subtraction of two integers into addition.				
		• Performing calculations on algebraic numbers.				
		• Using in calculations, the rule of multiplication of two integers of the same sign.				
		• Using in calculations, the rule of multiplication of two integers of the different signs.				
	4.2. Powers of a positive numbers having positive integer exponent.	1. Knowing the notation a^n and understanding its meaning.				
		2. Calculating the product of two powers of the same positive number.				
		3. Calculating the powers of the product and quotient of two positive numbers.				
		4. Calculating a power of power of a positive number.				
		• Knowing that a^n designates, when n is an integer greater than or equal to 2, the product of n factors equal to a (with a >0): $a^n = a \times a \times \ldots \times a$ (n times).				
		• Knowing the particular cases: $a^1 = a$ for every positive number a; $a^0 = 1$ for every nonzero positive number a.				
		• Knowing the meaning of terms: base, exponent, and power.				
		• Knowing that: $a^n \times a^m = a^{n+m}$, $(a \times b)^n = a^n \times b^n$, $\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$ (b>0), $(a^n)^m = a^{n\times m}$				
		• Decomposing a^n, when we have n= p+q, into a product of two powers of a: $a^n = a^p \times a^q$.				
		• Knowing the properties of calculation in the presence of powers.				
		• Applying the previous acquirements to the powers of 10: • $10^1 = 10$, $10^0 = 1$, $10^n \times 10^m = 1^{n+m} = 10^{n\times m}$				

		• Developing the algebraic expressions having powers.	X			
		• Using a calculator to calculate a power.				
		1. Calculating the fourth proportional.				
5. Proportionality	5.1 Directly proportional magnitudes.	• Defining proportion.	X			
		• Recognizing the terms of a proportion (means, extremes).				
		• Transforming a proportion to obtain another.				
		• Completing a proportion with a missing term (4^{th} proportional).				
		• Expressing the calculation of the fourth proportional by the rule of three.				
		• Using the calculation of the fourth proportional in problems (buying, selling, duration, speed, distance, dimensions, discount, etc.)				
6. Algebraic expressions	6.1. Calculation on algebraic expressions.	1. Developing and reducing algebraic expressions.				
		• Knowing the meaning of: algebraic term or monomial, coefficient, variable, algebraic expression.				
		• Recognizing the similar terms between several algebraic terms.				
		• Reducing the similar terms in an algebraic expression.				
		• Adding and subtraction algebraic expressions.				
		• Multiplying two algebraic expressions.				
7. Equations and inequations	7.1. Equations reduced to ax=b	1. Replacing an equation by an equation that is equivalent to it.				
		2. Solving an equation of the type ax=b where a≠0.				
		3. Organizing the given and translating it into an equation reduced to ax=b and the calculating x.				
		• Knowing that we do not change the equation when we add to the two members or when we multiply by the same quantity.				
		• Knowing that the equation ax=b has the solution $\frac{b}{a}$				

		• Reducing a linear equation to the form ax=b by a succession of operation listen in 1. and 2.	X			
		• Knowing to choose the unknown in a problem, writing the equation, solving the equation and giving solution of the problem.	X			X
		Geometry				
1. Location	1.1. Geometric loci and constructions.	1. Using geometric loci in constructions.	X			
		2. Finding the geometric loci of points verifying a given property.	X			
		• Differentiating between a fixed point and a variable point and knowing that the geometric locus is a fixed curve (line, circle, or other)on which a point varies verifying certain properties.				
		• Knowing the geometric locus of a variable point aligned with two fixed points.				
		• Finding and constructing the geometric locus of a variable point equidistant of two fixed points.				
		• Finding and constructing the geometric locus of a variable point equidistant of two fixed and parallel straight lines.				
		• Finding and constructing the geometric locus of a variable point having a fixed distance from a given point.				
		• Finding and constructing the geometric locus of a variable point having a fixed distance from a given straight line.				
		• Using the listed geometric loci in constructions.	X			
	1.2. Orthogonal system and coordinates of a point in a plane.	1. Using the system to determine a point where we know the coordinates or to determine the coordinates of a given point.				
		• Recognizing the abscissa of a point on an axis.				
		• Defining an orthogonal system x'x, y'y of origin O and knowing to find a point of the plane.				

		• Recognizing the orthogonal projections of a given point on the axes and finding the coordinates of a given point in the system by using orthogonal projections.				
		• Locating a point knowing its coordinates in the system.				
		• Recognizing the four quadrants of the plane with respect to a system,				
		• Characterizing several points on the same straight line that is parallel to the axes of the system.				
		• Finding the coordinates of a given point by using a grid paper.				
2. Solid Geometry	2.1 Plane representation of a cube and a rectangular prism.	1. Drawing a cube, a rectangular prism and a right prism				
		• Constructing a rectangular prism, a cube and a right prism by preparing the pattern of each one.				X
		• Plane representation of a rectangular prism (particular case of a cube)				X
		• Plane representation of a prism.				X
		• Recognizing a rectangular prism, a prism according to its drawing.				
		• Calculating the lateral and total area of a cube, or a rectangular prism and of a right prism.				
		• Calculating the volume of a cube, of a rectangular prism and of a right prism.				
3. Plane Figure	3.1. Cases of congruent triangles.	1. Knowing and using the sufficient conditions of two congruent triangles.				
		• Knowing what are two congruent triangles as well as the corresponding elements of two congruent triangles.				
		• Knowing that two triangles having respectively an equal side adjacent to two respectively equal angles are congruent.				

		• Knowing that two triangles having respectively an equal angle included between two equal sides are congruent.				
		• Knowing that two triangles having their sides respectively equal are congruent.				
		• Using the above conditions in the proof.				X
	3.2. Angles formed by two parallel straight lines cut by a transversal.	1. Knowing that a point outside a straight line can draw only one parallel to this straight line (Euclid postulate) and using this property in proofs.				X
		2. Using the equality of alternate interior and corresponding angles.				
		• Using Euclid's postulate to justify that if two straight lines are parallel, then every parallel to one is parallel to the other, and using this property in proofs.				
		• Using Euclid's postulate to justify that if two straight lines are parallel, then every straight line that cuts one cuts the other, and using this property in proofs.				
		• Knowing and using the property that the alternate interior angles formed by two parallel straight lines cut by a transversal are equal.				
		• Knowing and using the property that if the alternate interior angles formed by the two straight lines (d) and (d') cut by a transversal are equal, then (d) and (d') are parallel.				
		• Knowing and using the property that the corresponding angles formed by two parallel straight lines cut by a transversal are equal.				
		• Knowing and using the property that if the corresponding angles formed by the two straight lines (d) and (d') cut by a transversal are equal, then (d) and (d') are parallel.				
		• Knowing that, by a point we can drop one and only one perpendicular to a straight line.				

		• Constructing a straight line perpendicular to a given straight line.				
		• Knowing that two straight line perpendicular to a third are parallel.				
		• Constructing two parallel straight lines.				
		• Knowing the proof that the sum of angles if a triangle is 180^{o}				
	3.3 Characteristic properties of the perpendicular bisector of a segment.	1. Knowing and using the characteristic properties of the perpendicular bisector of a segment.				X
		• Knowing that every point on the perpendicular bisector of a segment is equidistant of the two extremities of this segment.				
		• Knowing that every point equidistant of two extremities of a segment belong to the perpendicular bisector.				
		• Using the characteristic properties of the perpendicular bisector of a segment to justify its construction.	X			X
		• Using the characteristic properties of the perpendicular bisector to construct the center of the circle passing through three non-collinear points.				
	3.4. Characteristic properties of the bisector of an angle.	1. Knowing and using the characteristic properties of the bisector of an angle.				
		• Knowing that every point of the bisector of an angle is equidistant to the two sides of this angle.				
		• Knowing that ever point equidistant of the two sides of an angle belongs to its bisector.				
		• Drawing the bisector of an angle.				
		• Using the characteristic properties of the bisector to construct the center of the circle inscribed in a triangle.				
4.	4.1. Translation.	1. Drawing the translation of a plane figure in the plane.				

Transformations and vectors		• Defining the displacement by sliding a figure according to given instruction.				
		• Defining the translation as a sliding in a given direction, in a given sense and of a given distance.				
		• Knowing to draw the translation of a figure knowing the translation of one of its points.				
		• Knowing that a segment and its translation are parallel and of the same length.				
		Statistics				
1. Handling data	1.1. Relative frequencies.	1. Calculating the relative frequencies of a distribution.				
		• Knowing to define distribution starting from collected data.				
		• Knowing to represent in a table the values and the absolute frequencies.				X
		• Knowing to calculate the relative frequencies for each value.				
	1.2. Representation of data: bar graph, frequency polygon	1. Representing a distribution with the help of a bar graph.				X
		2. Representing the frequency polygon of a distribution.				X

Table 2

The mapping of the grade 8 specific objectives to the general objectives of the Lebanese math curriculum.

The Specific Objectives at grade 8 of the Intermediate Level			**General Objectives of the Lebanese Math Curriculum**			
			Objective 1: Mathematical reasoning	**Objective 2:** Solve mathematical problems	**Objective 3:** Establish connections between mathematics and each of science and the surrounding reality	**Objective 4:** Communicate mathematically
Arithmetic and Algebra						
1. Natural Numbers	1.1. g.c.d and l.c.m of several integers.	1. Calculate the g.c.d and l.c.m of two or several integers.				
		• Calculate the g.c.d of several integers by writing each as a product of prime factor.				
		• Calculate the l.c.m of several integers by decomposing each into prime factors.				
2. Fractions	2.1 Literal Fractions.	1. Perform computations with literal fractions				
		• Identify a literal fraction $\frac{m}{n}$, for two integers m and n, (m ≠0)				
		• Multiply or divide literal fractions.				
		• Simplify a literal fraction.				
		• Reduce several literal fractions to the same denominator.				
		• Add or subtract literal fractions.				
		• Convert a fraction to one with positive denominator.				
	2.2 Compound Fractions	1. Extend fractions to the case where each term is a fraction.				
		2. Reduce a compound fraction to a simple fraction.				
		• Recognize that $\frac{a}{b}$ and $\frac{b}{a}$ are inverses of each other.				
		• Replace the writing $\frac{\frac{a}{b}}{\frac{c}{d}}$ by $\frac{a}{b} \div \frac{c}{d}$				
		• Use the correct operations to reduce a compound fraction to a simple fraction.	X			

3. Decimals	3.1. Compatibility of order with operations	1. Apply compatibility of order with operations to decimals for arbitrary decimals a, b, and c:				
		• Note that if $a < b$ then $a + c < b + c$ and $a – c < b – c$.				
		• Note that if $a < b$ and $b < c$ then $a < c$.				
		• Note that if $a < b$ and $c < d$ then $a + c < b + d$.				
		• Note that if $a < b$ and $c > 0$ then $ac < b c$.				
4. Square roots.	4.1 Square Roots.	1. Recognize the square roots of a positive number				
		2. Find the square roots of perfect squares				
		• Note that for every positive number a, there exists a positive number b such that $b^2= a$ and that b is called a square root of a and is denoted by $\sqrt{a}$				
		• Note that $\sqrt{a}$ is not always represented as a decimal number or a fraction.				
		• Determine the numbers which have the same squares				
		• Use the calculator to find the positive square root of a positive number.				
		• Give an approximate value to the positive square root of a positive number.	X			
		• Perform addition, subtraction, and multiplication on expressions involving radicals.	X			
5. Operations	5.1. Positive integral exponents of numbers.	1. Perform operations on positive integral exponents				
		• Calculate a^n				
		• Note that if $a>0$, the $a^n > 0$				
		• Note that if $a < 0$, there are two cases: 1st case: n is even; then $a^n >0$ 2nd case: n is odd; the $a^n < 0$				
		• Determine the sign of a power without doing computations.				
		• Use a calculator to find a power				
		• Note that a^n is divisible by a^{n-1}, a^{n-1}, a^{n-2},…, a				
		• Use the following relations to perform computations:	X			

		$a^n \times a^m = a^{n+m}$, $(a \times b)^n = a^n \times b^n$, $\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n}$ (b≠0), $(a^n)^m = a^{n \times m}$, $a^n \div a^p = a^{n-p}$ $0 \leq p \leq n$				
	5.2. Negative integral exponents of 10.	1. Use powers of 10				
		• Note that if n is a non-zero natural number, then 10^{-n} is the inverse of 10^n: $10^{-n} = \frac{1}{10^n}$				
		• Note that 10^{-n} is positive for every natural number n.				
		• Calculate the product and quotient of two powers of 10.				
		• Calculate the power of a power of 10.				
		• Use powers of 10 in the expanded writing of a decimal number.				
		• Use scientific notation.				
6. Proportion	6.1 Inversely proportional magnitude	1. Solve problems involving inversely proportional magnitudes.		X		
		• Consider magnitudes that are inversely proportional.				
		• Give the mathematical writing relating two magnitudes inversely proportional to each other.				X
		• Solve problems about inversely proportional magnitudes.		X		
7. Algebraic Expressions	7.1. Common identities.	1. Compute by using common identities.				
		• Expand $(a+b)^2$, $(a-b)^2$, (a +b)(a-b).				
		• Find a common factor of several monomials.				
		• Factorize polynomials.				
		• Factorize $a^2 + 2ab + b^2$, $a^2 - 2ab + b^2$, $a^2 - b^2$				
		• Use the common identities to factorize an algebraic expression				
		• Perform reasoned computations using common identities.	X			
	7.2. Literal expression in	1. Perform Computations on literal expressions given in fractional forms.	X			
		• Note that the denominator of a fractional expression				

	fractional form.	should be different from zero.				
		• Reduce several fractional expressions to the same denominator.				
		• Add or subtract two fractional expressions.				
		• Multiply or divide two fractional expressions.				
8. Equations and Inequalities.	8.1 Equations of type (ax+b)(cx+d)=0	1. Solve equations of type (ax + b)(cx + d) = 0				
		• Note that the product of two factors is zero if and only if one of the factors is zero.				
		• Use the preceding property in solving an equation of the form (ax + b)(cx + d) = 0				
		• Solve $x^2 – a = 0$ (where a > 0)				
	8.2. Inequalities of degree one in one unknown.	1. Solve inequalities of degree one in one unknown.				
		• Recognize the equivalence of two inequalities.				
		• Replace an inequality by an equivalent inequality.				
		• Recognize a solution of an inequality.				
		• Solve an equality of degree one with numerical coefficients, in one unknown.				
		• Organize data and translate it using an inequality of degree one in one unknown, and solve it.				
		• Represent the set of solutions on the number line.				X
		Geometry				
1. Location and Reference	1.1 Relative position of two circles.	1. Know the relative position of two circles.				
		• Determine the relative position of two circles knowing the relation between the distance of their centers and the sum or difference of their radii.				
		• Determine a relationship between the distance of the centers of two circles and the sum or difference of radii, knowing their relative position.	X			
		• Use the following property: the line determined by the centers of two circles is an axis of symmetry of the figure.				
	1.2.	1. Find the set of points verifying a given property.	X			

	Geometric laws and constructions.	2. Use geometric loci in constriction.	X			
		• Construct the locus of a variable point equidistant from two sides of an angle.				
		• Find and construct the locus of the variable vertex of the right angle of a right triangle where the hypotenuse is given.				
		• Construct the locus of a variable point M such that: the angle between (AM) and (AB) is constant; A and B are two fixed points.				
		• Use the locus mentioned in constructions.	X			
	1.3. Coordinates of the midpoint of a line segment.	1. Calculate the coordinated of the midpoint of a line segment in the plane.				
		• Calculate the abscissa of the midpoint of a segment line of an axis.				
		• Calculate the coordinates of the midpoint of a segment in the Cartesian coordinate plane.				
2. Solid Geometry	2.1. Plane representation of a cylinder, a pyramid, a cone, and a sphere	1. Draw a pyramid, a cone, a cylinder, and a sphere.				X
		• Draw a pyramid with a given base				X
		• Calculate the lateral area of a pyramid.				
		• Calculate the volume of a pyramid.				
		• Draw a cone.				X
		• Calculate the volume of a cone knowing the height and the radius of the base.				
		• Describe, develop, construct and draw a right cylinder.				X
		• Calculate the lateral area of a cylinder.				
		• Calculate the volume of a cylinder.				
		• Describe and draw a sphere.				X
		• Calculate the area of a sphere.				
		• Calculate the volume of a ball.				
	2.2. Relative positions	1. Recognize the relative position of two lines, two planes, and a line and a plane.				
		• In solids, recognize the relative position of two lines:				

	of lines and planes.	parallel, concurrent, non-coplanar.				
		• In solids, recognize the relative position of two planes: parallel or concurrent.				
		• Locate a line with respect to a plane, parallel to the plane, concurrent with the plane.				
3. Plane Figures	3.1. The theorem of Pythagoras.	1. Use the theorem of Pythagoras.				
		• Recognize the superposition of two right triangles where hypotenuse and one side of the right angle are equal.				
		• Characterize a right triangle by the relation that links the hypotenuse to the median relative to it.				
		• Use the relation of Pythagoras to calculate lengths.				
		• Characterize a right triangle by the relation of Pythagoras.				
	3.2. Midpoint theorem in the triangle and the trapezoid.	1. To know and use the theorems of the midpoints in a triangle and a trapezoid.				
		• Note that the segment joining the midpoints of two sides of a triangle is parallel to the third side and its length is half that of the third side.				
		• Note that the segment joining the midpoint of the non parallel sides of a trapezoid is parallel to the bases and that its length equals half the sum of the lengths of the bases.				
		• Characterize an isosceles trapezoid by the equality of its diagonals.				
	3.3. Characteristic properties of a parallelogram	1. Know and use the characteristic properties of a parallelogram.				
		2. Characterize the rectangle, rhombus, and square.				
		• Use properties of a parallelogram having to do with: sides diagonals opposite angles, and center of symmetry.				
		• Characterize the parallelogram as being a convex				

		quadrilateral having each of the following properties: - both pairs of opposite sides are parallel; - both pairs of opposite sides are equal; - a pair of opposite sides are parallel and equal; - the opposite angles are equal; - the diagonals bisect each other.				
		• Characterize a rectangle as a quadrilateral with three right angles.				
		• Characterize a rhombus as a quadrilateral with equal sides.				
		• Characterize a rectangle and a rhombus using their diagonals.				
		• Classify quadrilaterals according to various criteria.				
	3.4. Central angle in a circle, angle inscribed in a circle. Area of a circular sector.	1. Know and use the relation between the measure of the central angle of a circle and that of the intercepted arc.				
		2. Know and use the relation between the measure of the angle inscribes in a circle and that of the intercepted arc.				
		3. Calculate the area of circular sector.				
		• Know that the measure of an arc is expressed by the same number as the measure of the angle which it intercepts.				
		• Distinguish between measure in degrees of an arc and length of an arc.				
		• Calculate the length of an arc of a circle knowing the central angle which intercepts it.				
		• Calculate the angle of two secants of a circle that intersect either in the interior or the exterior of a circle.				
		• Calculate the angle formed by a tangent to a circle and a secant through the point of tangency.				
		• Recognize a circular sector.				
		• Calculate the area of a circular sector knowing its central angle.				

4. Transformations and Vectors	4.1. Vector and Translation	1. Identify the vector of translation.				
		2. Represent a vector geometrically.				X
		• Draw lines having the same direction.				
		• Identify the characteristics of a vector of a translation: support, direction, and length.				
		• Note that if the vector of the two translations have the same characteristics, then the two translations are identical.				
		• Represent a vector geometrically.				X
		• Draw the translate of a given figure by a given vector.				
		• Use the properties of invariance of length and angles under translation.				
		Statistic				
1. Management of Data	1.1. Cumulative items and frequencies.	1. Calculate the cumulative items of a set of statistical data.				
		2. Calculate the cumulative frequencies of a set of statistical data.				
	1.2. Graphical representation of data: circular diagram, polygon of cumulative frequencies	1. Represent grouped data by using a diagram.				X
		• Represent statistical data using a circular diagram and a polygon of cumulative frequencies.				X
		• Read and interpret a diagram.				X
		• Pass from one mode of representation to another.				X

Table 3

The mapping of the grade 9 specific objectives to the general objectives of the Lebanese math curriculum.

The Specific Objectives at Grade 9 of the Intermediate Level			**General Objectives of the Lebanese Math Curriculum**				
			Objective 1: Develop mathematical reasoning	**Objective 2:** Develop knowledge and strategies to solving mathematical problems.	**Objective 3:** Develop an understanding of mathematics in context of real life.	**Objective 4:** Communicate mathematically	**Objective 5:** Develop a positive attitude toward mathematics.
		Arithmetic and Algebra					
1. Natural Numbers	1.1. Rational and irrational numbers.	1. Know that unlike rational numbers, irrationals numbers have decimal parts that are non-terminating, and non-periodic sequence, hence they can only be represented by approximations.					
		2. Know some irrational numbers.					
		• Use the decomposition of integers into prime factors to know if $\sqrt{n}$ is rational or not.					
		• Give examples of irrational numbers as being numbers whose decimal part is non-terminating and non-periodic sequence.					
		• Use the calculator to find an approximate value of $\sqrt{n}$ (n > 0)					
2. Operations	2.1 Rationalizing the denominator of a numerical fraction	1. Rationalize the denominator of a numerical fraction.					
		• Use the property $\sqrt{a}$ x $\sqrt{a}$ = a for a> 0 to rationalize the denominator of a fraction if it is of the form b$\sqrt{a}$ (a and b being rational).					
		• Know the meaning of conjugate terms and use the conjugates to rationalize the denominator of a fraction if it is of the form x+y where x and/or y are irrational.					
		• Use these techniques in calculations.	X				
	2.2. Calculati	1. Perform the operations of calculation on real numbers.	X				
		• Add, subtract, multiply and divide real numbers.	X				

	on on real numbers	• Raise a real number to any power.					
		• Insert between two rational numbers a third rational number a in particular a decimal.					
3. Proportionality	3.1. Linear functions and proportionality	1. Recognize a linear situation (or of proportionality)					
		2. Know the different representations of linearity.			X		X
		• Recognize two proportional sequences with the help of a numerical table.					
		• Recognize a linear situation by the algebraic expression y=kx					
		• Represent a linear situation graphically.			X		X
		• Pass from representation to the other along the three preceding points.			X		X
4. Algebraic Expressions	4.1. Algebraic expressions having radicals.	1. Develop and reduce algebraic expression having radicals.	X				
		2. Reduce a radical.					
		• Recognize among several radicals those that are similar.					
		• Write $\sqrt{x}$ in the form $a\sqrt{b}$ where x, a, and b are integers, n being as small as possible.					
		• Knowing that $\sqrt{ab} = \sqrt{a}$ x$\sqrt{b}$.					
		• Know that $\sqrt{\frac{a}{b}}=\frac{\sqrt{a}}{\sqrt{b}}$; a ≥0 and b > 0					
		• Factor algebraic expressions by using radicals.					
	4.2. Polynomials in one variable.	1. Know the meaning of the degree of a polynomial in one variable.					
		2. Write a polynomial in one variable in a given order.					
		3. Know the relation between the degrees of two polynomials and the degree of their product.					
		4. Calculate the values of a polynomial for particular value of its variable.					
		5. Know the meaning of the zero or root of a polynomial.					
		• Know that a polynomial in one variable is the sum of several monomials and know the degrees of a polynomial.					

		• Reduce and write a polynomial in an increasing or decreasing order of degrees of the variable.					
		• Add two polynomials in the same variable and know that the degree of the sum is less than or equal to the larger degree of the two polynomials.					
		• Multiply two polynomials in the same variable and know that the degree of the product is equal to the sum of degrees of the two polynomials.					
		• Know that a polynomial is identically zero only in the case where all its coefficients are zero.					
		• Know that two polynomials are identical only in the case where they have the same degree and the same coefficient.					
		• Find particular values of a polynomial.					
		• Know the meaning of the zero or root of a polynomial.					
5. Equations and Inequalities	5.1. Equations of the from $\frac{ax+b}{cx+d}$= 0	1. Know the link between $\frac{a}{b} = 0$ and a= 0 (b≠0).					
		2. Solve equations of the form $\frac{P(x)}{Q(x)} = 0$ where P(x) and Q(x) are two polynomials in x.	X				
		• Know that a fractional expression $\frac{P(x)}{Q(x)}$ is only defined for Q(x)≠0 and know precisely the values of x for which this situation is valid.					
		• Reduce an expression of the form $\frac{P(x)}{Q(x)}$ where P(x) and Q(x) are polynomials in x.	X				
		• Know that $\frac{P(x)}{Q(x)}$ = 0 implies that P(x) = 0 and Q(x)≠0.					
		• Solve equations of the form $\frac{P(x)}{Q(x)}$ = 0, where P(x) is a reducible polynomial in x.	X				
	5.2. Systems of equation	1. Solve a system of two equations of the first degree in two unknowns.					
		2. Organize the hypotheses of a problem, translate them by a system of two equations of the first degree in two unknowns,		X			

	s of the first degree in two unknowns.	calculate these two unknowns and find the solution.					
		• Recognize a system of equations of the first degree in two unknowns.					
		• Verify whether a given pair is a solution of the system of two equations in to two unknowns or not.					
		• Solve a system of equations by eliminating one unknown.					
		• Solve a system of equations by substitution.					
		• Solve a system of equations by comparison.					
		• Solve a problem with two unknowns.		X			
		• Perform a change of variable convenient for solving a system of equations by reducing it to a system of linear equations.	X				
	5.3. Systems of inequalities of the first degree in one unknown.	1. Solve a system of inequalities of the first degree in one unknown with numerical coefficients.					
		2. Organize the given of a problem, translate it by a system of inequalities of the first degree in one unknown, solve this system and find the solutions.					
		• Verify whether one or more given values are solutions of the system of linear inequalities.					
		• Represent the solutions on the numerical axis.			X		X
		• Know how to translate a graphical representation on the numerical axis in to a system of inequalities.					
		• Solve a system of inequalities of the first degree in one unknown.					
		• Solve a problem leading to a system of inequalities.		X			
Geometry							
1. Location	1.1. Tangents and circles.	1. Know and use the properties issued from the configuration formed by a circle and the tangents issued from the same point.					
		• Define the tangent to a circle (C) of a center *O* and a point *A* of (C) as being the perpendicular at *A* to (OA).					
		• Know the position of line with respect to a circle.					

		• Know the number of tangents taken from a point to a circle according to the position of this point with respect to the circle.					
		• Show that, if we take two tangents to a circle from a point outside this circle, then the line joining this point to the center of the circle is an axis of symmetry of the obtained figure.	X		X		X
	1.2. Geometric loci and constructions	1. Find the geometric locus of points verifying the property.	X				
		2. Construct the tangents taken from a point to a circle.					
		• Use translation to find the geometric locus of a point.					
		• Use homotocy to find the geometric locus of a point.					
		• Use the geometric locii for constructing the tangents taken from a point to a circle.					
	1.3. Graphic representation of a straight line.	1. Draw a line defined by its equation.			X		X
		2. Determine the equation of a line defined by two points.					
		• Know that y=ax+b is the equation of a straight line not parallel to the y-axis.					
		• Know that a point belongs to a line if its coordinates satisfy the equation of this straight line and reciprocally.					
		• Know the equation of a line parallel to the y-axis.					
		• Know the equation of a line parallel to the x-axis.					
		• Know that the equation of a line can be written in the form of *ux+vy+w=0*; and know how to pass from one of these two forms of expressions to the other.					
		• Find the equation of a line passing through two distinct points.					
		• Draw a line knowing its equation.			X		X
		• Know the interpretation of *a* and *b* in the equation *y=ax+b*					
		• Find the equation of a line knowing its slope (directing coefficient) and the coordinated of one of its points.					
		• Know the relation between the position of a line with					

		respect to the reference and the sign of its directing coefficient.					
		• Know how to calculate the slope (directing coefficient) of a line passing through two points whose coordinates are given (without writing its equation).					
		• Know the interpretation of an equation of the form *y=ax*					
	1.4. Analytical properties of two parallel straight lines and of two orthogonal straight lines.	1. Know and use the condition of parallelism of two straight lines.					
		2. Know and use the condition of orthogonality of two lines in an orthonormal system.					
		• Know that two lines having the same directing coefficient are parallel.					
		• Know that two parallel lines have the same slope (directing coefficient) or are even parallel to one of the coordinate axes.					
		• Know that in orthonormal system, if the product of the slopes (directing coefficient) of two lines equal -1, these two lines are perpendicular.					
		• Know that in an orthonormal system, if two lines are perpendicular and if they are not parallel to the coordinate axis, then the product of their slopes (directing coefficients) is equal to -1.					
		• Write the equation of a line passing through a given point and parallel to a line whose equation is given.					
		• Write the equation of a line passing through a given point and perpendicular to a line whose equation is given.					
	1.5. Length of a segment in an	1. Calculate, in an orthonormal system, the length of a segment and the distance between two points.					
		• Calculate the length of a segment of a line parallel to the x-axis whose coordinates of the extremities are known.					
		• Calculate the length of a segment of a line parallel to the					

	orthnormal system.	y-axis whose coordinates of the extremities are known.					
		• Use the Pythagorean Theorem to calculate the length of a segment of a line not parallel to one of the coordinate axes.					
		• Know and use the formula concerning the distance between two points of the plane in an orthonormal system					
	1.6. Solving graphically a system of linear equation in two unknown	1. Solve graphically a system of equations of the first degree in two unknowns.					
		• Represent graphically an equation of the first degree in two unknowns.			X		X
		• Solve graphically a system of two equations in two unknowns.					
		• Determine the coordinates of the point of intersection of two lines when it exists and know how to interpret the result as a solution of a system of two equations of the first degree in two unknowns.	X				
		• Study the case when two lines are parallel and know how to interpret the results in the form of a system of two equations in two unknowns without a solution.	X				
		• Study the case of two equations having an infinite number of solutions and know how to interpret the results graphically.	X				
		• Study the case of two coincident lines and interpret the result as a solution of two equations with an infinite number of solutions.	X				
2. Solid Geometry	2.1. Intersection of a straight line and a common	1. Draw the intersection of a straight line and a common solid.					
		• Know how to draw the intersection of a straight line with a parallelepiped, a right prism, a cone, a cylinder, and a sphere.					

	solid.						
	2.2. Intersection of a plane and a common solid.	1. Draw the intersection of a plane and a common solid.					
		• Know that the intersection of a pyramid, cylinder, parallelepiped, a right prism, or a cone with a plane parallel to the base is a figure similar to the base.					
		• Know that the intersection of a plane and a sphere is a circle.					
		• Calculate the volume of a truncated cone.					
3. Plane Figures	3.1 Inscribed quadrilaterals	1. Know and use the necessary and sufficient conditions for a quadrilateral to fit into a circle.					
		• Know that opposite angles of an inscribable quadrilateral are supplementary angles and reciprocally.					
		• Know that angles formed by two opposite sides and the diagonals of an inscribable quadrilateral are equal, reciprocally.					
	3.2 Thales Theorem	1. Know and use Thales' theorem relative to triangles, and its conversal.					
		2. Construct the fourth proportional.					
		3. Enlarge or reduce a figure in a given ratio.					
		• Know that a parallel to a side of a triangle determines, on the other sides, proportional segments.					
		• Know that if a line cuts two sides of triangle into proportional segments, then it is parallel to the third side.					
		• Use Thales' theorem in the constructional of a fourth proportional.					
		• Use Thales' theorem to enlarge or reduce a figure in a given ratio.					
	3.3. Similar triangles.	1. Know and apply the conditions of similitude of two triangles.					
		• Identify two similar triangles by the fact that they have their respective angles equal and the sides opposite to					

		the equal angles respectively proportional.					
		• Characterize two similar triangles by the fact that they have two respective angles equal.					
		• Characterize two similar triangles by the fact that they have an equal angle included between two respectively proportional sides.					
		• Characterize two similar triangles by the fact that they have the three sides respectively proportional.					
		• Use similar triangles to establish relations of length in right triangles.	X				
4. Transformations and Vectors	4.1. Vectors in a plane.	1. Represent the sum p two vectors and use the relations $\overrightarrow{AB}$ + $\overrightarrow{BC}$ = $\overrightarrow{AC}$ and $\overrightarrow{AB}$ + $\overrightarrow{AC}$ = $\overrightarrow{AD}$ where D is the fourth vertex of the parallelogram ABDC.					
		2. Find the components of a vector $\overrightarrow{AB}$ knowing the coordinates f points A and B.					
		• Know that two vectors are equal if they have the same direction sense and length (modulus).					
		• Draw the point B obtained from point A by two consecutive translations and know that B is the translation of A by a unique translation that its vector is the sum of vectors og the two translations.					
		• Know and use the relation $\overrightarrow{AB}$ + $\overrightarrow{BC}$ = $\overrightarrow{AC}$ as well as the relation $\overrightarrow{AB}$ + $\overrightarrow{AC}$ = $\overrightarrow{AD}$ where D is the 4th vertex of the parallelogram ABDC.					
		• Calculate the components of a vector $\overrightarrow{AB}$ knowing the coordinates of A and B.					
5. Trigonometry.	5.1. Sine, Cosine, and tangent of an acute	1. Know and use the trigonometric lines in a right triangle.					
		• Define the cosine of an acute angle xOy as being the ratio of OB on OA where A is a point on [Ox) and B is the orthogonal projection of A on [Oy) and know that the cosine of this angle does not depend on the choice of point A.					

	angle in a right triangles.	• Know that the cosine of an acute angle is included between 0 and 1.					
		• Define the sine of an acute angle xOy as being the ratio of AB on OA where A is a point on [Ox) and B is the orthogonal projection of A on [Oy) and know that the sine of this angle does not depend on the choice of point A.					
		• Know that the sine of an acute angle is included between 0 and 1.					
		• Find and apply the relation $\sin^2\alpha + \cos^2\alpha=1$ for any acute angle α.					
		• Define the tangent of an acute angle xOy as being the ratio of AB on OB where A is a point on [Ox) and B is the orthogonal projection of A on [Oy) and know that the tangent of this angle does not depend on the choice of point A.					
		• Show that the tangent of an acute angle is equal to the ratio of its sine on its cosine.	X		X		X
		• Use the trigonometric lines (sine, cosine and tangent) in calculations.					
		• Use the trigonometric lines of the special angle 0°, 30°,45°,60°,90°,180°.					
		• Know that the directing coefficient of a line in an orthonormal system is nothing but the tangent of the angle formed by this line and the axis of abscissas.					
Statistics							
1. Handling Data	1.1. Distribution in one discrete variable; different represen	1. Study a distribution in one discrete variable and represent it by a statistical table and by graphs.			X		X
		2. Read and interpret the graphical representation of a distribution.			X		X

	tations.						
	1.2. Mean and weighted mean	1. Calculate the mean of a distribution in one discrete variable.					
		2. Calculate the weighted mean of a distribution in one discrete variable knowing that the data are weighted.					