LEBANESE AMERICAN UNIVERSITY

**A STUDY OF THE ALIGNMENT BETWEEN THE
LEBANESE SECONDARY-LEVEL NATIONAL MATH EXAMS
FOR THE LITERATURE AND HUMANITIES TRACK
AND THE REFORMED MATH CURRICULUM**

By

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Dedication Page

To my loving parents

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**A Study of the Alignment between the Lebanese Secondary-Level
National Math Exams for the Literature and Humanities Track
and the Reformed Math Curriculum**

Liwa Hamadan Sleiman

Abstract

Curriculum alignment is a systematic process to ensure strong congruency among the three curriculum aspects: the written, the taught, and the tested curricula. The purpose of this study was to investigate the alignment between the official exams for the “Literature and Humanities” track of the secondary school education and the Lebanese reformed math curriculum. The method is both qualitative and quantitative. Semi-structured interviews were conducted with two test developers of math official exams for grade 12. The interviews and the national curriculum texts were analyzed qualitatively. On the other hand, the model tests provided as part of the curriculum texts, as well as the official exams were quantitatively analyzed according to an analysis framework based on their respective objectives and the TIMSS cognitive domains. Correlations were calculated: 1) between the model test items and those of the official exams, 2) between the official exam test items for the years 2001-2005 and those for the years 2006-2010, and 3) between the test items in the first session of examinations and those of the second session. The results showed that there is a low positive correlation ($r = 0.06$) between the model tests and the official exams when considering the detailed objectives and the cognitive domains. On the other hand, when considering the math topics and the cognitive domains, high positive correlations were found between: (a) the model tests and the official exams ($r = 0.81$); (b) the model tests and the official exams of the years 2001-2005 ($r = 0.80$), as well as of the years 2006-2010 ($r = 0.80$); (c) the model tests and the official exams of session-1 ($r = 0.78$), as well as of the session-2 ($r = 0.81$); (d) the official exams of the years 2001-2005 and those of the years 2006-2010 ($r = 0.98$); and (e) the official exams of session-1 and those of session-2 ($r = 0.97$). However, the qualitative analysis showed problems in coverage. It was revealed that both, the official and the model tests, neglect some topics that are part of the curriculum content. They also neglect the cognitive domain *reasoning* and focus mostly on *knowing* and *applying*. Findings concurred to highlight the need for a revision of the Lebanese math curriculum as to its coherence and alignment of its assessment tools.

Keywords : National Curriculum, National Assessment, Alignment, Mathematics, Secondary School Education, Lebanon.

TABLE OF CONTENTS

Chapter	Page
1 – Introduction	1-11
1.1 – Overview	1
1.2 – Rationale and Significance of Study	2
1.3 – Case of Lebanon	3
1.3.1 – National Curriculum	3
1.3.2 – Participation in TIMSS	6
1.4 – Purpose of the Study	10
1.5 – Research Questions	11
2 – Literature Review	12-43
2.1 – Curriculum	13
2.1.1 – Traditional Curriculum vs. Curriculum Reform	14
2.1.2 – Curriculum Standards / National Curriculum	17
2.1.3 – Developing a National Curriculum	20
2.2 – Assessment	25
2.2.1 – Definitions	26
2.2.2 – Standards, Principles, and Purposes of Assessment	28
2.2.3 – International Assessment Frameworks	32
2.3 – Alignment Between Curriculum and Assessment	36
2.3.1 – Models for Alignment between Standards and Assessments	37
2.3.2 – Case Studies on Alignment	41
3 – Methodology	44-56
3.1 – Design and Procedures	44
3.1.1 – Interview	44
3.1.2 – Content Analysis	46
3.2 – Framework for Analyzing Exams	48
3.2.1 – Definition of a Test Item	49
3.2.2 – Qualitative Analysis	50
3.2.3 – Quantitative Analysis	50
3.2.3.1 – Coding.	50
3.2.3.2 – Mapping of Test Items.	53
3.2.3.3 – Correlations.	55
3.2.4 – Validity of the Analysis	55
4 – Findings	57-102
4.1 – The Interview	57
4.1.1 – About the Committee (OEC)	57
4.1.2 – Reformed Curriculum	59
4.1.3 – Process of Developing Official Exams	59
4.1.4 – Test Items and Grading Scheme	61
4.1.5 – Session 1 vs. Session 2	62

4.1.6 – Alignment with Curriculum	63
4.2 – Content Analysis	65
4.2.1 – Qualitative Analysis	65
4.2.1.1 – Qualitative Analysis of the Curriculum.	65
4.2.1.2 – Qualitative Analysis of the Model Tests.	69
4.2.1.3 – Qualitative Analysis of the Official Exams.	71
4.2.1.4 – Qualitative Analysis of the Test Items.	73
4.2.2 – Quantitative Analysis	82
4.2.2.1 – Correlations Between Official Exams and Model Tests.	83
4.2.2.2 – Correlations Between Official Exams (of the Years 2001-2005 and 2006-2010) and Model Tests.	88
4.2.2.3 – Correlations Between Official Exams (Session-1 and Session-2) and Model Tests.	96
5 – Conclusions and Recommendations	103-119
5.1 – Introduction	103
5.2 – Conclusions	109
5.2.1 – Research Question 1	110
5.2.2 – Research Question 2	112
5.2.3 – Research Question 3	113
5.2.4 – Research Question 4	115
5.3 – Recommendations	116
5.4 – Limitations of the Study	117
5.5 – Recommended Future Research	118
6 – References	120-124
7 – Appendices	125-167
Appendix A : The References of the Curriculum Documents	126
Appendix B : Interview Questions	128
Appendix C : General Principles about the Guidelines and the Way of Developing the Official Exam Questions in Mathematics for the General Secondary School Certificate	131
Appendix D : Model Test 2 (LHM2)	133
Appendix E : Session-2 Official Exam 2004 (LH042)	137
Appendix F : TIMSS Advanced 2008 – Mathematics Cognitive Domains	139
Appendix G : Coding the Details of Contents of the Lebanese Reformed Math Curriculum for the LH track at the Secondary School Level	144
Appendix H : Quantitative Analysis for Model Test 2 (LHM2)	149
Appendix I : Quantitative Analysis for the Official Exam LH042	150
Appendix J : Document Given By Interviewee	151
Appendix K : Frozen Themes and Details of Contents of the Mathematics Curriculum	153
Appendix L : Qualitative Analysis of the Model Tests and Official Exams	155
Appendix M : Quantitative Analysis of the Model Tests and Official Exams	165

LIST OF TABLES

Table	Table Title	Page
Table 1.1	The Scores and Ranking of the Arab Countries Participating in TIMSS 2003 for 8th Graders in Mathematics	7
Table 1.2	The Scores and Ranking of the Arab Countries Participating in TIMSS 2007 for 8th Graders in Mathematics	8
Table 1.3	The Scores and Ranking of the Countries Participating in TIMSS Advanced 2008 in Mathematics	10
Table 2.1	Contributors to the National Curriculum and Their Concerns	21
Table 2.2	Comparing NAEP, PISA, and TIMSS	34
Table 2.3	Comparing NAEP, PISA, and TIMSS Latest Mathematics Frameworks	35
Table 4.1	The Math Topics in the LH Track of the Third Secondary Year	68
Table 4.2	Correlations Between the Official Exams of the Years 2001-2010 and the Model Tests for Grade 12 LH Track	86
Table 4.3	Correlations Between the Official Exams of the Years 2001-2005 and the Official Exams of the Years 2006-2010 Respectively, between them and the Model Tests for Grade 12 LH Track	92
Table 4.4	Correlations Between the Official Exams of Session-1 and the Official Exams of Session-2 Respectively, between them and the Model Tests for Grade 12 LH Track	99

GLOSSARY OF TERM

AFL	Assessment for Learning
AOL	Assessment of Learning
CCSS	Common Core State Standards
CDC	Curriculum Development Committee
CEC	Curriculum Evaluation Committee
DOK	Depth of Knowledge
ECRD	Educational Center for Research and Development
GS	General Sciences
H	Humanities
LFA	Learning for Assessment
LH	Literature and Humanities
LS	Life Sciences
MEHE	Ministry of Education and Higher Education
NAEP	National Assessment of Educational Progress
NCTM	National Council of Teachers of Mathematics
OEC	Official Examinations Committee
PISA	Program for International Student Assessment
S	Sciences
SE	Sociology and Economics
SEC	Survey of the Enacted Curriculum
TIMSS	Trends in International Mathematics and Science Study
UBD	Understanding By Design

CHAPTER ONE

INTRODUCTION

1.1 – Overview

Educators distinguish among three curriculum model aspects: the intended, the implemented, and the attained curriculum (Mullis, Martin, Ruddock, O’Sullivan, & Preuschoff, 2009). The intended curriculum, at the national, social and educational level, is the written and documented curriculum in terms of objectives, scope and sequence, and content. The implemented curriculum is the taught curriculum at the school and classroom levels. The attained curriculum is the learned curriculum reflected by the students’ achieved learning outcomes. Balance and consistency among the intended, implemented and attained curricula constitute the curriculum alignment. Since the attained curriculum is measured by achievement tests, then curriculum alignment is defined as “a process of ensuring that the written, the taught, and the tested curricula are closely congruent” (Glatthorn, Boschee, & Whitehead, 2006, p. 278, as cited in Osta, 2007).

1.2 – Rationale and Significance of Study

A discrepancy in curriculum alignment leads to problems in education. In cases of national curriculum and national assessment, teachers tend to teach their students according to the national tests in order to prepare them for the national assessment. If the national assessment lacks coherence with the curriculum, then teachers would be deviating from the intended curriculum. This paper will investigate whether an alignment exists between the intended and the assessed national curriculum in Lebanon.

A few research studies in Lebanon investigated the curriculum alignment. Osta (2007) developed a framework for studying the alignment of the national math exam at the intermediate level with the pre-reform national curriculum in Lebanon. Throughout her paper, Osta analyzes “the characteristics of the national tests, which have set an ‘assessment culture’ during the long life of that curriculum. This assessment culture is believed to persist and affect the national tests under the reformed curriculum” (p.172). The present paper will use Osta’s framework to analyze the Lebanese reformed curriculum in mathematics and highlight the key changes to the reform. Additionally, it will investigate the alignment between the Lebanese mathematics national exams and the reformed curriculum.

Teachers in Lebanon can benefit from this study in understanding the process of developing national exams, their structure and content, and their aligned or non-aligned aspects with the curriculum. When teachers are more familiar with national exams, they

can improve their instruction and better prepare students to take the national tests. However, it is a critical issue if the results of this study show that the national exams are not aligned with the curriculum. Therefore, the mathematics Official Examinations Committee (OEC) could use the results of this study in evaluating and improving the alignment of the national exams at the secondary level with the national curriculum. Briefly, the results of this study are significant to OEC, teachers, and students.

1.3 – Case of Lebanon

1.3.1 – National Curriculum

The Lebanese Educational system adopts for schools a unified curriculum imposed by the Ministry of Education and Higher Education (MEHE). The Educational Centre for Research and Development (ECRD) is responsible for developing the curricula. While public schools completely abide by this curriculum and by the textbooks developed by ECRD, private schools may adopt other curricula in addition to the national one. That is, they may add to the curriculum and use a variety of textbooks and approaches. In order to unify the standards among all schools, the Lebanese government adopts nation-wide examinations (hereafter referred to as official exams) at the intermediate (end of grade 9) and secondary (end of grade 12) school levels. Passing the grade 9 official exams (known as Brevet) promotes students to the secondary-level education, while passing the grade 12 (general secondary) exams allows students to

graduate from school and eventually continue their studies at the university level. These official exams challenge schools and students to compete for better education and higher results.

In 1997, the MEHE and ECRD started a major endeavor to reform the curriculum (referenced as Document I in Appendix A). School education in Lebanon consists of two stages: 1) Basic Education consisting of the Elementary and Intermediate Levels, and 2) Secondary Education. Moreover, the reformed curriculum distributes the school years into cycles. Each three consecutive years determine a cycle as follows: (a) grades 1, 2, and 3 form the First Cycle at the Elementary Level; (b) grades 4, 5, and 6 form the Second Cycle also at the Elementary Level; (c) grades 7, 8, and 9 form the third cycle which is the Intermediate Level; and (d) grades 10, 11, and 12 form the fourth and last cycle which is the Secondary Education. There are two tracks at grade 11: Humanities (H) and Sciences (S) tracks. On the other hand, there are four tracks at grade 12: Life Sciences (LS), General Sciences (GS), Literature and Humanities (LH), and Sociology and Economics (SE) tracks. Usually, the school advises each student to choose the track for his/her studies according to the student's academic performance, interests, and plan for higher education.

The reformed curriculum distributes the content and objectives of each subject over the grade levels of the Basic and Secondary Education. MEHE and ECRD issued a written reformed curriculum documented in the following curricular texts:

1. The official text of the reformed curriculum for the Basic and Secondary Education as issued in 1997 (referenced as Document I in Appendix A): It includes the general and specific objectives as well as the scope and sequence and syllabi of all school subjects.
2. The details of contents: These texts include the detailed content for each subject along with the corresponding objectives and comments. Each subject has its separate texts. Three books for each subject were issued as follows: (a) details of contents for the first year of each cycle, that is the 1st, 4th, 7th, and 10th grade levels; (b) details of contents for the second year of each cycle, that is the 2nd, 5th, 8th, and 11th grade levels; and (c) details of contents for the third year of each cycle, that is the 3rd, 6th, 9th, and 12th grade levels.
3. Evaluation Guides for each subject for the Basic and Secondary Education: These guides determine the competencies and their corresponding domains for each grade level. Additionally, the guides also present propositions for official examinations and model tests for grade 9 and the four tracks of grade 12.

The curriculum was first implemented for the first grade level of each cycle in the academic year 1998-1999, the second grade of each cycle in the academic year 1999-2000, and the third grade of each cycle in the academic year 2000-2001.

During the academic year 2000-2001, the 9th and 12th grade students were examined in pilot exams on a trial basis for official exams, and then they were examined officially in June 2001 for the first time based on the reformed curriculum.

The regular official exams (session-1) are usually administered in June, at the end of each academic school year. However, a second session of official exams (session-2) is usually administered in September to give a second chance to students who fail or miss the regular June exam.

1.3.2 – Participation in the Trends in International Mathematics and Science Study (TIMSS)

Up to this date, Lebanon participated in TIMSS three times, on the years 2003, 2007, and 2011 for 8th graders, as well as TIMSS Advanced 2008 for 12th graders. Table 1.1 shows the scores and ranking of the participating Arab countries (total: 8 Arab countries among 45 participating international countries) in TIMSS 2003 for 8th graders in mathematics (as extracted from *Table 3* in Gonzales et al., 2004). Table 1.2 shows the scores and ranking of the participating Arab countries (total: 12 Arab countries among 48 participating international countries) in TIMSS 2007 for 8th graders in mathematics (as extracted from *Table 3* in Gonzales et al., 2008). The results of TIMSS 2011 are yet to be published.

Even though Lebanon's results have improved from TIMSS 2003 to TIMSS 2007, yet the scores remained below the international average score in both years. Lebanon got the highest score in mathematics among the Arab participating countries in

both TIMSS 2003 and 2007. Its score in mathematics on TIMSS 2007 was (449), one point less than the international average score (500).

Table 1.1

The Scores and Ranking of the Arab Countries Participating in TIMSS 2003 for 8th

Graders in Mathematics

Arab countries participating in TIMSS 2003	International rank (out of 45 countries)	Rank among Arab countries	Score (International Average Score in math = 466)
Lebanon	31	1	433
Jordan	32	2	424
Tunisia	35	3	410
Egypt	36	4	406
Bahrain	37	5	401
Palestinian National Authority	38	6	390
Morocco	40	7	387
Saudi Arabia	43	8	332

Source : Gonzales, P., Guzmán, J. C., Partelow, L., Pahlke, E., Jocelyn, L., Kastberg, D., et al. (2004). **Highlights From the Trends in International Mathematics and Science Study (TIMSS) 2003.** U.S. Department of Education, National Center for Education Statistics. Washington, DC.

Page 5

Table 1.2

*The Scores and Ranking of the Arab Countries Participating in TIMSS 2007 for 8th**Graders in Mathematics*

Arab countries participating in TIMSS 2007	International rank (out of 48 countries)	Rank among Arab countries	Score (International Average Score in math = 500)
Lebanon	28	1	449
Jordan	31	2	427
Tunisia	32	3	420
Bahrain	35	4	398
Syrian Arab Republic	37	5	395
Egypt	38	6	391
Algeria	39	7	387
Oman	41	8	372
Palestinian National Authority	42	9	367
Kuwait	44	10	354
Saudi Arabia	46	11	329
Qatar	48	12	307

Source : Gonzales, P., Williams, T., Jocelyn, L., Roey, S., Kastberg, D., & Brenwald, S. (2008). **Highlights From TIMSS 2007: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context.** U.S. Department of Education, National Center for Education Statistics, Institute of Education Sciences, Washington, DC.

Page 7

TIMSS Advanced tests assess the advanced students' achievement in mathematics and science in the final year of secondary schooling. This is the 12th year of formal schooling in most countries including Lebanon. Lebanon is the only Arab country among the 10 participating countries in TIMSS Advanced 2008. The Lebanese participating students are enrolled in the GS track of the Secondary Education. The findings of TIMSS Advanced 2008 in mathematics achievement show that:

- (a) The Lebanese program, as well as that of the Netherland, provide the greatest number of math instructional hours (*TIMSS Advanced 2008*, n.d.).

- (b) Russian Federation, the Netherlands, and Lebanon have the highest average achievement in advanced mathematics which is higher than the international scale average of 500. Table 1.3 shows the scores and ranking of the participating countries (total: 10 countries) in TIMSS Advanced 2008 in mathematics (as extracted from *Exhibit 2.1* in Mullis, Martin, Robitaille, & Foy, 2009).
- (c) The majority of students in seven countries including Lebanon taking advanced courses in mathematics were males (Lebanon had 71% males and 29% females). Moreover, Italy and Lebanon are the only countries where females (average achievement score of females in Lebanon is 554) had higher achievement than males (average achievement score of males in Lebanon is 541) in advanced mathematics (as extracted from *Exhibit 2.4* in Mullis, Martin, Robitaille, et al., 2009).

Table 1.3

The Scores and Ranking of the Countries Participating in TIMSS Advanced 2008 in Mathematics

Countries participating in TIMSS Advanced 2008	International rank (total: 10 countries)	Score (International Average Score in math = 500)
Russian Federation	1	561
Netherlands	2	552
Lebanon	3	545
Iran, Islamic Rep. of	4	497
Slovenia	5	457
Italy	6	449
Norway	7	439
Armenia	8	433
Sweden	9	412
Philippines	10	355

Source : Mullis, I.V.S., Martin, M.O., Robitaille, D.F., & Foy, P. (2009). *TIMSS Advanced 2008 International Report: Findings from IEA's Study of Achievement in Advanced Mathematics and Physics in the Final Year of Secondary School*. IEA TIMSS & PIRLS International Study Center. Boston College.
Page 65

1.4 – Purpose of the Study

This study aims at: (a) investigating the alignment between the Lebanese secondary-level official math exams and the reformed math curriculum for the LH track, (b) reflecting the OEC attitude toward the issue of alignment and procedures followed when setting the test items of the exams every year, (c) investigating the trend and direction of the official exams' evolution by comparing the extent of the above alignment in the starting five years (2001 to 2005) to the following five years (2006 to 2010) of implementing the reformed curriculum, (d) comparing the alignment of the

curriculum with the official exams in session-1 to that in session-2 for the LH track, and
(e) providing some recommendations for improving the alignment between the curriculum and the official exams.

1.5 – Research Questions

The research questions are:

1. Are the Lebanese secondary-level official math exams for the LH track aligned with the national reformed curriculum over the years 2001-2010?
2. How does the OEC approach the issue of alignment when setting the test items of the exams every year?
3. Is there any improvement in the alignment of the national exams from the years 2001-2005 to the years 2006-2010?
4. Are there differences in the extent of alignment with the curriculum between the exams in session-1 and session-2 of the academic years 2001-2010 for the LH track?

CHAPTER TWO

LITERATURE REVIEW

The purpose of this study, as mentioned earlier, is to investigate the alignment between the Lebanese national curriculum and the national assessment (official exams) in mathematics. This chapter aims to define the key terms and survey the literature for theoretical foundations and similar research on:

- (a) *Curriculum*. What are the varying aspects from a traditional curriculum to curriculum reform? What is a national curriculum? How is it developed?
- (b) *Assessment*. What is assessment? What are the purposes of assessment? Are there some rules or principles for assessment? Are there criteria or standards for assessment? What are the international assessment frameworks in mathematics?
- (c) *Alignment*. What does research indicate about the alignment between curriculum and assessment in mathematics? What are the common models for determining the alignment between standards and assessment?

This chapter attempts to answer the above questions within a reflection on the existing research and theoretical backgrounds concerning curriculum, assessment, and alignment between them.

2.1 – Curriculum

Education is important to develop knowledgeable, intellectual, sociable, responsible, and productive citizens. Education is a lifelong learning process; it does not stop at any life stage or age. Due to the rapid progress of science and technology, people need to be up to date. According to Sowell (2005), there are five purposes of education: (a) to organize thoughts, think, reason, and solve real life problems through the study of a variety of disciplines; (b) to prepare individuals for coping with the changing world, and reform the society; (c) to prepare individuals for discovering and experiencing new things, and enrich their potential; (d) to develop cognitive skills and abilities that are retained even when the taught content is forgotten; and (e) to facilitate learning and communicate knowledge in systematic and efficient techniques such as the use of technology.

These purposes of education affect the individual's knowledge, skills, and self-development while the second purpose of education focuses on the needs of society. Education affects the society and vice versa; that is, the curriculum (basically defined as what is taught to learners) must follow the needs and progress of the society as well as contribute to the reform of the society.

John Dewey, throughout his writings on the issue of education and society, argues that social reform must start from the school as a social institution for interactive learning processes (Dewey, 1916, 1929, 1965). Moreover, Brameld (1965) identifies

two major roles of education: “to transmit culture” and “to modify culture”. Therefore, based on the purposes of education and considering the needs of the society / culture, there should be a set criteria for curriculum and content selection among the wide variety of information and knowledge in the world. These criteria vary based on the nature and needs of different societies. It is important for curricular systems to reflect the social diversity rather than reinforcing and maintaining a controlled system that discriminates among communities.

2.1.1 – Traditional Curriculum vs. Curriculum Reform

The last century witnessed many changes and progress in science and technology. These evolutions along with theories on human nature and development had many influences on the field of education. Both the teaching methods and the content of the traditional curriculum have changed (Eggleston, 1970-1971). New attitudes toward teaching strategies evolved from the psychological theories on the different mental abilities of people and how they process data in their minds. Examples of these theories are the constructivist theory that was inspired by Piaget’s theory on cognitive development, the social learning theory of Bandura, and the multiple intelligences theory of Gardner. "Piaget (1976) focused on the personal construction of knowledge in such works as *To Understand Is To Invent*, while Vygotsky (1934) emphasized the social construction of meaning in his work on *Thought and Language*" (Gagnon & Collay, 2006, p. xiv).

Traditionally, curricula emphasized on teaching rather than learning where the weight was on inputs and giving information instead of outputs and gaining knowledge and learning outcomes (Wiggins & McTighe, 2005). They were teacher centered curricula where the teacher lectured and the students memorized. According to Wiggins and McTighe, students of traditional curriculum were passive in receiving knowledge and lacked the sense of exploration and curiosity to ask and look for more information and interpretation. Curricula were somehow based on the behaviorism theory where students memorized the knowledge to get rewarded in grades and do well on tests (Sowell, 2005).

Moreover, the subjects and contents in traditional curricula were taught as separate from each other with no connections in the content of the same subjects, among subjects, nor with real life situations. When there was rote learning, students would not understand the purpose of the subject, why they are learning it, and how they will use it or apply it in real life situations (Wiggins & McTighe, 2005).

However with the progress of science and technology, curricula experienced various changes in their structure and implementation. One of the new curricula perspectives introduced the Understanding By Design (UBD) where the emphasis is on learning.

UBD means that the curriculum is based and designed to assure students' achievement / fulfillment of learning outcomes. Both general and specific objectives

should be set to measure understanding of content in higher level of critical thinking and problem solving. The teacher in his / her classroom must help students achieve a deep understanding where they illustrate their abilities in explanation, interpretation, application, empathy, and self-knowledge (Williams, 1971). Understanding means the ability to explain the concept / phenomenon, interpret the results, apply the knowledge in different contexts, formulate an opinion, connect to real life situations and other concepts, analyze, and reason (Gagnon & Collay, 2006).

New curricula designs urge the integration of subjects that is the content of the same subjects are connected to each other; in addition, the content of different subjects are connected among each other and related to real life situations (Wiggins & McTighe, 2005). Therefore, these connections would help students in a better understanding of the purpose of each subject and how to adopt it in real life situations. Curricula in this case are given as process and framework.

Therefore, teachers' job is difficult because it needs both preparation and understanding: Teachers need to set the learning objectives, search for interesting and motivating activities, prepare lesson plans and different assessment techniques. Moreover, teachers have to understand students' characteristics, needs, and abilities in addition to the understanding of the subject / content in all its aspects to introduce this understanding to all students taking into consideration their variety of needs and their different levels of abilities (Kimball, 1999). As the curriculum needs to be revised and updated, teachers also must evaluate the influence of their methods and modify and

adjust them to reach students' needs and abilities and thus having a higher and improved achievement and deeper understanding (Sowell, 2005).

2.1.2 – Curriculum Standards / National Curriculum

The adoption of a national curriculum has been debated in the literature. Some arguments are against developing a national curriculum. These arguments are mainly based on the concern that a national curriculum is time consuming and expensive due to its need to be frequently evaluated and updated (Hummell, 2007; Williamson, 1962). On the other hand, many arguments favor a national curriculum. According to Lawton (1989), maintaining a national curriculum has many advantages in terms of:

- (a) Standardizing the aims and objectives, subjects and contents, as well as assessment of education at the national level. As a result, a national curriculum unifies schools' curricula in any subject.
- (b) Providing students with equal opportunities to education. Having equal chances to access a national curriculum reduces the differences in the quality of education among schools of same nation.
- (c) Transferring a cultural identity to students. Education in any nation is influenced by the nation's norms, traditions, and legal practices. Children go to school to become knowledgeable, sociable, and good productive citizens.
- (d) Facilitating the role of teachers. The teacher is not required to design a curriculum or choose the content, but to prepare classroom lesson plans that associate the

national curriculum, the school-based curriculum, and the teacher's strategies. Therefore, the teacher must be trained in various techniques to deliver the curriculum as well as follow the content, objectives, prerequisites, and sequence of the subject within the grade level and over the school cycles. Finally, teachers get the opportunity to further emphasize teaching strategies and search for motivating content related activities instead of wasting their time on looking for subject matter.

- (e) Increasing schools' accountability. Even though private schools might choose not to implement the national curriculum in their schools' programs, they can still use the national curriculum as a guide for basic education while adding new objectives, subjects, and contents. Once the national curriculum is ready for implementation, schools must not blindly adopt it; that is, schools must have their own aims that motivate their students to learn, acquire skills, and develop ethical values (Lawton, 1989).

Some nations, such as UK, adopt a detailed national curriculum with specified objectives, learning outcomes, and content for each subject at all grade levels. The National Curriculum in UK set out for each subject at each key stage the programs of what should be taught as well as the expected standards for students' achievement and performance. However, it is up to the school to form its own curriculum that encompasses the national curriculum in terms of the programs of study and the expected standards. (UK Department of Education, 2011).

On the other hand, other nations, such as USA, have standards that constitute the foundation for school curricula. These curriculum standards establish the general guidelines and the major criteria for education without imposing a detailed curriculum content. The U.S. Department of Education (2008) declares: “While there is no national curriculum in the United States, states, school districts and national associations do require or recommend that certain standards be used to guide school instruction. In addition, federal law mandates that state standards be developed and improved in order for states to receive federal assistance.” The Common Core State Standards (CCSS www.corestandards.org) were released in March 2010 for two subjects only: English language arts and mathematics. The goal is to unify and adopt the same standards across all states as well as to standardize the knowledge and expectations for students’ learning and success.

However, there are some arguments that the USA curriculum standards are not enough to assure a coherent curriculum. William Schmidt, the director of the U.S. National Research Center for TIMSS, as well as other researchers have contributed to the research on the issue of curriculum, standards, and curriculum coherence in USA with respect to other international countries. According to Schmidt, Hsing Chi, and McKnight (2005), “the presence of content standards is not sufficient to guarantee curricula that lead to high-quality instruction and achievement” (p. 525). The authors add that the “content standards (...) have yet to reflect the coherence that is typical of countries that achieved significantly better than the US in the TIMSS study” (p. 525). Note here, the performance of the USA in TIMSS 1995 exams shows differences

between the fourth-grade level (score above the international average in both math and science), the eighth-grade level (score at the international average) and finally to the secondary level (score below average). Two essential reasons lead to the latter arguments and the decline in TIMSS results. These reasons are basically related to the curriculum; that is, to what is taught to students. First, there are many more topics covered at each grade level in USA than those in the high-achieving countries in TIMSS. Second, in addition to the huge content at each grade, each topic is split in the curriculum over more grade levels than in the high-achieving countries in TIMSS. In short, the USA standards and the enacted curricula are a “mile wide and an inch deep”, as stated by Schmidt, Houang, and Cogan (2002, p. 3). Moreover, education in terms of schooling and teaching differs in the six highest achieving countries in TIMSS from that in USA. Unlike the teachers in the highest-achieving countries who have coherent curricula with set guidelines and materials as well as professional development programs, teachers in USA have lots of data about what should be taught with less guidance and training (Schmidt, Houang, & Cogan, 2002). Moreover, Schmidt et al. (2002) state that USA teachers are in need of a national coherent curriculum provided with necessary guidelines, texts, resources, and training.

2.1.3 – Developing a National Curriculum

School curriculum is a set of guidelines of the outcomes to be achieved, the content to be taught and how to teach it. Many factors contribute to the decision of what

to teach young children. Educators, sociologists, philosophers, psychologists, teachers, parents, students, employers, religious and political authorities in the same nation, all have different perspectives of curriculum purpose and content (Coulby, 2000). Table 2.1 summarizes Coulby's perception of some of these contributors and their concerns, organized in a table for clarity in this study.

There are conflicts within each field on deciding what to include or exclude as well as what to emphasize or de-emphasize. Conflicts arise as well when integrating the fields together in the curriculum. For example, some philosophical ideas might be opposed to some religious beliefs.

Table 2.1
Contributors to the National Curriculum and Their Concerns

Contributors	Concerns are in ...
Academic specialists	Including as much subject content as possible, hence leading to an overloaded curriculum.
Sociologists	The social and moral skills that the curriculum facilitates.
Religious authorities	The religious beliefs that are included in the curriculum.
Politicians	The political, civil, and legal issues that are incorporated in the curriculum.
Employers	Developing basic skills and knowledge needed in their particular line of work.
Parents	The social, cultural, and moral values.
Young students	The choice of materials and human knowledge.

Lunenburg (2011) identifies three key elements / components of a curriculum plan: (a) *objectives* indicating “where” to go, (b) *content* indicating “what” to teach, and (c) *learning experiences* indicating “how” to teach. However, other researches (Sowell, 2005; Coulby, 2000; Ornstein & Hunkins, 1998; Worthen & Sanders, 1987), identify the curriculum as a cycle with four components: *planning*, *developing*, *implementing*, and *evaluating*. A description of each curriculum component follows:

1. *Planning – curriculum aims, goals, and objectives*. The planning involves three points: forming a Curriculum Development Committee (CDC), naming the key issues and trends as global content areas, and considering the needs. Moreover, planning a national curriculum requires an introduction that clarifies its general purpose and aims. According to Sowell (2005), the introduction should specify the following: (a) purpose of curriculum development; (b) purpose of education; (c) consideration of the culture, society, school settings, and students; and (d) description of the tasks of the curriculum users.
2. *Developing - curriculum content or subject matter*. There are many subjects and contents concerning human knowledge, and it is not easy to choose what to include or exclude from the curriculum. Hence, the curriculum must be built according to specific criteria or standards referred to as knowledge protocols (Coulby, 2000). The major criteria for content selection are: self-sufficiency, significance, validity, utility, learnability, and feasibility. The content of the national curriculum comes from a *resource list* and *content statements* (Sowell, 2005). The resource list includes instructional materials such as textbooks and technology-based sources. The content statements essentially clarify the content

at each grade level in terms of: (a) the subjects included in the curriculum, (b) the breadth and depth of the content of each subject, and (c) the scope and sequence of each subject over the grade levels and school cycles.

3. *Implementing – curriculum experience.* The curriculum implementation takes place in the classroom through the teaching strategies that convert the written curriculum to instruction. One way to introduce knowledge to students and assess its acquisition is using the Bloom's taxonomy of educational objectives: (a) cognitive domain (knowledge, comprehension, application, analysis, synthesis, evaluation); (b) affective domain ; and (c) psychomotor domain (Bloom, 1956). Moreover, Teachers should be well trained to become familiar and experienced with the new program. Four issues are to be considered for effective and successful curricula implementation: (a) having an active start with a heavy participation, (b) making pressure for change and using support to prevent resistance, (c) involving individuals and changing the attitudes and conducts to adapt with the new curriculum, and (d) developing the sense of commitment and ownership (Fullan, 2001, as cited in Sowell, 2005). A complete implementation may possibly take up to five years long (Sowell, 2005).
4. *Evaluating – curriculum evaluation.* Curriculum evaluation is significant for: (a) the public to ensure that the intended objectives are met in the outcome; (b) teachers to ensure that their classroom instruction is effective; and (c) the CDC to improve, update, and determine the success of the curriculum. Evaluation is the process of gathering data on a program to determine its value and make judgmental decisions such as to edit, update, add to, and / or delete areas from

the curriculum (Ornstein & Hunkins, 1998; Worthen & Sanders, 1987). There should be a Curriculum Evaluation Committee (CEC) that will guide the evaluation process and establish criteria that help in identifying the strengths and weaknesses. This committee has two roles: organizing evaluation activities and reporting findings to concerned people under a certain schedule (Sanders and Davidson, 2003, as cited in Sowell, 2005). The CEC must abide by the following evaluation procedure (Sowell, 2005):

- (a) Identify the areas / aspects of the curriculum to be evaluated.
- (b) Make a schedule and identify the data collection instruments.
- (c) Collect data from interviews, surveys, meetings, etc. Feedback of the observations and experiences of the coordinators, teachers, students, and parents can help in evaluating and improving the curriculum.
- (d) Analyze data, indicate the results, and write recommendations.
- (e) Make a report for curriculum revision.
- (f) Follow up with the CDC in reviewing the curriculum.

The curriculum is regularly tested and revised before and during its implementation to assure that its goals and theories could be / are easily implemented at schools. The evaluation process is an ongoing process that sometimes requires a curriculum reform. According to the National Council of Teachers of Mathematics (NCTM, 1995), “reform is a journey, not a destination” (p. 83).

A national curriculum needs experts to establish it, to set basic criteria for education, and to continuously revise it. It takes years of study and revision. Accordingly, it should be revised and adjusted to reach all students and meet their various needs. National curriculum is usually nationally assessed. Official exams are one of the curriculum assessment tools. The national level assessment helps in evaluating (a) students' achievement at the national level, (b) the schools' performance in implementing the national curriculum (the school performance can be assessed from the grades of its students in the national exams), and (c) the national curriculum itself to determine if it needs revision and adjustment.

2.2 – Assessment

Every child has the right to education and is capable of learning. NCTM (1995) advocates this notion for mathematics and states that “all students are capable of learning mathematics, and their learning can be assessed” (p.1). Assessing students' learning should be an instrument to improve the learning process and achievement as well as to inspire for higher expectations.

2.2.1 – Definitions

“Teachers are in the best position to judge students’ progress” (NCTM, 1995, p. 1). Teachers assess students to keep track of their learning achievement and progress as well as prepare them to the next stage of learning.

Assessment, as defined by Linn and Miller (2005), “is a general term that includes the full range of procedures used to gain information about student learning (observations, ratings of performances or projects, paper-and-pencil tests) and the formation of value judgments concerning learning progress” (p. 26). That is, assessment consists of all measures used to estimate or appraise an individual's achievement. There are different ways of assessment such as forming general impressions, marking assignments, students' self-assessment, written tests, etc. These sources differ in their level of formality and standardization. Whenever there is a standardized curriculum there should be standardized achievement tests where all students are assessed based on similar content and criteria.

More specifically, NCTM (1995) defines assessment in mathematics 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” (p.87). That is, assessment must support the continuous learning of mathematics in order to develop student’s ability to explore, conjecture, reason,

communicate mathematically, connect ideas, and solve problems. NCTM defines these abilities / skills as “mathematical power”.

Consequently, assessment is an instrument used to evaluate students’ learning. Assessment may include both quantitative and qualitative descriptions of students’ performance. There are different forms or procedures of assessment such as: observation, questioning, portfolios, tests, etc. A test is only one of the procedures used to assess students’ learning. According to Linn & Miller (2005), “a *test* is a particular type of assessment that consists of a set of questions administered during a fixed period of time under reasonably comparable conditions for all students” (p. 26). Moreover, Hart (1994) and Airasian (1991), as cited in NCTM (1995), define a *test* as a formal and systematic measuring instrument of students’ behavior to assess and document their learning. According to Airasian, as cited in NCTM, test results are used to form expectations about the performance of students on resembling untested behaviors.

The terms *assessment*, *measurement* and *testing* are usually used interchangeably. However, technically speaking each has a different definition. “*Assessment* is a much more comprehensive and inclusive term than *measurement* or *testing*” (Linn & Miller, 2005, p. 27). Whereas, *measurement* is a term confined to assigning numerical results for students on any form of assessment based on a specific rule (Linn & Miller, 2005). We are interested in this study with testing, the traditional paper-and-pencil test, for being the procedure used for the official exams in Lebanon.

2.2.2 – Standards, Principles, and Purposes of Assessment

Standards are the criteria that specify the content to be taught and learned (Linn & Miller, 2005, pp. 6-7). In order to be effective, the standards must well clarify what students need to learn, and when the standards are met. Effective standards correspond to two types: content and performance standards. Content standards specify the “what”; that is, what students should know and do in a certain subject-matter area. Whereas, performance standards add to the content standards the specification of “how well”; that is, the expected level of students’ performance with respect to the content standards.

The *assessment standards*, according to NCTM (1995), provide “criteria for judging the quality of assessment practices, which embody a vision of assessment consistent with the curriculum and the teaching standards derived from shared philosophies of mathematics, cognition, and learning” (p. 87).

NCTM (1995) distinguishes among six *assessment standards in mathematics*: mathematics, learning, equity, openness, inferences, and coherence standards. According to NCTM, these standards involve major assessment issues in mathematics and promote an ongoing improvement of mathematics curricula, instruction, and assessment. The assessment standards in mathematics contributed to an improvement in assessment practices with respect to content, teaching, learning, assessment, evaluation, expectations, and achievement. NCTM states that this progress is toward: (a) interactive teachers who question and listen, (b) students who are dynamic and active, (c) problems

that reflect various topics and demonstrate students' full mathematical power, (d) evaluation of students' performance based on established criteria and multiple sources of evidence, and (e) alignment of assessment with curriculum instruction. One can relate this progress / shifts in assessment practices to the constructivist theory and the student-centered approach for learning as well as the Bloom's *taxonomy of educational objectives*.

Assessment is used to make value judgments concerning the quality (nature, what is learned) and quantity (degree, how well learned) of learning among students. Therefore, teachers must consider certain principles when assessing their students. Teachers must: (a) clearly specify what is to be assessed, (b) select an assessment procedure based on the attributes to be measured, (c) include various procedures taking into consideration the limitations of each, and (d) not forget the purpose of assessment (Linn & Miller, 2005). The purpose of assessment can be either internal or external. Whereas internal assessment provides information about students' performance and achievement, external assessment provides information about the curriculum and its success. NCTM (1995) affirms that there are four different purposes of assessment:

- (a) To monitor (based on performance tasks, projects, and portfolios) students' progress and learning through communication and self-assessment.
- (b) To make instructional decisions (based on observation, questioning, and listening) and take moment-by-moment decisions for improving instruction.
- (c) To evaluate students' achievement by recognizing students' accomplishment and comparing it with performance criteria.

- (d) To evaluate the program and modify it accordingly by using evidence and professional judgments of teachers.

The National Council for Curriculum and Assessment (NCCA, n.d.) distinguishes between *Assessment of Learning* (AOL) and *Assessment for Learning* (AFL). The following describes the characteristics of each:

- (a) AOL is a summative assessment that occurs after the learning is conveyed and acquired. The teacher gathers the information, transforms it into grades, and compares students' results to each other. The purpose of this assessment is to measure students' performance of past learning.
- (b) AFL is defined as "the process of seeking and interpreting evidence for use by learners and their teachers to decide where the learners are in their learning, where they need to go and how best to get there" (Assessment Reform Group, 2002, as cited in The Association for Achievement and Improvement through Assessment, n.d.). AFL is a formative assessment that is integrated within the learning process. The teacher shares the learning expectations with students so they know the required standards of the quality of learning. Next, the teacher compares students' results to the measured objectives and provides feedback to students on their performance. Hence, students get involved in assessing their own learning and do the necessary to fill any gap in their knowledge. AFL helps both the teacher and the learner to reflect on learning by determining whether learning has occurred and making decisions about the next stage of learning.

It is clear that AOL and AFL have different features, yet their practices do not oppose or contradict each other. While AOL is used to determine students' achievement and assign a grade, AFL is basically used to improve instruction and achievement. Together they give opportunities for teachers and students to evaluate and improve learning.

All types of assessment should be means to an end, which is achievement. Achievement is defined as a “successful accomplishment or attainment of educational goals” (NCTM, 1995, p. 87). However, unfortunately achievement is sometimes interpreted as the passing grade on assessment. Schools, teachers, students, and / or parents compete for students' “high achievement”, in other words high grades. Therefore, they put more emphasis on the grade itself rather than learning. Especially when there is national assessment, some teachers tend to prepare students to take the national assessment by shifting their instruction practices from “teaching for learning” to “teaching to the test”. At this point, the undesirable approach “teaching to the test” also known as *Learning for Assessment* (LFA) takes place. In this approach, understanding and learning are replaced by rote memorization of techniques and procedures to be used in the assessment. Therefore, LFA is opposed to the previously mentioned notions of AFL.

Educators must always keep in mind that the aim of education is *learning* and everything under education should be directed toward this aim. Therefore, the written,

the taught, and the assessed curricula should be aligned together for the purpose of improving learning.

2.2.3 – International Assessment Frameworks

A *framework*, as defined by NCTM (1995), is “an organizing system for, and arrangement of, the mathematical understanding, performances, and dispositions to be assessed, which will assist the planning of assessments” (p. 88). The *National Assessment of Educational Progress* (NAEP), the *Program for International Student Assessment* (PISA), and TIMSS develop regularly updated assessment frameworks and assess students’ achievement among different states / countries on a regular basis. Table 2.2 organizes the characteristics of, and compares the frameworks set by NAEP (*Mathematics Framework for the 2011 National Assessment of Educational Progress*, 2010), PISA (*PISA 2009 Assessment Framework*, n.d.), and TIMSS (Garden et al., 2006; Mullis, Martin, Ruddock, et al., 2009). The comparison is held with respect to the participating countries, administration years, grade levels and subjects. Such international assessment frameworks provide the participating states / countries with useful tools to assess their national / international standing in mathematics and other subjects.

Each international assessment mentioned conducts its own background questionnaires regarding curricula, schools, teachers, and students that help in

differentiating among the characteristics of the participating countries, and develops a framework for assessment based on content and cognitive domains. NAEP (*Mathematics Framework for the 2011 National Assessment of Educational Progress*, 2010) explains that “an assessment framework is like a blueprint. It lays out the basic design of the assessment by describing the mathematics content that should be tested and the types of assessment questions that should be included. It also describes how the various design factors should be balanced across the assessment” (p. 2). Table 2.3 organizes the characteristics of, and compares the latest mathematical frameworks by NAEP 2011 (*Mathematics Framework for the 2011 National Assessment of Educational Progress*, 2010), PISA 2009 (*PISA 2009 Assessment Framework*, n.d.), and TIMSS 2011 (Mullis, Martin, Ruddock, et al., 2009).

Table 2.2
Comparing NAEP, PISA, and TIMSS

	NAEP	PISA	TIMSS
Scope	USA-national	International	International
Years	conducted periodically for nearly four decades	conducted on a regular three-year cycle 2000 2003 2006 2009	conducted on a regular four-year cycle 1995 1999 2003 2007 2011
Grade Levels	Grade 4 Grade 8 Grade 12	administered to 15-year-old students	Grade 4 Grade 8 Grade 12 → TIMSS Advanced conducted in 1995 and 2008
Subjects	reading, mathematics, science, writing, U.S. history, civics, geography, and other subjects	Mathematical Literacy Problem Solving Reading Literacy Scientific Literacy	mathematics and science

Table 2.3

Comparing NAEP, PISA, and TIMSS Latest Mathematics Frameworks

	Latest Mathematics Frameworks		
	NAEP 2011	PISA 2009	TIMSS 2011
Math content	Percentage distribution of grade 12 items by math content area: - 10% Number properties and operations - 30% Measurement and Geometry - 25% Data Analysis, Statistics, and Probability - 35% Algebra	Overarching ideas: - Quantity - Space and shape - Change and relationships - Uncertainty	4 th Grade Math content domains: - 50% Number - 35% Geometric Shapes and Measures - 15% Data Display 8 th Grade Math content domains: - 30% Number - 30% Algebra - 20% Geometry - 20% Data and Chance
Math abilities	Three mathematics achievement levels: - Basic - Proficient - Advanced	Mathematical competency clusters: - Reproduction - Connections - Reflection	Math cognitive domains: - Knowing - Applying - Reasoning
Item format of math tests	Percentage of test items for each type: - 50% Multiple choice - 50% Constructed Response	Frequency of test items for each type: - 1/3 Open constructed response - 1/3 Close constructed response - 1/3 Multiple-choice	Frequency of test items for each type: - 2/3 multiple-choice - 1/3 constructed response

2.3 – Alignment between Curriculum and Assessment

According to Glatthorn (1999), a curriculum can be categorized into eight types: (a) the hidden or unintended curriculum, (b) the excluded curriculum (intentionally or unintentionally left out), (c) the recommended curriculum, (d) the written curriculum as documented in official texts, (e) the supported curriculum in textbooks and other materials, (f) the tested curriculum, (g) the taught curriculum, and (h) the learned curriculum. However, in a narrower view, a curriculum can be classified into three: the intended, the implemented, and the attained curriculum (Mullis, Martin, Ruddock, et al., 2009). Curriculum alignment refers to balance and consistency among the different curriculum aspects.

Determining whether a student has achieved the standards depends basically on his / her results on the standardized tests, and more importantly on the degree of alignment of the standardized tests with the curriculum standards (Bhola, Impara, & Buckendahl, 2003, as cited in Fulmer, 2010). According to Webb (1997), “assessments must achieve a high degree of match between what students are expected to know and what information is gathered on their knowledge” (p. 4). Therefore, the standardized tests must adequately reflect the standards they measure. However, one cannot expect the alignment to be perfect since the items in a standardized test represent only a sample of the curriculum standards (Fulmer, 2010). Fulmer states that an acceptable discrepancy may occur when the test encourages and challenges both teachers and students to be prepared for higher critical thinking than the curriculum standards do. Therefore, classroom instruction must reflect the intended curriculum and standards as

well as prepare students for the standardized test (Blank, 2002, as cited in Fulmer, 2010). The written and the assessed curricula, when they match properly, can guide the taught curriculum to align with the aims and standards.

2.3.1 – Models for Alignment between Standards and Assessments

Despite of other essential elements in an education system such as instruction and professional development, Webb (1997) focuses on the critical role of having an alignment of expectations and assessments to educators, students, and researchers. Such an alignment (a) assures a clearer understanding of what students are to learn, (b) provides consistent instruction, (c) indicates fairness for all students, (d) is critical to strengthen and improve the accountability of the education system, and (e) constitutes a major aspect of school effectiveness and curriculum reform.

Several research works distinguish among common models for determining alignment between standards and assessments (Rothman, Slattery, Vranek, & Resnick, 2002; Case, Jorgensen, & Zucker, 2004; Webb, 2007; Liu & Fulmer, 2008; Roach, Niebling, & Kurz, 2008; Martone & Sireci, 2009; Fulmer, 2010). A state or district must choose a model for studying curriculum alignment that best matches its particular alignment goals, criteria, and resources. The widespread alignment models are:

1. Webb's alignment model (Webb, 2007). Webb's model uses four criteria to evaluate the alignment between standards and assessment. These alignment criteria are:
 - (a) *Categorical Concurrence*. This criterion establishes an overall indication of alignment by determining whether standards and assessment encompass the same content categories; that is, whether all standards are measured in the assessment items.
 - (b) *Depth-Of-Knowledge (DOK) Consistency*. This criterion establishes an indication of alignment between standards and assessment in terms of complexity of knowledge required by each; that is, whether the assessment items are as demanding cognitively as the stated standards. There are four DOK levels assigned to the objectives within standards and assessment items: Level 1 (recall), Level 2 (skill / concept), Level 3 (strategic thinking), and Level 4 (extended thinking).
 - (c) *Range of Knowledge Correspondence*. This criterion establishes an indication of alignment between standards and assessment in terms of the breadth of knowledge required by each; that is, whether the assessment items have the same or a corresponding span of knowledge as the standards.
 - (d) *Balance of Representation*. This criterion establishes an indication of alignment by determining whether knowledge is equally distributed in both standards and assessment; that is, whether more emphasis is given to an objective than another on the assessment. A balance index is calculated to evaluate how the assessment items are distributed.

For each of the above four criteria, an acceptable level is specified as a minimum average required in order to be certain that a pupil had acquired the standards. Findings are reported for each of the four criteria, along with the attainment of specified acceptable levels. An acceptable level on each criterion is necessary but not sufficient for alignment; that is, all four criteria must be met in order to say that an assessment is entirely aligned to standards. “Thus, alignment is determined if there are sufficient number of items allocated to each standard with an appropriate level of complexity and coverage and without overemphasizing any one content area” (Webb, 2007, p. 16).

2. Porter’s model also named as the Survey of Enacted Curriculum (SEC) (Liu & Fulmer, 2008; Roach et al., 2008). Porter’s model of alignment requires a quantitative analysis in two tables: one for the curriculum and the other for the test. The rows in both tables represent the content; whereas, the columns represent the emphasized cognitive skill. The tables are compared based on the assigned numerical values (proportions totaling to 1) to each cell. The standardized cell values of these two tables are used to evaluate their agreement. Next, the Porter alignment index is found using the formula:

$$P = 1 - \frac{\sum_{i=1}^n |X_i - Y_i|}{2}$$

where ‘n’ represents the total number of cells in the table, and ‘i’ represents a certain cell such that ‘i’ varies from 1 to n. For instance, there are n = 30 cells and i ranges from 1 to 30 in a 5 × 6 table (5 contents and 6 cognitive skills).

X_i refers to the i^{th} cell in Table X (e.g., curriculum table), and Y_i refers to the corresponding i^{th} cell in Table Y (e.g., test table). The total absolute discrepancy between the i^{th} cells of Tables X and Y is then calculated by adding the absolute values of these differences ($X_i - Y_i$).

The Porter's alignment index is a statistical number that reflects the degree of alignment between a curriculum and a test using two variables for coding: content and cognitive complexity. The index $P = 1$ reflects a perfect alignment whereas $P = 0$ reflects no alignment. Additionally, significant findings about the alignment can be obtained from the marginal discrepancies in terms of each variable separately: content areas (considering the discrepancies in the rows of the matrix) and cognitive levels (considering the discrepancies in the columns of the matrix).

3. The Achieve model (Rothman et al., 2002; Case et al., 2004; Roach et al., 2008;). The Achieve alignment protocol provides both a qualitative and quantitative analysis to determine the alignment of a state's assessment to its related content standards. The model is initially applied to the test items separately and then to the whole test. A blueprint is created to map each test item to its related standard. Next, the alignment between assessment items and standards is investigated using the following criteria:
 - (a) *Content* Centrality. It matches content between item and standard by attributing one of the following: clearly consistent, not specific enough, somewhat consistent, and inconsistent.

- (b) *Performance Centrality*. It matches cognitive demand between item and standard by attributing one of the following: clearly consistent, not specific enough, somewhat consistent, and inconsistent.
- (c) *Challenge*. Sources of challenge and levels of challenge are both considered. The difficulty of a test item is categorized as appropriate or inappropriate source of challenge. Level of challenge matches the emphasis of performance between item and standard.
- (d) *Range*. It indicates the overall coverage of objectives within the assessment.
- (e) *Balance*. It indicates the over-assessed, under-assessed, and not assessed objectives in a standard by attributing one of the following: good, appropriate, fair, or poor.

2.3.2 – Case Studies on Alignment

A research conducted to investigate the relationship between four standards from the NCTM standards (problem solving, reasoning, communication, and connections) and the 1990 NAEP cognitive items for grade eight shows that there are some aspects that prevent from a complete alignment (Silver and Kenney, 1993). The main aspects of the non-alignment are as follows: (a) about half of the NAEP items did not designate any of the NCTM standards; and (b) two NCTM standards (communication and connections) were poorly used whereas the other two (problem solving and reasoning) were strongly covered in about half the NAEP items.

Moreover, Osta (2007) conducted a study on the alignment between national curriculum and assessment considering the case of Lebanon. She found a weak alignment between the Lebanese pre-reformed curriculum with its model tests and the official math tests, and hence discrepancies occur between the intended, the taught, and the tested curriculum.

The findings of the two above studies suggest the necessity of paying more attention to the alignment of assessment tools with the curriculum.

To sum up, this review of literature examined publications and research, based on theories concerning curriculum and assessment as well as the alignment between them.

The first section is related to curriculum. It states the major shifts from traditional curricula to curriculum reforms. Next, it argues based on research and supportive examples of two countries (one adopting a national curriculum and the second adopting curriculum standards) that curriculum standards are not sufficient to assure effective learning and high achievement. Finally, this section describes the different stages of curriculum development.

The second section in this chapter addresses assessment. It defines key terms and clarifies some misconceptions regarding assessment. A discussion follows on the

standards, principles, and purposes of assessment. In addition, a clarification of the differences among AOF, AFL, and LFA is provided, as well as their implications on learning. Last, this section ends with a comparison among three common international assessment frameworks (NAEP, PISA, and TIMSS) in mathematics.

The third and last section in this review of literature addresses alignment. Research works attribute a critical importance to the alignment between curriculum and assessment because such alignment affects the education system in general and more specifically the classroom instruction, students' understanding, and achievement. Then, three common models for determining curriculum alignment are described. Last, case studies of curriculum alignment are presented.

The following chapter describes the method used for addressing the research questions, which aim to investigate the alignment between the Lebanese national curriculum and the national assessment (official exams) in mathematics.

CHAPTER THREE

METHODOLOGY

3.1 – Design and Procedures

The main method used is content analysis. The analyzed documents are the national math exams and the national reformed Lebanese math curriculum in terms of its objectives, content, and model tests. The said documents are analyzed both quantitatively and qualitatively. Moreover, a semi-structured interview with two national test developers was conducted.

3.1.1 – Interview

The participants are:

1. The Secretary of the math OEC for all grade 12 tracks. He was a member in the OEC in mathematics for grade 9 in the pre-reformed Lebanese curriculum (before the year 2001). Then, with the reformed curriculum (starting year 2001), he became vice secretary of the math OEC for all grade 12 tracks, and two years ago, he became the secretary of the Committee, after retirement of the former secretary. Furthermore, the interviewee has previously taught mathematics at grade 12 level with its four tracks in public and private schools. Though he was a member in the math OEC for grade 9, yet he never taught 9th-grade students. Currently, he is a member of the Directorate of the MEHE Orientation and Guidance unit whose

mandate is to (a) investigate the needs and problems of public schools, and follow up with them to reach solutions; and (b) offer teachers workshops referred to as “journées pédagogiques” (pedagogical days). An example of these workshops is “how to prepare exams according to the new curriculum for grade 9 and for the four grade 12 tracks?”. As for his education, the interviewee has a bachelor degree and a teaching diploma in mathematics.

2. A member of the math OEC for all grade 12 tracks. She is a secondary school teacher. She participated in developing the reformed math curriculum, and she is a member of the Evaluation and Examinations Committees.

The semi-structured interview with the two test developers was conducted in a Public Secondary School in Beirut. The interview was conducted in Arabic, since one of the interviewees is French educated and the other is English educated.

The interviewees answered all questions and were assured about the confidentiality of their names. The interview questions (see Appendix B) asked each test developer about his/her education and experience, the committee, the process of developing official exams, and the Lebanese evaluation system in general.

Data obtained from this interview are qualitatively analyzed. The results of this interview are significant to the study because they clarify the basis on which the official exams are developed and highlight the perceptions of test developers on the following:

1. The alignment between national curriculum and official exams (1st research question).
2. The evolution of official exams over years (3rd research question).
3. The possible differences in the extent of alignment with the curriculum between session-1 and session-2 official exams (4th research question).

3.1.2 – Content Analysis

The analyzed curricular texts include:

1. The official text of the mathematics reformed curriculum for the secondary school level as issued in 1997 by the MEHE and ECRD (referenced as Document I in Appendix A). It includes the general and specific objectives as well as the scope and sequence and syllabus.
2. Curriculum of mathematics – Decree N^o: 10227 – details of contents of the third year of each cycle, a document issued in May 1997 by MEHE and ECRD (referenced as Document II in Appendix A). It includes the detailed content along with the corresponding objectives and comments for the third year of each cycle. This study is concerned with the detailed content of the LH track. Some objectives from grade 9 (third year – Intermediate Level – Basic Education) are also occasionally considered in the analysis.
3. Evaluation Guide for Mathematics for the Secondary Cycle, a document issued in October 2000 by the MEHE and ECRD (referenced as Document III in Appendix A). It consists of two units. The first unit includes the competencies for each year of

the secondary cycle along with sample test items for each competency. The competencies are classified in domains. For example, there are two domains in LH track: “calculation processes” and “problem solving and communication”. The second unit is a set of model tests for official examinations. It includes a set of criteria for the content and format of the official exams (see Appendix C) in addition to model tests for each of the four tracks in grade 12 and their corresponding “elements of solution and marking scheme”. The model tests for the LH track (see sample in Appendix D) are regarded in this study as a reference that represents the philosophy of assessment in the reformed curriculum, while the actual official exams represent the practical implementation of that philosophy.

4. A sample of the official math exams for the LH track (see sample in Appendix E). Twenty exams administered between 2001 and 2010 are considered. Those exams include ten session-1 and ten session-2 official exams.

Occasionally, there was a need to refer to additional documents. Since the curriculum of the secondary level is split over three years (grades 10, 11, & 12), the objectives of previous grade levels were implicitly included and assessed in the grade 12 official exams. Therefore, the document containing the details of contents of grade 11 was also used in the analysis; Mathematics Curriculum – Decree N° 10227 – details of contents of the second year of each cycle, a document issued in 1998 by the MEHE and the ECRD (referenced as Document IV in Appendix A).

The analysis of the documents is both quantitative and qualitative. The curriculum texts and the official exams are analyzed qualitatively as to their structure, content and objectives. Then the model tests and official tests are analyzed and compared quantitatively using descriptive correlational statistics (namely Pearson Product-Moment coefficient). More specifically, data are quantitatively analyzed as follows:

1. The official exams and the model tests are analyzed and compared quantitatively.
2. The official exams of the years 2001-2005 are analyzed and compared to those of the years 2006-2010 in order to check the evolution of the official exams under the reformed curriculum.
3. The session-1 official exams of the years 2001-2010 are analyzed and compared to those of session-2 in order to check their compatibility.

3.2 – Framework for Analyzing Exams

As previously mentioned, Osta (2007) conducted a study on the alignment of mathematics national examinations with the Lebanese pre-reform curriculum. Within her study, Osta developed a framework for studying the alignment between assessment and curriculum. Using statistical tables for each model test and official exam, Osta mapped the test items of both the official exams and the model tests according to two criteria: their respective math content within the curriculum, and the NAEP mathematical abilities (Procedural Knowledge, Conceptual Understanding, and Problem

Solving). Then, Osta used these tables to find the Pearson correlation between the model tests and official exams in terms of math content and mathematical abilities.

In this paper, the design for analysis developed by Osta (2007) is adopted. However, instead of relating to the NAEP mathematical abilities as in Osta's framework, this study considers the cognitive domains – knowing, applying, and reasoning – of TIMSS Advanced 2008 (Garden et al., 2006) Mathematics Framework (see Appendix F). The major reason for choosing TIMSS framework instead of NAEP or PISA is that Lebanon is one of the countries participating in TIMSS assessment.

3.2.1 – Definition of a Test Item

In what follows the term *test item* occurs frequently. NCTM (1995) defines *an item* as “a single, often decontextualized test question or problem” (p. 88). More specifically, and because the Lebanese tests are not simple objective tests, this paper adopts the definition of a test item by Osta (2007):

We define a “test item” as being any part of the test that requires a response from the student which entitles him/her to a part of the grade. A test item may take one of the two following forms:

- A question that requires an answer. For example, “What is the nature of triangle ABC?”
 - An imperative sentence, such as “Calculate the coordinates of point I.”
- In the case of many components required in one sentence, it is considered to stand for more than one test item. For example, “Plot the points A, B, C, and the straight line (D)” is counted for four items, because it stands for “Plot point A, plot point B, plot point C, and plot straight line (D).”

3.2.2 – Qualitative Analysis

The structure and content of the curriculum, model tests, and official exams are qualitatively analyzed as follows:

1. The curriculum is described in terms of its structure, content, and objectives.
2. The model tests and official exams are described in terms of their structure and content.
3. The test items in both the model tests and official exams are classified according to topics: *propositional calculus, equations and inequalities, rational functions, simple and compound interest, statistics, and probability*. Then, a descriptive analysis follows in addition to supportive examples.

3.2.3 – Quantitative Analysis

Using statistical tables for each model test and official exam, the test items are analyzed as to their corresponding curriculum objectives, and the TIMSS Advanced 2008 cognitive domains they measure.

3.2.3.1 – Coding.

The national exams for the LH track are coded as LH011, LH012, LH021, LH022, ... LH091, LH092, LH101, and LH102. The letters represent the LH track, the first two numbers specify the year of the exam, and the last number specifies whether

the exam is first or second session. For example, LH032 is the second session LH official exam administered in 2003.

The model tests for the LH track are coded as LHM1, LHM2, LHM3, and LHM4. The first two letters of the code represent the LH track, the “M” for “model” test, and the number is to distinguish among the four model tests.

The coding system of the details of contents of the national reformed mathematics curriculum for the LH track at the secondary school level (referenced as Document II in Appendix A) is adopted in this study. The sub-objectives are coded using the Roman numbering i, ii, iii, etc. Appendix G represents the coding of the curriculum details of contents.

The official exams at the end of Grade 12 LH track address all content of the 3 LH secondary years. The following are the test items addressed in the model tests and the official exams that relate to the curriculum content studied at grade levels preceding Grade 12 LH track. In other words, the following test items can be associated to the curriculum content at grade 9, 10, or 11. These test items are coded (A, B, ..., R) and classified per topics (lines, functions, interest, statistics, or probability).

- A. *Lines*: Draw a line defined by its equation. (retrieved from the details of contents for grade 9)
- B. *Lines*: Write the equation of a line parallel to the y-axis. (retrieved from the details of contents for grade 9)

- C. *Lines*: Find the equation of a line passing through two distinct points. (retrieved from the details of contents for grade 9)
- D. *Functions*: Calculate $f(2)$ given the algebraic expression $f(x)$.
- E. *Functions*: Write the equation of the tangent to the graph of the function at the point $(a, f(a))$. (retrieved from the details of contents for grade 11H)
- F. *Functions*: Calculate the derivative and determine its sign. (retrieved from the details of contents for grade 11H)
- G. *Functions*: Graphically, determine if $f'(2)$ is > 0 , < 0 , or $= 0$.
- H. *Functions*: Determine analytically the points of intersection of curve and line.
- I. *Functions*: Given table of variation, solve inequalities of the form: $f(x) \geq m$ (resp. $\leq$) for a given real value of m .
- J. *Functions*: Given $f(x)$ in terms of a, b, c find a, b, c
- K. *Interest*: Which choice is more profitable?
- L. *Interest*: Find earned interest (new amount - old amount)
- M. *Statistics*: Recognize a class and determine its center. (retrieved from the details of contents for grade 11H)
- N. *Statistics*: Calculate items and cumulative frequencies and represent them graphically. (retrieved from the details of contents for grade 11H)
- Draw the table of cumulative items of statistical data in a continuous variable and complete it with cumulative frequencies.
- Read a graph of cumulative items of statistical data in a continuous variable.
- O. *Statistics*: Complete table of frequency.

- P. *Probability*: Calculate the probability of an event using the basic properties of probability. (retrieved from the details of contents for grade 11H)
- Q. *Probability*: Know that, for two events A and B, $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$. (retrieved from the details of contents for grade 11H)
- R. *Probability*: Know that if A and $\bar{A}$ are complementary events then: $P(A) + P(\bar{A}) = 1$. (retrieved from the details of contents for grade 11H)

3.2.3.2 – Mapping of Test Items.

Appendix H represents an excerpt from the table of the quantitative analysis of the second model test LHM2 (Appendix D). The rows of the table are headed by the codes of the curriculum content and objectives. Whereas, the columns are headed by the distribution of the test items over the cognitive domains: knowing, applying, and reasoning. Each test item in LHM2 is analyzed as to the objective(s) it measures and to the cognitive domain(s) it addresses. One numerical point for each test item is split over the objectives and cognitive domains. That is,

1. If a test item covers two objectives x and y such that x corresponds to knowing and y corresponds to applying, then $\frac{1}{2}$ is assigned to the cell representing x-knowing and another $\frac{1}{2}$ is assigned to the cell representing y-applying.
2. If a test item can be solved in two methods then half point is assigned to each method. For example, if the first method covers objective x that corresponds to knowing and applying, and the second method requires objective y that corresponds to knowing, then $\frac{1}{4}$ for x-knowing, $\frac{1}{4}$ for x-applying, and $\frac{1}{2}$ for y-knowing.

Furthermore, the columns obtained under the cognitive domains are calculated in percentages to unify the basis of comparison.

The same table in Appendix H is constructed for each of the model tests and official exams. Appendix I represents an excerpt from the quantitative table analyzing the official exam LH042 (Appendix E). This analysis results in 23 quantitative tables: three tables for the model tests and 20 tables for the official exams.

Since the tables have the same size, content, and format and since they differ only in the numbers and the percentages based on the exams they analyze, then the tables are easily added by adding the numbers in the cells that correspond to the same objective and cognitive domain. These tables are added as follows:

1. The tables for the model tests are added in one table to be named Mod.
2. The tables for the official exams are added in one table to be named OffEx.
3. The tables for the official exams of the years 2001-2005 are added in one table to be named OffEx1-5, and the tables for the official exams of the years 2006-2010 are added in an another table to be named OffEx6-10.
4. The tables for the official exams of the session-1 are added in one table to be named OffEx1, and the tables for the official exams of the session-2 are added in an another table to be named OffEx2.

3.2.3.3 – Correlations.

The obtained 23 tables (3 model tests and 20 official exams) are compared as follows:

1. Tables Mod and OffEx are compared using correlation in order to analyze quantitatively the alignment between the official exams and the model tests.
2. Each of the tables OffEx1-5 and OffEx6-10 is compared to table Mod using correlation. The two obtained correlations are compared in order to determine quantitatively the evolution of the official exams over the years of implementing the reformed curriculum. Moreover, the tables OffEx1-5 and OffEx6-10 are compared to each other using correlation in order to quantitatively determine the compatibility between the official exams of the years 2001-2005 and the years 2006-2010.
3. Each of the tables OffEx1 and OffEx2 is compared to table Mod using correlation. The two obtained correlations are compared in order to determine quantitatively if there are differences among the official exams in the first and second sessions. Moreover, the tables OffEx1 and OffEx2 are compared to each other using correlation in order to quantitatively determine the compatibility between the official exams in the first and second sessions.

3.2.4 – Validity of the Analysis

The researcher resorted to judging in order to validate the analysis of this study and prevent any subjectivity in mapping the test items. The judge is a Lebanese

graduate student studying for an MA in Math Education; he is also a math coordinator and teacher at a private Lebanese secondary school. The author asked the judge to perform the same analysis of the model tests and official exams. He also analyzed the test items as to their corresponding curriculum objectives, and the TIMSS Advanced 2008 cognitive domains they measure. Both the author and the judge discussed their analyses and agreed on a unified mapping used in this study.

CHAPTER FOUR

FINDINGS

This chapter includes two parts: the qualitative analysis of the interview, and both the qualitative and quantitative analysis of the documents.

4.1 – The Interview

A semi-structured interview with two test developers was conducted to support the analysis and results of the study. The interviewees are two members of the math OEC for all grade 12 tracks; one of them is the Secretary of the committee. The interview is qualitatively analyzed according to some significant themes: OEC, curriculum reform, process of developing official exams, test items and grading scheme, session-1 and session-2 exams, and alignment of exams with curriculum.

4.1.1 – About the Committee (OEC)

The OEC is composed according to the following hierarchy:

1. The Director General of MEHE (also the chairperson of OEC).
2. The Head of Official Exams Department (part of his/her duties are announcing and publishing results).

3. The Examination Committees. There are two examination committees for each subject: one for grade 9 and one for grade 12. Each of these committees includes:
(a) the Secretary, (b) the Vice Secretary, and (c) the members.

The members of the OEC for each subject are appointed by the Director General. There is no fixed number of members in the examinations committees for each subject. Currently, the math OEC for grade 12 consists of 9 members other than the secretary and vice secretary. Each committee must be heterogeneous; that is, it must consist of people knowing English and people knowing French as well as people from public and private education sectors. The interviewees declare that “the committee members must be competent and efficient in their work; additionally, they are trained according to the reformed curriculum and its official exams”.

The executive committee, composed of the Director General and the secretary of each examination committee, meets to take decisions regarding issues such as the penalty for students who cheat in official exams. The Director General sets the dates of the official exams according to the public schools’ reports.

OEC members are selected based on their experience and their effective work. They get trained based on the curriculum and techniques for developing official exams using the necessary documents and they are evaluated by the ministry. Therefore, we assume that since experts are developing the official exams, there should be a high alignment between the official exams and the curriculum.

4.1.2 – Reformed Curriculum

According to the interviewees, the reformed curriculum was written based on objectives and details of contents. There are too many objectives, so they were integrated to make competencies. The competencies were classified into domains. For example, the LH track has two domains: *calculation processes* and *problem solving and communication*.

The interviewees state that “the old curriculum had no specified objectives, so when developing the test items we had no limits/boundaries for objectives. We could go deeply or shallowly in each concept. However, with the reformed curriculum, developing test items became much easier because we have documents in terms of objectives, details of contents, and competencies to refer to”.

4.1.3 – Process of Developing Official Exams

According to the interviewees, when developing test items, the examination committee uses the following documents: math reformed curriculum content, textbooks, general and specific objectives, competencies, evaluation guide, and a descriptive booklet of official examinations. Both the objectives and competencies are used in developing test items. They also follow the six cognitive domains of Bloom’s taxonomy (knowledge, comprehension, application, analysis, synthesis, and evaluation).

The interviewees state: “Some members in the committee prepared samples for exams and discussed them with the committee. Others relied on the meeting to develop questions on the spot. We try to choose problems reflecting real life situations. Such problems are multi-steps problems.” This is how the committee members developed the test items for all official exams from 2001 session-1 till 2007 session-1. However, starting from the official exams in 2007 session-2, the committee is using a test bank developed by the math OEC for grade 12 as well as other math teachers. The committee chooses problems from the test bank to form the required official exam. According to the interviewees, the test bank consists of 30 ready exams for each grade 12 track; moreover, “when the test bank is big enough, we can publish it. If students can solve all its problems, then we reached our aim, that is, they have learned.”

The interviewees declare that the committee subjects its work to a thorough review. Every committee member solves the exam and times his/her solution. Discussion continues until every member agrees. Finally, the official exam is evaluated. One of the interviewees, the Secretary of the math OEC for all grade 12 tracks, stated that the official exam tests are evaluated by using the documents in Appendix J. The first page in this Appendix is a checklist that associates the questions of the first session official exam in 2007 for the LS track to the competencies of the curriculum. The second and last page of this Appendix is the table of competencies for the LS track of the third secondary year; it is retrieved from Document III in Appendix A. Each official exam is evaluated according to a similar checklist. These checklists insure the coverage of all competencies.

According to the interviewees, all official exams are developed based on the objectives and competencies as well as other curricular documents, yet they are evaluated only by competencies. Moreover, the Evaluation Guide for Mathematics for the Secondary Cycle (referenced as Document III in Appendix A) is based on competencies. This document includes the competencies, the criteria for developing official exams, and the model tests. Hence, the focus in both the official exams and the model tests is on the competencies. However, this paper studies the official exams and the model tests with respect to the curriculum objectives for two reasons. First, in principle, the objectives and the competencies reflect the same curriculum; therefore, the evaluation by objectives or by competencies must give the same result. Second, since the curriculum was first developed by objectives and details of contents before these objectives were classified into competencies, and since the objectives are more detailed and numerous, this paper considers the objectives in analyzing the official exams and model tests to reveal more accurate results.

4.1.4 – Test Items and Grading Scheme

As stated by the interviewees, the test items should be direct and in simple language so they are understood by all students across Lebanon. “Problems are given in a way that, if the answer of a question depends on the answer of the previous one, you can still solve the problem even if you get the previous question wrong. That is, if you do not know ‘*part c*’ of a problem you can solve ‘*part d*’. For example, instead of

asking *find $f'(x)$, study the variation, and draw the graph of f* , the question would be *show that $f'(x) = \dots\dots\dots$, study the variation, and draw the graph of f* .”

The interviewees claim that the official exams are balanced in terms of competencies, difficulty level, progression in difficulty level of test items. Moreover, they add that “there is no top-down decision concerning the difficulty level of exams. Official exams are made so that more than 50% of students get at least a grade 11 or 12 / 20. The time that students need for solving a math exam is about 2.5 times the time that teachers need.”

Moreover, the interviewees add that the grade distribution over problems is set according to the time required to solve the problem. For example, in the official exams for LH track, every 3 minutes are associated to 1 point out of 20.

According to the interviewees, sometimes when grading the exams, the committee may find out that a certain question should have been written in a different way or should have not been included at all. The committee then considers such issues in developing subsequent exams.

4.1.5 – Session-1 vs. Session-2

In Lebanon, there is no explicit law to have session-2 official exams. Every year MEHE comes up with a decision to have session-2 official exams that is called

“exceptional session”. Session-2, or the exceptional session, is a second chance for students who fail session-1 exams. Till now, both session-1 and session-2 exams are always held, so it became difficult to cancel session-2.

The interviewees state that “sometimes we add questions in session-2 about a concept that was not included for a long time in order to send a message to teachers that all concepts are important and must be covered in classroom instruction”. This statement is significant to the 4th research question about the alignment between session-1 and session-2 official exams. Therefore, we will try in the content analysis to identify the infrequent content that occurs only in session-2 official exams.

4.1.6 – Alignment with Curriculum

The interviewees claim that “the curriculum is completely covered in the official exams over every 3 to 5 years”. Moreover, when the researcher asked the interviewees about their perception of the alignment between the official exams and math curriculum, the interviewees considered the general and specific objectives while answering:

- In terms of specific objectives and math content, both interviewees agree that there is 100% alignment of official exams with curriculum in all grade 12 tracks.
- In terms of the general objectives, the interviewees state that there is no complete alignment at all grade 12 tracks because it is difficult to connect math to real life problems or to other subjects. One of the reasons is the language issue, that is,

students might not understand a problem because of unfamiliar words / terms in French or English. Another reason is that math teachers are not necessarily familiar with other subjects therefore it is impossible for them to connect math instruction to other subjects. However, “LH track has an advantage for a higher alignment because students in LH track are supposed to be better in languages.”

Hence, a limitation to have a perfect alignment between official exams and the curriculum is that mathematics is taught in French or English (non-native languages in Lebanon).

In conclusion, this semi-structured interview with two test developers (members of the math OEC for all grade 12 tracks) was conducted to provide information across some significant themes that support the analysis and results of the study. The interviewees shared their experience in developing official exams as well as their perception toward: (a) the alignment between national curriculum and official exams (1st research question), (b) the evolution of official exams over years (3rd research question), and (c) the possible differences in the extent of alignment with the curriculum between session-1 and session-2 official exams (4th research question).

4.2 – Content Analysis

4.2.1 – Qualitative Analysis

The structure and content of the curriculum, model tests, and official exams are qualitatively analyzed as follows:

4.2.1.1 – Qualitative Analysis of the Curriculum.

The mathematics curriculum, as issued in Document I, Appendix A, involves five sections: introduction, general objectives, table of distribution of periods per week / year, basic education, and secondary education. We are concerned in this research with the following sections:

1. Introduction. The introduction of the reformed math curriculum states the importance of mathematics for the individual, the society, and the world. Mathematics is a rich, delicate, and accurate subject that activates the mind, develops critical and objective thinking, and is recommended for learning topics about social life and real world. The mathematical tool has always been basic for the development in science and technology. Its use permitted to shift the perception of reality from a qualitative description to a more quantitative modeling. Therefore, mathematics is becoming a necessity for society development and should be learned by citizens. The spirit and the use of mathematics have changed in: (a) The

Formulation of Objectives stressing the individual construction of mathematics through mental activities and mathematical reasoning as well as the *Communication* through interpreting and explaining mathematical text, symbols, graphs, tables; (b) *Remodeling Contents* with the use of calculator and computer technologies; and (c) *Method of Teaching* by relating mathematics to everyday life. These changes constitute a shift from the traditional to the reformed curriculum in the perception of mathematics in terms of teaching, learning, and assessment.

2. General Objectives. The general objectives of the reformed math curriculum are: (a) *Mathematical Reasoning* through constructing and evaluating arguments as well as developing critical thinking; (b) *Solving Mathematical Problems* through use of various strategies; (c) *Relating Mathematics to the Surrounding Reality* by practicing scientific approaches and improving research skills as well as valuing the role of mathematics in the development of technology, economics, and culture; (d) *Communicating Mathematically* through oral and written interpretations; and (e) *Valuing Mathematics* as an art of connected methods and theories that improve students' intuition, imagination, and creativity.
3. Secondary Education. The Secondary Education includes the grades 10 to 12 (age 15 to 17). It gives a choice of four tracks: LH, SE, GS, and LS. The section on Secondary Education includes: (a) the objectives of each of the four tracks; (b) tables showing the scope and sequence by math topics over the three years of each of the four tracks; and (c) the syllabus presenting the topics and the allocated time (per hour) for each topic for the four tracks (LH, SE, GS, and LS tracks) of the secondary years.

The focus in this study is on the LH track over the secondary years where the general objectives are: (a) *mathematical reasoning*, (b) *problem solving*, (c) *communication*, (d) *spacial*, (e) *numerical and algebraic*, (f) *calculus*, and (g) *statistics & probability*. The math domains of this cycle consist of *algebra*, *geometry*, *calculus* (numerical functions), *trigonometry*, and *statistics & probability*. The content of these domains is not necessarily included in the three years of the LH secondary cycle. Some content is taught only at the first year (grade 10) such as *geometry* and *trigonometry*, while *statistics* is distributed over the three secondary years, *probability* is first taught at the second year (grade 11) and continues to the third year (grade 12).

Mathematics at grade 12 LH track is assigned two periods per week and 60 periods per academic year. The math content is distributed over three domains: *Algebra*, *Calculus (Numerical Functions)*, and *Statistics & Probability*. Table 4.1 organizes the syllabus of the LH track at the third secondary year in a table for clarity in this study. The syllabus presented in the table shows the main content under the three domains along with the allocated time for each (refer to Appendix G for the details of contents of the LH track).

Table 4.1

The Math Topics in the LH Track of the Third Secondary Year

Code	Math Topics	Allocated Time
1	ALGEBRA	20 hours
1.1.	- Foundations	10 hours
1.1.1.	→ Binary operations	
1.1.2.	→ Structure of group	
1.1.3.	→ Propositional calculus	
1.2.	- Equations & Inequalities	10 hours
1.2.1.	→ Situations- problems leading to the solutions of equations and inequalities	
2	CALCULUS (NUMERICAL FUNCTIONS)	25 hours
2.1.	- Definitions & Representations	15 hours
2.1.1.	→ Simple rational functions	
2.1.2.	→ Graphical interpretation	
2.1.3.	→ Exponential growth and exponential function	
2.2.	- Mathematical Models for Economics and Social Sciences	10 hours
2.2.1.	→ Simple interest, compound interest	
3	STATISTICS AND PROBABILITY	15 hours
3.1.	- Statistics	10 hours
3.1.1.	→ Measures of central tendency and measures of variability of a distribution of one (continuous or discrete) variable	
3.2.	- Probability	5 hours
3.2.1.	→ Conditional probability: definition, independence of two events	

However, the government, after setting the reformed curriculum and printing the national textbooks, announced what it calls “reduction of the curriculum”. It is a decision made by MEHE and ECRD to diminish the content of the math curriculum because it was seen to be too heavy to be taught in one academic year. Document V referenced in Appendix A includes the themes and details of contents that were

cancelled from the mathematics curriculum and the national school textbook for the third secondary year at the LH track. The omitted topics from the taught and assessed curriculum in the grade 12 LH track are (see Appendix K): *binary operations, structure of group*, and *exponential growth and exponential function*.

The Evaluation Guide (Document III referenced in Appendix A) includes a section (written in Arabic language) under the following title: General principles about the guidelines and the way of developing the official exam questions in mathematics for the general secondary school certificate (see Appendix C). This section contains the bases for the selection of questions in terms of content and format. These criteria are common to all grade 12 tracks. We will discuss the findings based on these content criteria for developing official exams (see Appendix C).

4.2.1.2 – Qualitative Analysis of the Model Tests.

The Evaluation Guide (Document III referenced in Appendix A) includes four model tests for the LH track referred to in this research as LHM1, LHM2, LHM3, and LHM4 (refer to Appendix D presenting as a sample the second model test, coded as LHM2).

Unlike the three other model tests, LHM4 consists of two problems. The first is a statistical problem whose test items are chosen from the objectives of grade 11. The

second problem is on the exponential growth and exponential function which is part of the omitted topics. Therefore, LHM4 is not considered in this study since its test items do not represent the taught curriculum at the LH track of grade 12.

Table 1 in Appendix L presents the codes of the math topics included in the model tests. LHM1 and LHM2 consist of three problems each based on one domain: *Algebra*, *Calculus*, or *Statistics & Probability*. However, LHM3 has two problems on *Algebra*, one problem on *Calculus*, and no problem on *Statistics & Probability*. Therefore, LHM3 does not cover that considerable section of the curriculum.

Furthermore, Table 1 in Appendix L shows that each of the three model tests consists of three problems. One problem is on *rational functions* (2.1 – Definitions & Representations). The given of the problems on *rational functions* in LHM1 and LHM2 is the graph of a rational function; whereas, the given in LHM3 is the algebraic expression of the rational function $f(x)$. A second problem is on *equations / inequalities* (1.2 – Equations & Inequalities). Two model tests (LHM2 and LHM3) involve a problem on *equations* while one model test (LHM1) involves a problem on *inequality*. A third problem is on *probability* (3.2 – Probability) in LHM1 and LHM2, and on *propositional calculus* (1.1.3 – Propositional Calculus) in LHM3. *Statistics* (3.1 – Statistics) is not included in these model tests but it constitutes a problem in LHM4. On the other hand, there are no test items regarding *interest problems* (2.2.1 – Simple Interest, Compound Interest) in any of the model tests.

The distribution of grades over the math topics in the model tests for the LH track is presented in Table 2 in Appendix L. The highest grade point is given to *equations / inequalities* (1.2 – Equations & Inequalities) in LHM1 and LHM3 and to *rational functions* (2.1 – Definitions & Representations) in LHM2. The problems on *probability* (3.2 – Probability) have the lowest grade points in LHM1 and LHM2. The problems on *propositional calculus* (1.1.3 – Propositional Calculus) and *functions* (2.1 – Definitions & Representations) in LHM3 are given equal distribution of grades.

4.2.1.3 – Qualitative Analysis of the Official Exams.

Twenty official exams for the LH track administered between 2001 and 2010 are analyzed. They include ten session-1 and ten session-2 official exams. Those exams are referred to in this research as LH011, LH012, LH021, LH022, ... LH091, LH092, LH101, and LH102 (refer to Appendix E presenting as a sample the session-2 LH official exam administered in 2004, coded as LH042).

Table 1 in Appendix L presents the codes of the math topics included in the official exams in the first and second sessions of the years starting from 2001 till 2010. The table shows that each official exam consists of three problems. All official exams include problems on *Calculus*. The official exams LH011, LH032, and LH102 do not include problems on *Algebra*. The official exams LH021 and LH042 do not include problems on *Statistics & Probability*.

More specifically, all official exams include a problem on *rational functions* (2.1 – Definitions & Representations) where the given is the algebraic expression of $f(x)$, the table of variations of f , or the graph of f . *Probability* (3.2 – Probability) is the second most occurring problem; it occurs in all official exams except LH021 and LH042. *Propositional calculus* (1.1.3 – Propositional Calculus) does not occur in any of the session-1 official exams. It occurs only in two session-2 official exams LH022 and LH042. Test items on *Equations* (1.2 – Equations & Inequalities) occur in the official exams of every year, at least in one of the sessions. No questions on *Inequalities* (1.2 – Equations & Inequalities) are included in the official exams. *Statistics* (3.1 – Statistics) and *interest problems* (2.2.1 – Simple Interest, Compound Interest) do not occur frequently. The official exams LH022, LH051, LH062, LH071, LH082, and LH091 include, each, one problem combining both *Statistics* (3.1 – Statistics) and *Probability* (3.2 – Probability).

The distribution of grades over the math topics in the official exams for the LH track is presented in Table 2 in Appendix L. The grade points assigned to the problem on *rational functions* (2.1 – Definitions & Representations) is the highest in all official exams. Starting with the official exam LH071 until LH101 the distribution of grades over the three domains has become 5, 10, 5 for *Algebra*, *Calculus (Numerical Functions)*, and *Statistics & Probability* respectively where the 10 points are assigned to the problem on *rational functions* (2.1 – Definitions & Representations). Therefore, *rational functions* constitutes half of the official exams, in terms of grade distribution.

4.2.1.4 – Qualitative Analysis of the Test Items.

The topics as well as the test items assessed in the model tests and the official exams are analyzed. The topics assessed in both the model tests and the official exams are: *propositional calculus*, *equations*, *rational functions*, and *probability*. One topic *inequalities* occurs only in the model tests; whereas, two topics *simple and compound interest* and *statistics* occur only in the official exams.

Propositional Calculus

Propositional calculus is a topic classified under *Algebra*. Table 3 in Appendix L presents the test items on *propositional calculus* as well as the exams where they occur.

The test items on *propositional calculus* in the official exams require basically to translate word propositions into symbolic language and vice versa. The first two test items in Table 3 in Appendix L go under the cognitive domain “applying” while the third goes under “knowing”. The following is an example of the *propositional calculus* problems retrieved from the official exam LH022.

Consider the following propositions:

p : Samir is a student.

q : Samir speaks English.

Copy and complete the following table:

Symbolic Language	Usual Language
P	Samir is a student.
Q	Samir speaks English.
	Samir is a student who does not speak English.
$(\neg q) \Rightarrow (\neg p)$	
	If Samir is not a student, then he does not speak English.
$(\neg p) \vee (\neg q)$	

On the other hand, *propositional calculus* occurs only in the model test (LHM3) where the test items go under the cognitive domain “reasoning”. The following is the only problem retrieved from the model test LHM3 under the topic *propositional calculus*.

Soha and Rima are friends. Hiba and Maya are not.

The friends of Soha and those of Rima know the theorem of Pythagores.

The friends of Maya do not know this theorem.

1) Do Maya and Soha have a friend in common? Justify your answer.

2) Does Maya know the theorem of Pythagores?

3) Does Hiba know the theorem of Pythagores?

4) Choose, with justification, the correct answers:

To be a friend of both Rima and Soha “it is sufficient”, it is necessary” or “it is necessary and sufficient” to know the theorem of Pythagores.

Note from the previous two examples that the test items under *propositional calculus* in the official exams and those in the model tests are of different type, different cognitive domains, and do not align. The following objectives under the topic *propositional calculus* were never addressed in the official exams:

1.1.3.1. Identify a proposition.

1.1.3.1.i. → Identify a proposition as being a declarative phrase.

1.1.3.1.ii. → Identify a tautology as being the proposition that is always true.

1.1.3.2.iv. → Identify the implication as being the proposition $(\neg P) \vee Q$.

1.1.3.3. Use the table of truth.

1.1.3.3.i. → Fill the table of truth of a proposition.

Equations & Inequalities

The topic *equations and inequalities* is also classified under *Algebra*. The test items implicitly require three steps: 1) to identify the unknowns, 2) to translate word problems into equations or inequalities, and 3) to solve the system. The first step requires the cognitive ability “knowing”, the second requires “reasoning”, and the third requires both “knowing” and “applying”. Table 4 in Appendix L presents the occurrences of test items on *equations & inequalities* as well as the exams where they occur.

The following is an example of the problem on *equations* retrieved from the official exam LH021.

The owner of a flower shop has a stock of 300 roses and 800 tulips.
He wants to use all of these flowers to make two types A and B of flower arrangements:
Type A: an arrangement of 5 roses and 10 tulips.
Type B: an arrangement of 2 roses and 6 tulips.
How many arrangements of each type can he make?

The following is one of the two problems on *equations* retrieved from the model test LHM2.

The average monthly income of either an employee or a technician in a firm is 600,000 LP.
If we raise the wage of the employee by 10% and we reduce that of the technician by 10%, the average income becomes 590,000 LP.
What is the monthly income of each of them?

Both problems require reading the given, identifying the unknowns, transforming the text into a system of two equations in two unknowns, and finally solving the system using a procedural method (elimination or substitution). Therefore, we conclude from the previous two samples that the test items under *equations* in the official exams and those in the model tests match and align.

On the other hand, there are no test items under *inequalities* in the official exams so we compare them to those in the model tests. Therefore, there is a lack of alignment between the official exams and the model tests under *inequalities*.

Rational Functions

The topic *rational functions* is classified under *Calculus (Numerical Functions)*. It is considered to be an important topic, as every official exam includes a problem on *rational functions*. Table 5 in Appendix L presents the test items on rational functions as well as the exams where they occur. The most occurring questions according to Table 5 in Appendix L are: (a) write the equation of the tangent line to the graph of f at a given point, (b) find the limits and deduce asymptotes, (c) set the table of variation, (d) draw the graph of f , and (e) solve graphically $f(x) < \text{or } > \text{or } = y$ where $y = g(x)$ is a given line. These test items vary between the cognitive domains: “knowing”, “applying” or both.

The following is an example of the problems on *rational functions* retrieved from the model test LHM3. This example involves the algebraic form of a rational function and has two questions.

Let f be a function defined on $]0, \infty[$ by $f(x) = x - 1 + \frac{1}{x}$. We call (C) its representative curve in an orthonormal system $(\vec{O}, \vec{i}, \vec{j})$ (1 unit = 1 cm).

- 1) Prove that the lines $x = 0$ and $y = x - 1$ are asymptotes of (C).
- 2) Study the variations of f and sketch (C).

Answering these two questions in the model test require multi-steps: (a) finding the limits to prove the asymptotes, (b) finding the derivative, (c) solving $f'(x) = 0$, (d) studying the variation, and finally (e) drawing the graph.

On the other hand, the questions in the official exams are elaborated in a manner that there is almost a test item for each step in the solution. For instance, the following is an example of the problems on *rational functions* retrieved from the official exam LH071. It also involves the algebraic form of a rational function but has several specific questions.

Consider the function f defined, on $] -\infty; 1[\cup] 1; +\infty[$, by: $f(x) = \frac{x^2 - 2x + 2}{x - 1}$. Designate by (C) the representative curve of f in an orthonormal system $(\vec{O}, \vec{i}, \vec{j})$.

- 1) Calculate $\lim_{x \rightarrow 1^-} f(x)$ and $\lim_{x \rightarrow 1^+} f(x)$. Deduce an asymptote (D) of (C).
- 2) a- Calculate $\lim_{x \rightarrow -\infty} f(x)$ and $\lim_{x \rightarrow +\infty} f(x)$.
b- Show that the line (d) of equation $y = x - 1$ is an asymptote of (C).
- 3) Verify that $f'(x) = \frac{x(x-2)}{(x-1)^2}$.
- 4) Set up the table of variations of f .
- 5) Draw the lines (D), (d) and the curve (C).
- 6) Discuss graphically, according to the values of the real number m , the number of solutions of the equation $\frac{x^2 - 2x + 2}{x - 1} = m$.

Thus, we conclude from the previous two samples that the test items under *rational functions* in the official exams and those in the model tests have a different structure yet about similar content.

Simple Interest, Compound Interest

Simple and compound interest is a topic also classified under *Calculus (Numerical Functions)*. It occurs only in the official exams where the test items are basically to calculate the simple and compound interest and find the earned interest. Table 6 in Appendix L presents the test items on *interest problems* as well as the exams where they occur. The test items in Table 6 in Appendix L go mainly under both cognitive domains “knowing” and “applying”.

The following objectives under the topic *simple interest, compound interest* were never addressed in the official exams:

- 2.2.1.2. Find an element among the four elements concerned by the calculation of interest knowing the other three.
- 2.2.1.2.i. → Know the terminology: capital, simple interest, compound interest, interest rate, period of placement, actual value, acquired value.
- 2.2.1.2.ii. → Know and apply the relation linking the capital, rate, duration and interest.
- 2.2.1.2.iii. → Know and apply the formula linking the acquired value, capital, interest rate and duration.
- 2.2.1.2.iv. → Know and use the formulas of annuity.

The following is an example of the interest problems retrieved from the official exam LH102.

Walid wants to constitute a capital to buy a house; he has to choose between the following two options:

Option A: To deposit in a savings account, at the end of each month, a sum

- of 1 250 000 LL for a period of 8 years at an annual interest rate of 6% compounded monthly.
- Option B: To deposit in a bank a sum of 100 000 000 LL for a period of 8 years at an annual interest rate of 5% compounded annually.
- 1) Calculate the future value in Walid's account if he chooses option A.
 - 2) Calculate the future value in Walid's account if he chooses option B.
 - 3) Which of the two options is more profitable for Walid ?

On the other hand, there are no test items under *simple and compound interest* in the model tests so we compare them to those in the official exams. Therefore, there is a lack of alignment between the official exams and the model tests under *simple and compound interest*.

Statistics

Statistics is a topic classified under *Statistics & Probability*. It occurs only in the official exams where the test items ask basically to find the center, range, median, mode, mean and/or standard deviation. Table 7 in Appendix L presents the test items on *statistics* as well as the exams where they occur. The test items in Table 7 in Appendix L go under the cognitive domain "knowing".

The following is an example of the *statistics* problems retrieved from the official exam LH011.

In a mathematics test, the distribution of marks obtained by 40 students is as shown in the following table:

Class	[0 ; 4 [	[4 ; 8 [	[8 ; 12 [	[12 ; 16 [	[16 ; 20]
Frequency	5	13	11	8	3

- 1- Determine, with justification, the modal class and the median class of this distribution.
- 2- a) Determine the center of each class of this distribution.
b) Calculate the mean of this distribution, and give a meaning of the obtained value.
- 3- Calculate the standard deviation of this distribution.
- 4- Find the new mean if each of the obtained marks is increased by 2 points.

On the other hand, there are no test items under *statistics* in the model tests so we compare them to those in the official exams. Therefore, there is a lack of alignment between the official exams and the model tests under *statistics*.

Probability

Probability is also a topic classified under *Statistics & Probability*. Its problems include test items to find the probability of events such as $P(A)$, $P(A \text{ and } B)$, $P(A \text{ or } B)$, and $P(A / B)$. Table 8 in Appendix L presents the test items on *probability* as well as the exams where they occur. The test items in Table 8 in Appendix L go under the cognitive domains “knowing” and “applying”.

The following is an example of the *probability* problems retrieved from the official exam LH092.

A box contains 60 tokens distributed as shown in the following table:

	Blue	Green
Large	15	10
Small	17	18

- 1) A token is drawn randomly from this box.
 - a- What is the probability that it is small?
 - b- What is the probability that it is small and blue?
 - c- Knowing that the chosen token is small, what is the probability that it is blue?

- 2) Two tokens are drawn randomly and successively without replacement from this box.
What is the probability of drawing 2 small tokens?

The following is an example of the *probability* problems retrieved from the model test LHM2.

The students of a secondary school are distributed according to the following table:

	Boys	Girls
External	650	850
Half-internal	550	450

We randomly pick up one student.

Compute the probability that this student is external given that he is a boy.

Thus, we conclude from the previous two samples that the test items under *probability* in the official exams are more numerous than those in the model tests yet the problems have a similar structure.

The qualitative analysis of the model tests and official exams shows that the topic *inequalities* in the curriculum was never addressed in the official exams. Likewise, the topic *simple interest*, *compound interest* was never addressed in the model tests. Furthermore, some topics in the curriculum, such as *rational functions* and *probability*, were over emphasized in the official exams. Similarly, topics like *propositional calculus* were rarely addressed in the official exams.

Concerning the specific objectives under the topics, many objectives were never addressed in the official exams. Most of these objectives belong to the topics *propositional calculus* and *simple interest, compound interest*.

As for the evolution of the official exams, some topics were addressed in the first years of administering the official exams under the new curriculum. For example, the topic *propositional calculus* was addressed only twice in session-2 official exams in the years 2002 and 2004 and never been addressed afterwards. Another example is the topic *simple interest, compound interest* which was addressed in the official exams in one of the sessions of the years 2002, 2003, and 2004. Then, it was later addressed in the session-2 official exam in 2010.

In conclusion, the topics *rational functions*, *probability*, and *equations* are considered essential in the official exams. The topic *statistics* was addressed less frequently. However, topics like *inequalities*, *propositional calculus*, and *simple interest, compound interest* are getting more and more neglected.

4.2.2 – Quantitative Analysis

In this section, Pearson Product-Moment correlation coefficients between the corresponding data in the categorization tables are presented and discussed.

4.2.2.1 – Correlations Between Official Exams and Model Tests.

Taking into consideration Osta's (2007) definition of a test item (quoted in chapter three), there are 49 test items in the 3 model tests and 464 test items in the 20 official exams. The data in Table Mod (presenting numerical data for the three model tests together) and Table OffEx (presenting numerical data for the 20 official exams together) were converted into percentages to establish a unified base for comparison.

Table 1 in Appendix M presents the distribution in percentages of the test items in the model tests and official exams as to their corresponding cognitive domains and the math topics they address. The data in Table 1 in Appendix M are extracted from Tables Mod and OffEx.

It is noticed, from Table 1 in Appendix M, that the model tests and the official exams do not assess in a balanced way the different topics of the math curriculum. The percentages of the test items in the official exams are distributed over 6 topics while those in the model tests cover only 4 topics. More than half of the test items are assigned to the topic *rational functions* (57.14 %) in the model tests and (55.38 %) in the official exams.

The topic *rational functions* gets the highest percentage out of the test items in the official exams. Next is *probability* (18.75 %), then *statistics* (10.56 %) and

equations (10.34 %). Huge discrepancies in the percentages out of the test items in the model tests and the official exams occur under the topics *propositional calculus* (12.24 % and 2.15 % respectively), *equations and inequalities* (26.53 % and 10.34 % respectively), and *probability* (4.08 % and 18.75 % respectively). Even though no test items under the topics *simple & compound interest* and *statistics* could be found in the model tests, the official exams assign to them 2.80 % and 10.56 % of the test items respectively.

As to the cognitive domains, Table 1 in Appendix M shows that there is a similar imbalance between the percentages out of the test items in the model tests and the official exams. Half of the test items address the cognitive domain “knowing” (50.00 %) in the model tests while about 2/3 of the test items (67.37 %) in the official exams. Next is the cognitive domain “applying” (32.99 %) in the model tests and (24.23 %) in the official exams. Last is the cognitive domain “reasoning” (17.01 %) in the model tests and (8.41 %) in the official exams. Both the curriculum, as demonstrated in the model tests, and the official exams emphasize the cognitive domain “knowing” over “applying” and “reasoning”.

Concerning both math topics and cognitive domains, the only topic having a higher percentage out of test items in “applying” than “knowing” is *propositional calculus* in the official exams. *Rational functions* have the highest percentages out of test items at two cognitive domains in the model tests and at the three cognitive domains in both model tests and official exams.

In addition to percentages, correlations were calculated between the respective numbers in the Tables Mod and OffEx. The overall correlation is very low positive ($r = 0.06$) between the official exams and model tests when considering all objectives and the three cognitive domains. This correlation was found using Pearson Product-Moment coefficient under Microsoft Excel by correlating data in the two tables cell by cell, that is considering the detailed objectives and cognitive domains. It is very low correlation because it is difficult to have a good match between the model tests and official exams under every objective and cognitive domain. Therefore and in order to better study the alignment, correlations were calculated between the respective numbers in Table 1 in Appendix M, that is by comparing the math domains rather than the objectives.

Table 4.2 presents the correlation between the official exams of the years 2001-2010, both sessions every year, and the model tests for the LH track at grade 12. Also, it presents the correlations of the test items in terms of the cognitive domains and math domains (not objectives).

Table 4.2

Correlations Between the Official Exams of the Years 2001-2010 and the Model Tests for Grade 12 LH Track

	Overall correlation	in terms of cognitive domains			in terms of math content		
		<u>K</u>	<u>A</u>	<u>R</u>	<u>Alg.</u>	<u>Calc.</u>	<u>S.P.</u>
OE & MT	0.81	0.89	0.77	-0.09	0.27	0.99	0.26

K : Knowing

A : Applying

R : Reasoning

Alg. : Algebra

Calc. : Calculus (Numerical Functions)

S.P. : Statistics & Probability

OE & MT : Correlation between the official exams of the years 2001-2010 (OE) and the model tests (MT)

Results presented in Table 4.2 show that, overall, there is an alignment (with a high overall positive correlation $r = 0.81$) between the official exams and model tests. Many reasons may have contributed to this result. However, a major reason for not having a perfect alignment is the imbalance in the content coverage and discrepancy in the percentages out of the test items in the official exams as compared to the model tests.

According to Table 4.2, the correlation between the official exams and model tests in terms of the cognitive domain “knowing” is $r = 0.89$, “applying” is $r = 0.77$, and “reasoning” is $r = -0.09$. Pearson Product-Moment coefficient under Microsoft Excel was calculated between the respective numbers in the columns of Table 1 in Appendix M. The reason for the first two non-perfect positive correlations is the gap in the content coverage under each cognitive domain. This gap is shown in the percentages of test

items associated to each cognitive domain under a certain topic in the model tests and the official exams. The correlation calculated for “reasoning” is very low and negative because there is a huge discrepancy and imbalance in the content coverage under this cognitive domain.

Table 4.2 also shows the correlation between the official exams and model tests in terms of the math domains. Pearson Product-Moment coefficient under Microsoft Excel was calculated between the respective numbers in the rows of Table 1 in Appendix M.

- A low positive correlation ($r = 0.27$) is noticed under the *Algebra* domain. The domain *algebra* includes two sub-topics *propositional calculus* and *equations & inequalities*. These two together constitute 38.77 % of the model tests and 12.49 % of the official exams. This discrepancy in the percentages leads to a low correlation. Moreover the correlation is low because the test items address different objectives under the same sub-topics. That is, the test items in the model tests under *propositional calculus* address different objectives than those in the official exams. Moreover, the test items in the model tests under *equations & inequalities* address both contents *equations* and *inequalities*; whereas, those in the official exams address only *equations*.
- A very high positive correlation ($r = 0.99$) is noticed under the *Calculus* domain. The domain *calculus* includes two sub-topics *rational functions* and *simple & compound interest*. These two together constitute 57.14 % of the models tests and 58.18 % of the official exams. The percentages are quite similar, and the correlation

is very high. However, all the 57.14 % reflect the percentages of test items in the model tests under *rational functions*. Whereas, the 58.18 % reflect the percentages of test items in the official exams under both *rational functions* and *simple & compound interest*.

- A low positive correlation ($r = 0.26$) is noticed under the *Statistics & Probability* domain. The domain *statistics & probability* includes two sub-topics *statistics* and *probability*. These two together constitute 4.08 % of the model tests and 29.31 % of the official exams. There are two reasons for the low correlation. First, the huge gap in the percentages of test items. Second, the 4.08 % reflect the percentages of test items in the model tests under *probability*; whereas, the 29.31 % reflect the percentages of test items in the official exams under both *statistics* and *probability*. On the other hand, the reason for the positive correlation is that the test items under probability address about the same objectives in the model tests and the official exams.

4.2.2.2 – Correlations Between Official Exams of the Years 2001-2005 and 2006-2010 Respectively and Model Tests.

Taking into consideration Osta's (2007) definition of a test item (quoted in chapter three), there are 49 test items in the 3 model tests, 215 test items in the 10 official exams of the years 2001-2005, and 249 test items in the 10 official exams of the years 2006-2010. The data in Table Mod, Table OffEx1-5 (presenting numerical data for the 10 official exams from 2001 to 2005), and Table OffEx6-10 (presenting

numerical data for the 10 official exams from 2006 to 2010) were converted into percentages to establish a unified base for comparison.

Table 2 in Appendix M presents the distribution in percentages of the test items in the model tests, the official exams of the years 2001-2005, and the official exams of the years 2006-2010 as to their corresponding cognitive domains and the math topics they address. The data in Table 2 in Appendix M are extracted from Tables Mod, OffEx1-5, and OffEx6-10.

It is noticed, from Table 2 in Appendix M, that the model tests, the official exams of the years 2001-2005, and the official exams of the years 2006-2010 do not assess in a balanced way the different topics of the math curriculum. The percentages of the test items in the official exams of the years 2001-2005 are distributed over 6 topics while those in the official exams of the years 2006-2010 are distributed over 5 topics. Those in the model tests cover only 4 topics. More than half of the test items are assigned to the topic *rational functions* (57.14 %) in the model tests, (55.35 %) in the official exams of the years 2001-2005, and (55.42 %) in the official exams of the years 2006-2010.

The topic *rational functions* gets the highest percentage out of the test items in the official exams of both the years 2001-2005 and 2006-2010. Next is *probability* (19.07 % in the official exams of the years 2001-2005 and 18.48 % in the official exams of the years 2006-2010). Then, *statistics* follows (9.31 %) in the official exams of the

years 2001-2005 while *equations* follows (13.25 %) in the official exams of the years 2006-2010. Moreover, huge discrepancies in the percentages out of the test items in the model tests, the official exams of the years 2001-2005, and the official exams of the years 2006-2010 occur under the topics *propositional calculus* (12.24 %, 4.65 %, and 0.00 % respectively) and *equations & inequalities* (26.53 %, 6.98 %, and 13.25 % respectively). However and even though no test items under the topics *simple & compound interest* and *statistics* could be found in the model tests, the discrepancies in the percentages out of the test items in the official exams of the years 2001-2005 and those of the years 2006-2010 is not as high under the topics *simple & compound interest* (4.66 % and 1.20 % respectively) and *statistics* (9.31 % and 11.65 % respectively).

As to the cognitive domains, Table 2 in Appendix M shows that there is a similar imbalance between the percentages out of the test items in the model tests, the official exams of the years 2001-2005, and the official exams of the years 2006-2010. Half of the test items address the cognitive domain “knowing” (50.00 %) in the model tests while about 2/3 of the test items (68.72 %) in the official exams of the years 2001-2005 and (66.20 %) in the official exams of the years 2006-2010. Next is the cognitive domain “applying” (32.99 %) in the model tests, (24.77 %) in the official exams of the years 2001-2005, and (23.76 %) in the official exams of the years 2006-2010. Last is the cognitive domain “reasoning” (17.01 %) in the model tests, (6.51 %) in the official exams of the years 2001-2005, and (10.04 %) in the official exams of the years 2006-2010. The curriculum, as demonstrated in the model tests, the official exams of the

years 2001-2005, and the official exams of the years 2006-2010 emphasize the cognitive domain “knowing” over “applying” and “reasoning”.

Concerning both math topics and cognitive domains, *propositional calculus* is the only topic having a higher percentage out of test items in “applying” than “knowing” in the official exams of the years 2001-2005. Whereas, no topics in the official exams of the years 2006-2010 have a higher percentage out of test items in “applying” than “knowing”. The topic *rational functions* have the highest percentages out of test items at two cognitive domains in the model tests, and at the three cognitive domains in the official exams of the years 2001-2005 and the years 2006-2010.

In addition to percentages, correlations were calculated between the respective numbers in Table 2 in Appendix M, that is by comparing the math domains rather than the objectives.

According to Table 4.3, the correlation is $r = 0.80$ between the official exams of the years 2001-2005 and the model tests, and between the official exams of the years 2006-2010 and the model tests. Hence, over the years the alignment between the official exams and the model tests is stable. The reason for not having a perfect alignment is the imbalance in the content coverage and discrepancy in the percentages out of the tests items in the official exams of the years 2001-2005 and the years 2006-2010 as compared to the model tests. However, the correlation is $r = 0.98$ between the official exams of the years 2001-2005 and those of the years 2006-2010. This very high positive

correlation shows that the official exams of the years 2001-2005 and those of the years 2006-2010 may be regarded as consistent.

Table 4.3

Correlations Between the Official Exams of the Years 2001-2005 and the Official Exams of the Years 2006-2010 Respectively, between them and the Model Tests for Grade 12 LH Track

	<u>Overall Correlation</u>	<u>in terms of cognitive domains</u>			<u>in terms of math content</u>		
		<u>K</u>	<u>A</u>	<u>R</u>	<u>Alg.</u>	<u>Calc.</u>	<u>S.P.</u>
OE1-5 & MT	0.80	0.90	0.63	-0.09	-0.32	0.99	0.34
OE6-10 & MT	0.80	0.88	0.77	-0.08	0.35	0.99	0.18
OE1-5 & OE6-10	0.98	0.98	0.94	0.99	0.59	0.99	0.98

K : Knowing

A : Applying

R : Reasoning

Alg. : Algebra

Calc. : Calculus (Numerical Functions)

S.P. : Statistics & Probability

OE1-5 & MT : Correlation between the official exams of the years 2001-2005 (OE1-5) and the model tests (MT)

OE6-10 & MT : Correlation between the official exams of the years 2006-2010 (OE6-10) and the model tests (MT)

OE1-5 & OE6-10 : Correlation between the official exams of the years 2001-2005 (OE1-5) and those of the years 2006-2010 (OE6-10)

In terms of the cognitive domain “knowing”, refer to Table 4.3, the correlation is $r = 0.90$ between the official exams of the years 2001-2005 and the model tests; whereas, the correlation is $r = 0.88$ between the official exams of the years 2006-2010 and the model tests. On the other hand, the correlation in terms of the cognitive domain “knowing” is $r = 0.98$ between the official exams of the years 2001-2005 and those of the years 2006-2010. These high positive correlations in terms of the cognitive domain

“knowing” show that the official exams of the years 2001-2005 and those of the years 2006-2010 are consistent with each other and with the model tests.

In terms of the cognitive domain “applying”, refer to Table 4.3, the correlation is $r = 0.63$ between the official exams of the years 2001-2005 and the model tests; whereas, the correlation is $r = 0.77$ between the official exams of the years 2006-2010 and the model tests. On the other hand, the correlation in terms of the cognitive domain “applying” is $r = 0.94$ between the official exams of the years 2001-2005 and those of the years 2006-2010. These correlations in terms of the cognitive domain “applying” show that the official exams of the years 2001-2005 and those of the years 2006-2010 may be regarded as consistent with each other and with the model tests.

In terms of the cognitive domain “reasoning”, refer to Table 4.3, the correlation is $r = -0.09$ between the official exams of the years 2001-2005 and the model tests; whereas, the correlation is $r = -0.08$ between the official exams of the years 2006-2010 and the model tests. On the other hand, the correlation in terms of the cognitive domain “reasoning” is $r = 0.99$ between the official exams of the years 2001-2005 and those of the years 2006-2010. These correlations in terms of the cognitive domain “reasoning” show that the official exams of the years 2001-2005 and those of the years 2006-2010 are consistent with each other but not with the model tests.

In terms of the math content *algebra*, refer to Table 4.3, the correlation is $r = -0.32$ between the official exams of the years 2001-2005 and the model tests; whereas,

the correlation is $r = 0.35$ between the official exams of the years 2006-2010 and the model tests. The domain *algebra* includes two sub-topics *propositional calculus* and *equations & inequalities*. These two together constitute 38.77 % of the models tests, 11.63 % of the official exams of the years 2001-2005, and 13.25 % of the official exams of the years 2006-2010. This discrepancy in the percentages leads to low correlations. Moreover one correlation is negative because the test items address different objectives under the same sub-topics. That is, the test items in the model tests under *propositional calculus* address different objectives than those in the official exams of the years 2001-2005. Moreover, the test items in the model tests under *equations & inequalities* address both contents *equations* and *inequalities*; whereas, those in all the official exams address only *equations*. On the other hand, the correlation in terms of the math content *algebra* is $r = 0.59$ between the official exams of the years 2001-2005 and those of the years 2006-2010. This mid positive correlation in terms of the math content *algebra* shows that the official exams of the years 2001-2005 and those of the years 2006-2010 are not very consistent with each other. The reason is that *propositional calculus* is not addressed in the official exams of the years 2006-2010.

In terms of the math content *calculus*, refer to Table 4.3, the correlation is $r = 0.99$ between the official exams of the years 2001-2005 and the model tests, between the official exams of the years 2006-2010 and the model tests, and between the official exams of the years 2001-2005 and those of the years 2006-2010. The domain *calculus* includes two sub-topics *rational functions* and *simple & compound interest*. These two together constitute 57.14 % of the models tests, 60.01 % of the official exams of the

years 2001-2005, and 56.62 % of the official exams of the years 2006-2010. The percentages are close, and the correlations are very high. These high positive correlations in terms of the math content *calculus* show that the official exams of the years 2001-2005 and those of the years 2006-2010 may be regarded as consistent with each other and with the model tests.

In terms of the math content *statistics & probability*, refer to Table 4.3, the correlation is $r = 0.34$ between the official exams of the years 2001-2005 and the model tests; whereas, the correlation is $r = 0.18$ between the official exams of the years 2006-2010 and the model tests. The domain *statistics & probability* includes two sub-topics *statistics* and *probability*. These two together constitute 4.08 % of the models tests, 28.38 % of the official exams of the years 2001-2005, and 30.13 % of the official exams of the years 2006-2010. There are two reasons for these low correlations. First, the huge gap in the percentages of test items. Second, the 4.08 % reflect the percentages of test items in the model tests under *probability*; whereas, the 28.38 % and 30.13 % reflect the percentages of test items in the official exams of the years 2001-2005 and the years 2006-2010 respectively under both *statistics* and *probability*. The correlation in terms of the math content *statistics & probability* is $r = 0.98$ between the official exams of the years 2001-2005 and those of the years 2006-2010. These correlations in terms of the math content *statistics & probability* show that the official exams of the years 2001-2005 and those of the years 2006-2010 are consistent with each other but not with the model tests.

4.2.2.3 – Correlations Between Official Exams of Session-1 and Session-2 Respectively and Model Tests.

Taking into considering Osta's (2007) definition of a test item (quoted in chapter three), there are 49 test items in the 3 model tests, 245 test items in the ten session-1 official exams, and 219 test items in the ten session-2 official exams of the years 2001-2010. The data in Table Mod, Table OffEx1 (presenting numerical data for the 10 session-1 official exams), and Table OffEx2 (presenting numerical data for the 10 session-2 official exams) were converted into percentages to establish a unified base for comparison.

Table 3 in Appendix M presents the distribution in percentages of the test items in the model tests, the session-1 official exams, and the session-2 official exams as to their corresponding cognitive domains and the math topics they address. The data in Table 3 in Appendix M are extracted from Tables Mod, OffEx1, and OffEx2.

It is noticed, from Table 3 in Appendix M, that the model tests, the session-1 official exams, and the session-2 official exams do not assess in a balanced way the different topics of the math curriculum. The percentages of the test items in the session-1 official exams are distributed over 5 topics while those in the session-2 official exams are distributed over 6 topics. Those in the model tests cover only 4 topics. More than half of the test items are assigned to the topic *rational functions* (57.14 %) in the model

tests, (52.65 %) in the session-1 official exams, and (58.45 %) in the session-2 official exams.

The topic *rational functions* gets the highest percentage out of the test items in both session-1 and session-2 official exams. Next is *probability* (19.18 % in the session-1 official exams and 18.26 % in the session-2 official exams). Then, *statistics* follows (14.69 %) in the session-1 official exams while *equations* follows (8.68 %) in the session-2 official exams. Moreover, huge discrepancies in the percentages out of the test items in the model tests, the session-1 official exams, and the session-2 official exams occur under the topics *propositional calculus* (12.24 %, 0.00 %, and 4.57 % respectively) and *equations & inequalities* (26.53 %, 11.84 %, and 8.68 % respectively). However and even though no test items under the topics *simple & compound interest* and *statistics* could be found in the model tests, the discrepancies in the percentages out of the test items in the session-1 official exams and those in the session-2 is not as high under the topic *simple & compound interest* (1.63 % and 4.11 % respectively) as under the topic *statistics* (14.69 % and 5.94 % respectively).

As to the cognitive domains, Table 3 in Appendix M shows that there is a similar imbalance between the percentages out of the test items in the model tests, the session-1 official exams, and the session-2 official exams. Half of the test items address the cognitive domain “knowing” (50.00 %) in the model tests while about 2/3 of the test items (70.20 %) in the session-1 official exams and (64.19 %) in the session-2 official exams. Next is the cognitive domain “applying” (32.99 %) in the model tests, (22.45 %)

in the session-1 official exams, and (26.22 %) in the session-2 official exams. Last is the cognitive domain “reasoning” (17.01 %) in the model tests, (7.35 %) in the session-1 official exams, and (9.59 %) in the session-2 official exams. The curriculum, as demonstrated in the model tests, the session-1 official exams, and the session-2 official exams emphasize the cognitive domain “knowing” over “applying” and “reasoning”.

Concerning both math topics and cognitive domains, *propositional calculus* is the only topic having a higher percentage out of test items in “applying” than “knowing” in the session-2 official exams. Whereas, no topics in the session-1 official exams have a higher percentage out of test items in “applying” than “knowing”. The topic *rational functions* have the highest percentages out of test items at two cognitive domains in the model tests, and at the three cognitive domains in the session-1 and the session-2 official exams.

In addition to percentages, correlations were calculated between the respective numbers in Table 3 in Appendix M, that is by comparing the math domains rather than the objectives.

According to Table 4.4, the correlation is $r = 0.78$ between the session-1 official exams and the model tests; whereas, the correlation is $r = 0.81$ between the session-2 official exams and the model tests. Hence, session-2 official exams have a higher alignment with the model tests. However, the correlation is $r = 0.97$ between the session-1 and session-2 official exams. These correlations shows that the session-1 and

session-2 official exams may be regarded as quite consistent among each other and the model tests.

Table 4.4

Correlations Between the Official Exams of Session-1 and the Official Exams of Session-2 Respectively, between them and the Model Tests for Grade 12 LH Track

	<u>Overall Correlation</u>	<u>in terms of cognitive domains</u>			<u>in terms of math content</u>		
		<u>K</u>	<u>A</u>	<u>R</u>	<u>Alg.</u>	<u>Calc.</u>	<u>S.P.</u>
OE1 & MT	0.78	0.86	0.76	-0.08	0.39	0.99	0.16
OE2 & MT	0.81	0.91	0.67	-0.08	-0.26	0.99	0.73
OE1 & OE2	0.97	0.97	0.95	0.98	0.72	0.99	0.90

K : Knowing

A : Applying

R : Reasoning

Alg. : Algebra

Calc. : Calculus (Numerical Functions)

S.P. : Statistics & Probability

OE1 & MT : Correlation between the official exams of session-1 (OE1) and the model tests (MT)

OE2 & MT : Correlation between the official exams of session-2 (OE2) and the model tests (MT)

OE1 & OE2 : Correlation between the official exams of session-1 (OE1) and those of session-2 (OE2)

In terms of the cognitive domain “knowing”, refer to Table 4.4, the correlation is $r = 0.86$ between the session-1 official exams and the model tests; whereas, the correlation is $r = 0.91$ between the session-2 official exams and the model tests. On the other hand, the correlation in terms of the cognitive domain “knowing” is $r = 0.97$ between the session-1 and session-2 official exams. These high positive correlations in terms of the cognitive domain “knowing” show that the session-1 and the session-2 official exams are consistent with each other and with the model tests.

In terms of the cognitive domain “applying”, refer to Table 4.4, the correlation is $r = 0.76$ between the session-1 official exams and the model tests; whereas, the correlation is $r = 0.67$ between the session-2 official exams and the model tests. On the other hand, the correlation in terms of the cognitive domain “applying” is $r = 0.95$ between the session-1 and session-2 official exams. These correlations in terms of the cognitive domain “applying” show that the session-1 and the session-2 official exams may be regarded as consistent with each other but not highly consistent with the model tests.

In terms of the cognitive domain “reasoning”, refer to Table 4.4, the correlation is $r = -0.08$ between the session-1 official exams and the model tests, and between the session-2 official exams and the model tests. On the other hand, the correlation in terms of the cognitive domain “reasoning” is $r = 0.98$ between the session-1 and session-2 official exams. These correlations in terms of the cognitive domain “reasoning” show that the session-1 and session-2 official exams are consistent with each other but not with the model tests.

In terms of the math content *algebra*, refer to Table 4.4, the correlation is $r = 0.39$ between the session-1 official exams and the model tests; whereas, the correlation is $r = -0.26$ between the session-2 official exams and the model tests. The domain *algebra* includes two sub-topics *propositional calculus* and *equations & inequalities*. These two together constitute 38.77 % of the models tests, 11.84 % of the session-1 official exams, and 13.25 % of the session-2 official exams. This discrepancy in the

percentages leads to low correlations. Moreover one correlation is negative because the test items address different objectives under the same sub-topics. That is, the test items in the model tests under *propositional calculus* address different objectives than those in the session-2 official exams. Moreover, the test items in the model tests under *equations & inequalities* address both contents *equations* and *inequalities*; whereas, those in all the official exams address only *equations*. On the other hand, the correlation in terms of the math content *algebra* is $r = 0.72$ between the session-1 and the session-2 official exams. This correlation in terms of the math content *algebra* shows that the session-1 and the session-2 official exams are not very consistent with each other. The reason is that *propositional calculus* is not addressed in the official exams of the years 2006-2010.

In terms of the math content *calculus*, refer to Table 4.4, the correlation is $r = 0.99$ between the session-1 official exams and the model tests, between the session-2 official exams and the model tests, and between the session-1 and session-2 official exams. The domain *calculus* includes two sub-topics *rational functions* and *simple & compound interest*. These two together constitute 57.14 % of the models tests, 54.28 % of the session-1 official exams, and 62.56 % of the session-2 official exams. The percentages are close, and the correlations are very high. These high positive correlations in terms of the math content *calculus* show that the session-1 and session-2 official exams are consistent with each other and with the model tests.

In terms of the math content *statistics & probability*, refer to Table 4.4, the correlation is $r = 0.16$ between the session-1 official exams and the model tests; whereas, the correlation is $r = 0.73$ between the session-2 official exams and the model tests. The domain *statistics & probability* includes two sub-topics *statistics* and *probability*. These two together constitute 4.08 % of the models tests, 33.87 % of the session-1 official exams, and 24.20 % of the session-2 official exams. There is a huge gap in the percentages of test items. The reason for the low correlation is that the 4.08 % reflect the percentages of test items in the model tests under *probability*; whereas, the 33.87 % reflect the percentages of test items in the session-1 official exams under both *statistics* (14.69 %) and *probability* (19.18 %). On the other hand, the reason for the high correlation is that the 4.08 % reflect the percentages of test items in the model tests under *probability*; whereas, the 24.20 % reflect the percentages of test items in the session-2 official exams under both *statistics* (5.94 %) and *probability* (18.26 %). That is, there is much less test items under statistics in session-2 official exams. The correlation in terms of the math content *statistics & probability* is $r = 0.90$ between the session-1 and session-2 official exams. This correlation in terms of the math content *statistics & probability* shows that the session-1 and session-2 official exams are consistent with each other.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 – Introduction

The purpose of this study was to examine the alignment between the intended and assessed Lebanese curriculum in mathematics. The Lebanese national curriculum in mathematics in LH track of the Secondary Education is the concern in this study. The study investigated the alignment of the latter curriculum with the official exams over the years 2001 to 2010.

The findings of this research show an agreement between the qualitative and quantitative analyses. The following discusses the results of this investigation with the existing literature.

Both the qualitative and quantitative results of this study can be summarized in the following characteristics of the official exams:

- All official exams consist of three sections. Each section in most of the official exams covers a domain *algebra* (12.49 %), *calculus* (58.18 %), or *statistics & probability* (29.31 %).

- The math topic *inequalities* and many objectives under other topics (such as *propositional calculus* and *simple interest, compound interest*) are never addressed in the official exams, even though they are included in the curriculum.
- The math content *rational functions* under *algebra* occupies a whole section in every official exam. It is given high importance since its test items cover 55.38 % of the official exams. On the other hand, the topics *propositional calculus* and *simple interest, compound interest* are rarely addressed in the official exams (2.15 % and 2.80 % respectively).
- The official exams put the greatest emphasis on the cognitive domain “knowing” (67.37 % of the test items in the official exams) then “applying” gets 24.23 %. “Reasoning” is almost neglected in the official exams (8.41 %). The test items in the official exams are all routine questions previously seen in class. They do not challenge students’ mathematical reasoning, critical thinking, or problem solving skills.

The above characteristics of the official exams shape the national assessment in Lebanon, and hence they form a certain guide that encourages teachers to adopt instead of the curriculum texts. This fact is consistent with what Osta (2007) reached after analyzing the Grade 9 official exams of the pre-reform Lebanese curriculum. “Based on the assumption that what is tested is what is valued, the official exams determine a mini-curriculum from which specific topics are considered for test items, in questions that are stereotyped in content and format” (Osta, 2007, p.194). This leads teachers to teach for the test. That is, they ignore the curriculum texts and focus on teaching the

topics addressed in the official exams at the same cognitive levels. Moreover, teachers tend to assign problems to students that are similar to those addressed in the official exams, so that students by drill and practice become familiar with such problems and ready to take the test. This contradicts with the general objectives of the curriculum to encourage critical thinking rather than rote learning. At the school level, teachers must use AFL to prepare students with good acquisition and understanding of the math content. Whereas, the national assessment is summative, and hence its purpose is AOF. Therefore, the official exams should never be used as a guide for “teaching for the test” and must never shift the purpose to LFA.

Having a national curriculum facilitates the role of teachers; whereas, having a national assessment sometimes leads to teaching to the test. That is, the assessed curriculum affects the taught curriculum. Therefore, the alignment between the national assessment and the national curriculum is of high importance to insure that the intended curriculum in documents, the taught curriculum, and the assessed curriculum overlap and are consistent with no discrepancies or gaps. Only when there is such an alignment, the national assessment has many advantages in terms of evaluating schools’ educational systems as well as students’ achievement at the national level. When such an alignment does not exist; that is, when the test is not consistent with the intended curriculum, then what are we testing and what did students achieve?

According to the NCTM (1995), the assessment standards in mathematics must promote an ongoing improvement of curricula, instruction, and assessment. Curriculum

reform promotes students' understanding, critical thinking, reasoning, and different levels of abilities (Williams, 1971; Kimball, 1999; and Gagnon & Collay, 2006). Similarly, the Lebanese reformed curriculum also promotes these in its general objectives. The qualitative analysis of the curriculum shows that the reformed Lebanese curriculum for the LH track, as intended in the documents, suggests introducing and integrating the general objectives and focus on: (a) mathematical reasoning, (b) problem solving, and (c) communication. These objectives are not reflected in the official exams. Therefore, the reform should not be limited to the curriculum texts but also to the assessments and official exams. The Lebanese official exams at the end of the LH track at Grade 12 must be revised and improved to reach a good alignment with the math curriculum. One major NCTM assessment standard states that the problems must reflect various topics and demonstrate students' full mathematical power. This standard needs to be considered when evaluating the official exams so they cover all topics and objectives and assess in a balanced way the cognitive domains, especially "reasoning" which was somehow ignored in the official exams.

Ongoing curriculum evaluation constitutes a major stage in curriculum development. It includes curriculum evaluation of intended, implemented, and assessed curricula to ensure good alignment. The intended curriculum involves assessment standards that should be clearly considered when developing official exams. The Evaluation Guide (Document III referenced in Appendix A) includes a section (written in Arabic language) under the following title: General principles about the guidelines and the way of developing the official exam questions in mathematics for the general

secondary school certificate (see Appendix C). This section states that the aim of the official exam in mathematics is to measure the competencies acquired by students. It contains the bases for the selection of questions in terms of content and format. These criteria are common to all grade 12 tracks. We will discuss the findings based on these content criteria for developing official exams (see Appendix C).

1. “The official exams must abide by the general and specific objectives of the subject”. The general objectives of the mathematics curriculum and those specific to the LH track over the secondary years overlap in three main goals: mathematical reasoning, problem solving, and communication. The test items in both the model tests and the official exams require some problem solving skills to solve only routine problems. Furthermore, the problems require communication, and interpretation of different mathematical representations (text, graphs, and tables). However, reasoning is somehow ignored in the exams.
2. “The official exams must balance among the basic three levels of knowledge: acquisition, application, and analysis”. We can associate these levels to the TIMSS cognitive domains: “knowing”, “applying”, and “reasoning”. Table 1 in Appendix M represents the distribution in percentages of the cognitive domains in the model tests and official exams over the topics in the math curriculum of the LH track at grade 12. The data in Table 1 in Appendix M is obtained from tables Mod and OffEx. The test items are classified as “knowing” (50.00 % in model tests and 67.37 % in official exams), “applying” (32.99 % in model tests and 24.23 % in official exams), and/or “reasoning” (17.01 % in model tests and 8.41 % in official exams).

Therefore, there is no balance among the three levels of knowledge in both the model tests and official exams.

3. “The official exams must test the competencies from all aspects covering a wide range of the content”. Each of the model tests and the official exams consists of three sections. Each section in most of the model tests (2 model tests out of 3) and the official exams (15 official exams out of 20) covers one math domain: Algebra, Calculus, and Statistics and Probability. This shows that the exams do not necessarily cover all the latter domains.
4. “The official exams must move away from a test pattern, that is to neither permanently neglect any part of the curriculum nor always adopt the same concept”. However, the analysis of the exams shows that there is more emphasis on some content while other content is almost neglected. That is, the topic *rational functions* is the most occurring content; it occurs in all the official exams. On the other hand, *inequalities* and most of the objectives under *simple and compound interest* are totally neglected in the official exams. Finally, *propositional calculus* is almost neglected in the official exams; it occurs only twice in LH022 and LH042. Furthermore, the results in Table 2 in Appendix L show that distribution of grades has the lowest grade points on probability in the model tests and the highest grade points on rational functions in the official exams. This is consistent with the time allocated to classroom instruction for these contents (refer to Table 4.1): 15 hours for rational functions and 5 hours for probability.
5. “The official exams must care for the formulation of questions and clarity to avoid any confusion”. A global reading of the exams shows that the questions are clearly

formulated, and there is no chance for misinterpreting a question. However, the wording and clarity of the questions are not part of this study.

6. Last, “the official exams must ask diverse types of questions between open-ended questions, short response, multiple-choice questions as well as diverse questions based on text, diagram, graph, etc”. Most of the test items in the model tests and the official exams are open-ended questions. Moreover, they include a wide range of problems that differ among different representations. For example, rational functions are represented in graph form, table form, and explicit function form.

5.2 – Conclusions

The research questions for this study are: (a) are the Lebanese secondary-level official math exams for the LH track aligned with the national reformed curriculum over the years 2001-2010?, (b) how does the OEC approach the issue of alignment when setting the test items of the exams every year?, (c) is there any improvement in the alignment of the national exams from the years 2001-2005 to the years 2006-2010?, and (d) are there differences in the extent of alignment with the curriculum between the exams in session-1 and session-2 of the academic years 2001-2010 for the LH track?

Next in this section, we will discuss the results of this study in relation to the above four research questions.

5.2.1 – Research Question 1

Are the Lebanese secondary-level official math exams for the LH track aligned with the national reformed curriculum over the years 2001-2010?

There is a high correlation ($r = 0.81$) between the official exams and the model tests when considering the math domains and cognitive abilities. However, in general, the correlation is very low ($r = 0.06$) when considering all objectives and the three cognitive domains. Moreover, the total percentages of the test items under the math topics and the cognitive domains are quite different in the official exams and the model tests (refer to Table 1 in Appendix M). They somehow match under the math topic *rational functions*.

Therefore, the Lebanese secondary-level official math exams for the LH track are more aligned with the national reformed curriculum over the years 2001-2010 in terms of the math domains than the general and specific objectives. The aspects that cause a low alignment are:

First, a major reason for the low alignment is that both the model tests and the official exams do not cover the whole curriculum. The topics *simple interest*, *compound interest* and *statistics* are two topics having no test items in the model tests (note that *statistics* is addressed in LHM4 but this model test is not considered in this study). Whereas, the topic *inequalities* is not addressed in the official exams. Moreover, the test items in the model tests classified under *propositional calculus* relate to different

objectives than those in the official exams. Hence, the low alignment is because the model tests and the official exams do not all cover the same content (refer to Table 1 in Appendix L).

Second, we think another major reason for the overall low alignment is the unlike structure and a different number of test items between the model tests and official exams. That is, the questions or test items in the official exams are much more detailed and numerous. There are 49 test items in 3 model tests (i.e., about 16 test items per model test); whereas, there are 464 tests items in 20 official exams (i.e., about 23 test items per official exam). In the model tests, the question is cut very short but the solution involves many steps (refer to the given examples under *rational functions* and *probability* in section 4.2.1.4). The researcher believes that the model tests are constructed by competencies integrating many objectives each, while the official exams by objectives. This explains the unlike structure of the test items.

From this study and from the above two reasons for the low alignment, the researcher believes that only three model tests cannot cover all topics, while it is possible with 20 official exams. The three model tests do not adequately reflect the various curriculum topics (e.g. *simple interest*, *compound interest*), specific objectives (e.g. objectives under *propositional calculus*) as well as the general objectives (e.g. mathematical reasoning, problem solving, and communication), and the cognitive domains (e.g. “reasoning”). Therefore, more model tests could be added, so they encompass most of if not all of the curriculum.

5.2.2 – Research Question 2

How does the OEC approach the issue of alignment when setting the test items of the exams every year?

When developing test items, OEC uses the following documents: math reformed curriculum content, textbooks, general and specific objectives, competencies, evaluation guide, and a descriptive booklet of official examinations. Then, the committee reviews its work and evaluates the exam by using similar checklist to that in Appendix J. These checklists insure the coverage of all competencies. However, even though all official exams are developed based on the objectives and competencies as well as other curricular documents, yet they are evaluated only by competencies. The interviewees claim that the official exams are balanced in terms of competencies, difficulty level, and progression in difficulty level of test items.

The interviewees claim that “the curriculum is completely covered in the official exams over every 3 to 5 years”. Moreover, the interviewees claim that there is 100% alignment between the official exams and the curriculum in terms of specific objectives and math content. However, in terms of the general objectives, the interviewees state that there is no complete alignment because it becomes difficult to connect math to real life problems or to other subjects. The interviewees agree that the alignment would have been 100% in all tracks and all aspects if mathematics is taught in Arabic, the native language.

Two major conclusions can be drawn from the interview. First, OEC evaluates each official exam while developing it; however, the committee does not consider evaluating many official exams over years. Each exam when analyzed by itself is considered aligned with the curriculum because it is impossible to have test items addressing all curriculum content and objectives in a one-hour exam. This is why the interviewees show confidence that the official exams are 100 % aligned with the curriculum and that only the language issue can cause problems. However, when considering a set of official exams like in this study, OEC can observe, evaluate, and improve some aspects such as having a pattern in the structure and content of questions, having some neglected topics, etc. Second, OEC develops the official exams by objectives and competencies, but evaluates only by competencies. This paper analyzes the test items only by objectives.

5.2.3 – Research Question 3

Is there any improvement in the alignment of the national exams from the years 2001-2005 to the years 2006-2010?

In general, the official exams are consistent and aligned among each other. This is shown in the high correlation ($r = 0.98$) between the official exams over the years 2001-2005 and 2006-2010. The total percentages of the test items under the math topics and the cognitive domains are quite similar in the official exams of the years 2001-2005

and the years 2006-2010 (refer to Table 2 in Appendix M). They only differ under the math topics: *propositional calculus*, equations, and *simple interest, compound interest*.

Moreover, the evolution of the official exams did not basically change over the years. The correlation between the official exams of the years 2001-2005 and the model tests ($r = 0.80$) is the same as the correlation between the official exams of the years 2006-2010 and the model tests ($r = 0.80$). However, there are some changing aspects in the evolution of official exams over the years. These changes are:

The topics *propositional calculus* and *simple interest, compound interest* are considered less important with the evolution of the official exams. This is shown in the following examples (refer to Table 1 in Appendix L):

- The topic *propositional calculus* is neglected in the official exams of the years 2006-2010. It occurs only twice in the official exams of the years 2001-2005 (LH022 and LH042).
- The topic *simple interest, compound interest* is almost neglected in the official exams of the years 2006-2010. It occurs once in the official exams of the years 2006-2010 (LH102) and 3 times in the official exams of the years 2001-2005 (LH021, LH032, and LH042).

On the other hand, the topic *equations* is considered more important with the evolution of the official exams (refer to Table 1 in Appendix L). It only occurs in one of

the sessions of the official exams of the years 2001-2004. Later on, it occurs in every session of the official exams from LH051 to LH101.

5.2.4 – Research Question 4

Are there differences in the extent of alignment with the curriculum between the exams in session-1 and session-2 of the academic years 2001-2010 for the LH track?

In general, the session-1 and session-2 official exams are consistent and aligned among each other. This is shown in the high correlation ($r = 0.97$) between the session-1 and session-2 official exams. Moreover, the correlation between session-1 official exams and the model tests ($r = 0.78$) is close to that between session-2 official exams and model tests ($r = 0.81$). However, session-1 and session-2 official exams differ in some aspects.

First, the total percentages of the test items under the math topics and the cognitive domains vary between the session-1 and session-2 official exams (refer to Table 3 in Appendix M). They mostly match under the math topic *probability*.

Second, session-2 official exams cover more topics of the curriculum than those of session-1. Examples are (refer to Table 1 in Appendix L):

- The topic *propositional calculus* is almost neglected in the official exams; it occurs twice in only session-2 official exams (LH022 and LH042).

- The topic *simple interest*, *compound interest* is almost neglected in the session-1 official exams; it occurs once in session-1 official exams (LH021) and later on only in only session-2 official exams (LH032, LH042, and LH102).

These examples show that the topics *propositional calculus* and *simple interest*, *compound interest* are considered less important. They also concur with the interviewees' statement: "some topics that are not frequently addressed in the official exams are added in session-2 official exams just to send a message to teachers that all concepts are important and must be covered in classroom instruction".

5.3 – Recommendations

The results of this research show that the official exams focus on "knowing" and "applying" the concepts of mathematical topics rather than challenging students with higher problem solving skills and critical thinking. The test items represent some major aspects of the curriculum objectives. However, they don't address the main concerns of the general objectives: mathematical reasoning, solving non-routine problems, communication, and connections. Research shows that it is not easy to assess mathematical communication and connections and therefore a poor alignment occur within these areas (Silver and Kenney, 1993).

Therefore, the model tests and the test bank should be revised and evaluated taking into consideration the neglected general objectives of the curriculum: reasoning,

problem solving of non-routine problems, and relating mathematics to the surrounding society. Though there is no perfect alignment (Fulmer, 2010), yet we can minimize the discrepancies once we detect the non-aligned aspects.

5.4 – Limitations of the Study

This study has two limitations. One limitation is the number of model tests versus the number of official exams studied. We considered 3 model tests and 20 official exams. Therefore, there is low possibility that the 3 model tests cover the whole curriculum from different aspects (general and specific objectives as well as cognitive abilities) as compared to 20 official exams.

Another limitation of this study is that the test items in the model tests and the official exams were analyzed by objectives and not by competencies. It is believed that better alignment results could be found if the analysis was by competencies. The reason is that there are only 10 competencies under which all objectives are classified. Therefore, there is a big chance that the test items cover all competencies but not all objectives.

5.5 – Recommended Future Research

The following are recommendations for future research:

1. A study of the alignment between the Lebanese national exams and the reformed curriculum for each subject at the intermediate level and the four tracks of the secondary level. These studies are similar to this study that considers the math subject at the LH track of the secondary level.
2. A study comparing the alignment between the Lebanese secondary-level national math exams and the reformed math curriculum at the LH track to that at the GS track. The aim of such a study is to evaluate the Lebanese secondary-level math curriculum and national exams at two tracks: the LH track where the mathematics content is condensed and the GS track where the subject is extended pure mathematics.
3. A study of the alignment between the ECRD textbooks and the reformed curriculum for each subject at the intermediate level and the four tracks of the secondary level. The aim of such a study is to evaluate the ECRD textbooks and determine how well they match with the general and specific objectives of the intended curriculum; in addition, determine whether they encourage reasoning and critical thinking.
4. A study of the alignment between the Lebanese national exams and the ECRD textbooks for each subject at the intermediate level and the four tracks of the secondary level. The aim of such a study is to determine whether the national test items are “déjà vu” in the textbook questions and problems.

5. A study of the alignment between the Lebanese secondary-level national math exams at the GS track and the TIMSS Advanced mathematics assessment framework. Since Lebanon, through its grade 12 students at the GS track, participates in the TIMSS advanced mathematics assessment, then a significant study would compare the national Lebanese assessment to that by TIMSS. Likewise, such a study may be inspired by studies in the literature conducted with similar purpose, e.g.: (a) the alignment between New Mexico Standards Based Assessment and the 2009 NAEP mathematics framework (Shapley & Brite, 2008a), (b) the alignment between Oklahoma Core Curriculum Tests and the 2009 NAEP mathematics framework (Shapley & Brite, 2008b), and (c) the alignment between Arkansas state assessments and the 2009 NAEP in science (Timms, Schneider, Lee, & Rolfhus, 2007). The aim of such studies is not necessarily to seek a better alignment but to compare and highlight the common and different aspects between both assessments.

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APPENDICES

APPENDIX A

The References of the Curriculum Documents

Document I

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 n° 10227* (pp. 287-327). Lebanon: Ministry of National Education, Youth and Sports & National Center of Educational Research and Development.

Document II

Ministry of National Education, Youth and Sports & National Center of Educational Research and Development (1997). *Curriculum of Mathematics. Decree n° 10227. 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.

Document III

Ministry of Education and Higher Education & Educational Center for Research and Development (2000). *Evaluation Guide. Mathematics Secondary Cycle*. Lebanon: Ministry of National Education, Youth and Sports & National Center of Educational Research and Development.

Document IV

وزارة التربية الوطنية والشباب والرياضة، والمركز التربوي للبحوث والإنماء (1998). *مناهج التعليم العام وأهدافها*. تعميم رقم 35 / م / 98. *تفاصيل محتوى منهج مادة الرياضيات السنة الثانية من كل حلقة ومرحلة*. لبنان: وزارة التربية الوطنية والشباب والرياضة، والمركز التربوي للبحوث والإنماء.

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Document V

وزارة التربية والتعليم العالي، والمركز التربوي للبحوث والإنماء (2001). *المحاور والدروس المطلوب تعليق العمل بها (للعام الدراسي 2001 - 2002)*. تعميم رقم 59 / م / 2001. تاريخ 2001/9/11. لبنان: وزارة التربية والتعليم العالي والمركز التربوي للبحوث والإنماء.

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APPENDIX B

Interview Questions

I. Interviewee's Biographic Data

- 1- Would you please give me some feedback about yourself as a professional and teacher?
- 2- Do you teach in a private or public school? Do you teach Grade 12 students?
- 3- For how long have you been writing question items for official exam tests in Lebanon?

II. About the Committee

- 1- Would you please describe the committee?
- 2- Is there a hierarchy in this committee?
- 3- On what criteria are the committee members selected?
- 4- Is there a different committee for mathematics at grade 12 for each track?

III. About the Official Exam Tests

a- Criteria

- 1- Have you participated in writing the official exam tests under the old Lebanese program? If yes, did you change the style of your questions according to the requirements and objectives of the reformed curriculum? How and in what ways?

- 2- What criteria do you follow in writing test items? Are there set criteria? By whom?
- 3- Do you use the competencies in developing the official exams?
- 4- Does the committee consider different criteria for the second session test items? In difficulty level? Content? Distribution of grades?
- 5- Does the committee consider the results of the first session in writing the test items for the second session? How?
- 6- On what criteria is the distribution of grades set?

b- Process, Validity and reliability

- 1- What is the process for writing and choosing the test items for official exam tests?
- 2- Do you have a test bank from which you choose your test items?
- 3- What are the difficulties faced during this process?
- 4- How does the committee insure the validity and reliability of the test items (i.e. Validity: the degree to which the content of the test matches a content domain – Reliability: consistency of assessment results)?

c- Evaluation

- 1- Does the committee make any evaluation of the process of work? of the criteria? of the tests?

- 2- How do you define a good alignment between the official exam tests and Lebanese curriculum in mathematics? To which extent do you think/ believe such an alignment exists?
- 3- What are, in your opinion, the weaknesses in the process of writing/ choosing the test items?
- 4- Do you suggest any improvement?

APPENDIX C

General Principles about the Guidelines and the Way of Developing the Official Exam Questions in Mathematics for the General Secondary School Certificate

Retrieved from:

Ministry of Education and Higher Education & Educational Center for Research and
Development (2000). *Evaluation Guide. Mathematics Secondary Cycle.*
Lebanon: Ministry of National Education, Youth and Sports & National Center
of Educational Research and Development.

مبادئ عامة حول أصول وطريقة وضع أسئلة الامتحانات الرسمية في الرياضيات للمشهادة الثانوية العامة

تهدف مسابقة الرياضيات في الامتحانات الرسمية إلى قياس مدى اكتساب التلاميذ للكفايات العائدة لهذه المرحلة (راجع لوائح
الكفايات لمادة الرياضيات العائدة لصفوف الثالث ثانوي بفروعها الأربعة).

الأسس المتبعة لاختيار الأسئلة

في المضمون

ينبغي أن تراعي أسئلة الرياضيات الأسس التالية:

- التقيّد بأهداف المادة (العامة والخاصة) وذلك من خلال احترام نظام التقييم الجديد وفلسفته (دليل المعلم للتقييم).
- التوازن بين مستويات المعرفة الأساسية الثلاثة (الاكتساب – التطبيق – التحليل).
- اختيار الكفايات من كافة المجالات وتضمين الاختبار أسئلة تقيّم كفايات متداخلة تغطي عدة مواضيع من المنهاج.
- الابتعاد عن نمط معين للاختبار، وذلك من خلال عدم إهمال أي جزء من المنهاج بشكل دائم (بمعنى ألا يُستبعد بشكل دائم موضوع ما من أسئلة الاختبار)، وكذلك عدم اعتماد حتمية وجود موضوع ما في كافة الاختبارات.
- العناية بصياغة الأسئلة ووضوحها منعاً لكل التباس.
- تنوع أشكال الأسئلة: أسئلة مغلقة أو مفتوحة (تتطلب اتخاذ قرار من قبل المرشح)، أسئلة الاختيارات المتعددة، أسئلة
مبنية على مستند (نصّ – جدول – بيانات – رسومات هندسية أو تحليلية – الخ.) أو غير ذلك.

في الشكل

- يتكون اختبار الرياضيات من عدة مسائل إلزامية (ليس هناك شرط على عدد المسائل).
- تأتي الأسئلة في كراس (على الأقل أربع صفحات (A3 مطوية).
- ينبغي أن يكون الاختبار سهل القراءة لجهة اختيار نوع البنت (Font) وحجمه، والمسافات بين الأسطر والهوامش العامة أو الداخلية.
- ترقم المسائل بالترقيم الروماني (I, II, III, etc.). ترقم الأسئلة للمسألة الواحدة بالأرقام العربية (1, 2, 3, etc.). وترقم الأسئلة الفرعية بالأحرف اللاتينية (a- b- c- etc.).
- تذكر علامة كل مسألة من المسائل الواردة في الاختبار دون تحديد العلامة لكل سؤال في المسألة الواحدة.
- تخصص الصفحة الأولى من كراس أسئلة الاختبار لتوصيف الاختبار وتتضمن بعض الإرشادات العامة (أنظر التفصيل لاحقاً).

تتضمن الصفحة الأولى المعلومات التالية :

- الكتابة الرسمية (الجمهورية اللبنانية – وزارة التربية .. الخ).
- اسم الشهادة الرسمي.
- المادة.
- اللغة.
- عدد المسائل.
- مدة الاختبار.
- تعداد الأدوات اللازمة (أدوات الرسم الهندسي – آلة حاسبة غير قابلة للبرمجة أو لاختزان المعلومات أو لرسم البيانات – الخ).
- إرشادات عامة للمرشحين : قراءة كافة الأسئلة قبل البدء بالإجابة – اختيار الترتيب الذي يلائم المرشح في كتابة الحلول – الاعتناء بالخط لجهة الوضوح والترتيب وتجنب التشطيب قدر الإمكان – الخ.

APPENDIX D

Model Test 2 (LHM2)

Retrieved from:

Ministry of Education and Higher Education & Educational Center for Research and Development (2000). *Evaluation Guide. Mathematics Secondary Cycle*.
Lebanon: Ministry of National Education, Youth and Sports & National Center of Educational Research and Development.

الشهادة الثانوية العامة
فرع الآداب والإنسانيات
أختبار الرياضيات (فرنسي)
(نموذج ٢)

السنة :
عدد الأسئلة : ثلاثة
مدة الاختبار : ساعة

إرشادات عامة:

- يجب أن يكون مع المرشح : أدوات الرسم الهندسي - آلة حاسبة غير قابلة للبرمجة أو اختزان المعلومات أو رسم البيانات.
- يجب أن يستخدم المرشح قلم حبر (سائل أو ناشف) أزرق أو أسود بشكل عام. ويحق للمرشح استخدام أقلام ملونة أو قلم رصاص للرسم أو للإيضاح.
- يستحسن أن يقرأ المرشح كافة أسئلة الاختبار قبل البدء بالإجابة.
- يستطيع المرشح الإجابة بالترتيب الذي يناسبه (دون الالتزام بترتيب المسائل الوارد في الاختبار).
- إن لجان التصحيح تولي أهمية خاصة للخط (الجهة الواضوح) والترتيب، لذلك ينصح المرشح بالكتابة بشكل واضح والترتيب قدر الإمكان، مع تجنب التشطيب.

I. (3 points)

The students of a secondary school are distributed according to the following table:

	Boys	Girls
External	650	850
Half-internal	550	450

We randomly pick up one student.

Compute the probability that this student is external given that he is a boy.

II. (6 points)

The average monthly income of either an employee or a technician in a firm is 600 000 LP.

If we raise the wage of the employee by 10% and we reduce that of the technician by

10%, the average income becomes 590 000 LP.

What is the monthly income of each of them?

III. (11 points)

The following curve (C) represents the function f defined by $f(x) = ax + b + \frac{4}{x+c}$ where a ,

b , c are real numbers. By reading the

graph :

- 1) Calculate c .
- 2) Determine $f(3)$ and $f(-1)$. Deduce the values of a and b .
- 3) Give the table of variations of f and specify the limits of $f(x)$ at the bounds of its domain of definition.
- 4) Prove that the line $y = x + 1$ is an asymptote of (C).
- 5) Solve the equations $f(x) = -3$ and $f(x) = 7$.
- 6) Find the set of values of x satisfying: $-3 \leq f(x) \leq 7$.

Elements of solutions and marking scheme

Question	Short answers	Note
I	$P(E/G) = \frac{P(E \cap G)}{P(G)}$ (2)	2
	Calculation (1).	1
II	Translation into a system $\begin{cases} x + y = 1200000 \\ 1,1x + 0,9y = 1180000 \end{cases}$ (4)	6
	Solution of the system $x = 500\,000 \text{ L.L.}$ $y = 700\,000 \text{ L.L.}$ (2)	
III.1	$c = -1$	1
III.2	$a = 1, b = 1$	2
III.3	Readings from the representative curve.	4
III.4	Limit of $f(x) - (x + 1) = 0$	1
III.5	$x = 0$ or $x = -3$; $x = 2$ or $x = 5$	1
III.6	$-3 \leq x \leq 0$ or $2 \leq x \leq 5$	2

APPENDIX E

Session-2 Official Exam 2004 (LH042)

وزارة التربية والتعليم العالي
المديرية العامة للتربية
دائرة الامتحانات

امتحانات الشهادة الثانوية العامة
فرع الآداب والإنسانيات

دورة سنة ٢٠٠٤ الاستثنائية

عدد المسائل : ثلاث	مسابقة في الرياضيات المدة: ساعة واحدة	الاسم: الرقم:
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ملاحظة: يسمح باستعمال آلة حاسبة غير قابلة للبرمجة أو اختزان المعلومات أو رسم البيانات.
يستطيع المرشح الإجابة بالترتيب الذي يناسبه (دون الإلتزام بترتيب المسائل الواردة في المسابقة).

I-(10 points)

The curve (C), drawn in the orthonormal system below, is the representative curve of a function f .

- 1) Determine $\lim_{x \rightarrow 1^-} f(x)$, $\lim_{x \rightarrow 1^+} f(x)$, $\lim_{x \rightarrow -\infty} f(x)$ and $\lim_{x \rightarrow +\infty} f(x)$.
- 2) Set up the table of variations of f .
- 3) What is the number of solutions of the equation $f(x) = -5$? Justify your answer.
- 4) Solve the inequality $f(x) > 0$.

5) Copy and fill in the blanks using either one of the following symbols: $=$; $<$; $>$.

$$f'(-2) \dots\dots 0 \quad .$$

$$f'(-1) \dots\dots 0 \quad .$$

$$f'(0) \dots\dots 0 \quad .$$

$$f'(3) \dots\dots 0 \quad .$$

6) In this part, let $f(x) = x - 1 + \frac{4}{x-1}$.

a- Prove that the line (d) of equation $y = x - 1$ is an asymptote of the curve (C).

b- Write an equation of the line that is tangent to (C) at the point E of abscissa 2.

II-(5 points)

Consider the following propositions:

p : Beirut is a capital.

q : Beirut is overpopulated.

1) Write each of the following propositions in a symbolic language:

a : Beirut is overpopulated and is not a capital.

b : Beirut is not a capital and is not overpopulated.

c : It is not true that Beirut is an overpopulated capital.

d : If Beirut is a capital then it is overpopulated .

e : If Beirut is not overpopulated then it is not a capital.

2) Among the 5 propositions mentioned in the first part, indicate two propositions that are equivalent.

III-(5 points)

Jamil has a capital of 20 000 000 LL. He deposits **half** of his capital in bank A at an **annual interest rate** of 8% compounded **quarterly**, and **the other half** in bank B at an **annual interest rate** of 7.5% compounded **monthly**.

1) Determine the amount compounded in Jamil's account in bank A after 5 years.

2) Determine the amount compounded in Jamil's account in bank B after 5 years.

3) What is the amount of interests gained by his capital during these five years?

APPENDIX F

TIMSS Advanced 2008 – Mathematics Cognitive Domains

Retrieved from:

Garden, R. A., Lie, S., Robitaille, D. F., Angell, C., Martin, M. O., Mullis, I.V.S., ... Arora,

A. (2006, September). *TIMSS advanced 2008 assessment frameworks*. Retrieved

from TIMSS & PIRLS International Study Center website:

http://timss.bc.edu/PDF/TIMSS_Advanced_AF.pdf

Advanced Mathematics Cognitive Domains

To respond correctly to TIMSS test items, students need to be familiar with the mathematics content being assessed, but they also need to draw on a range of cognitive skills. Describing these skills is an essential aspect of developing the assessment of achievement in Advanced Mathematics because this ensures that the important cognitive goals of school mathematics education are surveyed across the content domains already defined.

A central aim of school mathematics programs at all levels is to have students understand the subject matter of the courses they are studying. Understanding a mathematics topic consists of having the ability to operate successfully in three cognitive domains. The first domain, *knowing*, covers the facts, procedures, and concepts students need to know, while the second, *applying*, focuses on the ability of students to make use of this knowledge to select or create models and solve problems. The third domain, *reasoning*, goes beyond the solution of routine problems to encompass the ability to use analytical skills, generalize, and apply mathematics to unfamiliar or complex contexts.

Each content domain will include items developed to address each of the three cognitive domains. For example, the algebra domain will include knowing, applying, and reasoning items, as will the other content domains.

Knowing

Facility in using mathematics or reasoning about mathematical situations depends on mathematical knowledge and familiarity with mathematical concepts. The more relevant knowledge a student is able to recall and the wider the range of concepts he or she has understood, the greater the potential for engaging in a wide range of problem- solving situations and for developing mathematical understanding.

Without access to a knowledge base that enables easy recall of the language and basic facts and conventions of number, symbolic representation, and spatial relations, students would find purposeful mathematical thinking impossible. *Facts* encompass the factual knowledge that provides the basic language of mathematics, and the essential mathematical facts and properties that form the foundation for mathematical thought.

Procedures form a bridge between more basic knowledge and the use of mathematics for solving routine problems, especially those encountered by many people in their daily lives. In essence, a fluent use of procedures entails recall of sets of actions and how to carry them out. Students need to be efficient and accurate in using a variety of computational procedures and tools. They need to see that particular procedures can be used to solve entire classes of problems, not just individual problems.

Knowledge of *concepts* enables students to make connections between elements of knowledge that, at best, would otherwise be retained as isolated facts. It allows them to make extensions beyond their existing knowledge, judge the validity of mathematical statements and methods, and create mathematical representations.

Behaviors Included in the Knowing Domain

Recall	Recall definitions, terminology, notation, mathematical conventions, number properties, geometric properties.
Recognize	Recognize entities that are mathematically equivalent (e.g., different representations of the same function or relation).
Compute	Carry out algorithmic procedures (e.g., determining derivatives of polynomial functions, solving a simple equation).
Retrieve	Retrieve information from graphs, tables, or other sources.

Applying

Problem solving is a central goal, and often a means, of teaching mathematics, and hence this and supporting skills (e.g., select, represent, model) feature prominently in the domain of *applying* knowledge. In items aligned with this domain, students need to apply knowledge of mathematical facts, skills, procedures, and concepts to create representations and solve problems. Representation of ideas forms the core of mathematical thinking and communication, and the ability to create equivalent representations is fundamental to success in the subject.

Problem settings for items in the applying domain are more routine than those aligned with the reasoning domain and will typically have been standard in classroom exercises designed to provide practice in particular methods or techniques. Some of these problems will have been expressed in words that set the problem situation in a quasi-real context. Though they range in difficulty, each of these types of “textbook” problems is expected to be sufficiently familiar to students that they will essentially involve selecting and applying learned procedures.

Problems may be set in real-life situations or may be concerned with purely mathematical questions involving, for example, numeric or algebraic expressions, functions, equations, geometric figures, or statistical data sets. Therefore, problem solving is included not only in the *applying* domain, with emphasis on the more familiar and routine tasks, but also in the *reasoning* domain.

Behaviors Included in the Applying Domain

Select	Select an efficient/appropriate method or strategy for solving a problem where there is a commonly used method of solution.
Represent	Generate alternative equivalent representations for a given mathematical entity, relationship, or set of information.
Model	Generate an appropriate model such as an equation or diagram for solving a routine problem.
Solve Routine Problems	Solve routine problems, (i.e., problems similar to those students are likely to have encountered in class). For example, differentiate a polynomial function, use geometric properties to solve problems.

Reasoning

Reasoning mathematically involves the capacity for logical, systematic thinking. It includes intuitive and inductive reasoning based on patterns and regularities that can be used to arrive at solutions to non-routine problems. Non-routine problems are problems that are very likely to be unfamiliar to students. They make cognitive demands over and above those needed for solution of routine problems, even when the knowledge and skills required for their solution have been learned. Non-routine problems may be purely mathematical or may have real-life settings. Both types of items involve transfer of knowledge and skills to new situations, and interactions among reasoning skills are usually a feature. Problems requiring reasoning may do so in different ways. Reasoning may be involved because of the novelty of the context or the complexity of the situation, or because any solution to the problem must involve several steps, perhaps drawing on knowledge and understanding from different areas of mathematics.

Even though many of the behaviors listed within the reasoning domain are those that may be drawn on in thinking about and solving novel or complex problems, each by itself represents a valuable outcome of mathematics education, with the potential to influence learners' thinking more generally. For example, reasoning involves the ability to observe and make conjectures. It

also involves making logical deductions based on specific assumptions and rules, and justifying results.

Behaviors Included in the Reasoning Domain

Analyze	Investigate given information, and select the mathematical facts necessary to solve a particular problem. Determine and describe or use relationships between variables or objects in mathematical situations. Make valid inferences from given information.
Generalize	Extend the domain to which the result of mathematical thinking and problem solving is applicable by restating results in more general and more widely applicable terms.
Synthesize/
Integrate	Combine (various) mathematical procedures to establish results, and combine results to produce a further result. Make connections between different elements of knowledge and related representations, and make linkages between related mathematical ideas.
Justify	Provide a justification for the truth or falsity of a statement by reference to mathematical results or properties.
Solve
Non-
routine
Problems	Solve problems set in mathematical or real-life contexts where students are unlikely to have encountered similar items, and apply mathematical procedures in unfamiliar or complex contexts.

APPENDIX G

Coding the Details of Contents of the Lebanese Reformed Math Curriculum

For the LH track at the Secondary School Level

Retrieved from:

Ministry of National Education, Youth and Sports & National Center of Educational Research and Development (1997). *Curriculum of Mathematics. Decree n° 10227. 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.

Codes	<i>Math Curriculum for the LH track at the Secondary School Level</i>
1	ALGEBRA
1.1.	Foundations
1.1.1.	Binary operations
1.1.1.1.	Identify a binary operation.
1.1.1.1.i.	→ Identify a binary operation on a set E as a rule which associates to every pair $(x,y) \in E \times E$ an element $z \in E$.
1.1.1.2.	Recognize the properties of a binary operation.
1.1.1.2.i.	→ Identify an associative binary operation.
1.1.1.2.ii.	→ Identify a commutative binary operation.
1.1.1.3.	Recognize certain particular elements.
1.1.1.3.i.	→ Identify a neutral element (an identity element) for a binary operation.
1.1.1.3.ii.	→ Identify the symmetric element of an element for a binary operation.
1.1.2.	Structure of group
1.1.2.1.	Define a group.
1.1.2.1.i.	→ Clarify the structure of the set of integers provided by addition.

Codes	<i>Math Curriculum for the LH track at the Secondary School Level</i>
1.1.2.1.ii.	→ Identify a group as being a set provided by a binary operation which verifies certain properties.
1.1.3.	Propositional calculus
1.1.3.1.	Identify a proposition.
1.1.3.1.i.	→ Identify a proposition as being a declarative phrase.
1.1.3.1.ii.	→ Identify a tautology as being the proposition that is always true.
1.1.3.2.	Recognize and use the basic logical operators.
1.1.3.2.i.	→ Identify the negation of a proposition.
1.1.3.2.ii.	→ Identify the conjunction of a proposition.
1.1.3.2.iii.	→ Identify the disjunction of a proposition.
1.1.3.2.iv.	→ Identify the implication as being the proposition $(\neg P) \vee Q$.
1.1.3.2.v.	→ Identify the equivalence as being the proposition $(P \Rightarrow Q) \wedge (Q \Rightarrow P)$.
1.1.3.3.	Use the table of truth.
1.1.3.3.i.	→ Fill the table of truth of a proposition.
1.2.	Equations & Inequalities
1.2.1.	Situations- problems leading to the solutions of equations and inequalities
1.2.1.1.	Analyze a problem and put it in equations and/or inequalities.
1.2.1.1.i.	→ Choose the unknown or the unknowns.
1.2.1.1.ii.	→ Write the equations, systems of equations, inequalities or systems of inequalities which must verify the unknowns.
1.2.1.2.	Clarify the constraints on solutions imposed by the studied situation.
1.2.1.3.	Solve the equations and/or the inequalities and verify the validity of the solutions found.
1.2.1.3.i.	→ Solve the equations and/or inequalities.
1.2.1.3.ii.	→ Asses the relevance of the solutions.
2	CALCULUS (NUMERICAL FUNCTIONS)
2.1.	Definitions & Representations
2.1.1.	Simple rational functions
2.1.1.1.	Study and represent graphically simple rational functions.
2.1.1.1.i.	→ Recognize a rational function as being a function of the form $x \rightarrow f(x) = P(x) / Q(x)$ where P and Q are polynomials.
2.1.1.1.ii.	→ Determine the domain of definition of a rational function.
2.1.1.1.iii.	→ Determine the parity of a rational function and exploit it.
2.1.1.1.iv.	→ Study the sense of variation of a rational function.

Codes	<i>Math Curriculum for the LH track at the Secondary School Level</i>
2.1.1.1.v.	→ Calculate the limits at the neighborhood of the domain of definition of a rational function.
2.1.1.1.vi.	→ Find the vertical, horizontal asymptotes.
2.1.1.1.vii.	→ Interpret the limits graphically.
2.1.1.1.ix.	→ Find that a given line is an asymptote.
2.1.1.1.ix.	→ Represent graphically a rational function.
2.1.1.1.x.	→ Solve graphically an equation of the form $P(x) / Q(x) = m$ where m is a real number.
2.1.2.	Graphical interpretation
2.1.2.1.	Interpret a graph and grasp the essential information that are presented.
2.1.2.2.	Use the representative curve of a function to:
2.1.2.2.i.	→ Find from a graph the domain of definition of the function corresponding to this graph.
2.1.2.2.ii.	→ Determine the intervals of increase (resp. of decrease) of the correspondent function.
2.1.2.2.iii.	→ Determine graphically the extrema and characterize them.
2.1.2.2.iv.	→ Determine graphically the points of discontinuity.
2.1.2.2.v.	→ Clarify the limits if they exist.
2.1.2.2.vi.	→ Graphically locate the value of $f(x)$ for a given x .
2.1.2.2.vii.	→ Graphically locate the value of x for a given $f(x)$.
2.1.2.2.ix.	→ Solve graphically inequalities of the form: $f(x) \geq m$ (resp. $\leq$) for a given real value of m .
2.1.2.2.ix.	→ Compare f and g on a given interval where g is a reference function for a given x .
2.1.3.	Exponential growth and exponential function
2.1.3.1.	Calculate a^x for a real positive number a in the two cases $a > 1$ and $0 < a < 1$.
2.1.3.2.	Know and use the properties: $a^x \cdot a^y = a^{x+y}$ $(a^x)^y = a^{x \cdot y}$
2.1.3.3.i.	→ Represent graphically, point by point the function: $x \rightarrow a^x$ for a given real positive number a .
2.1.3.3.ii.	→ Read graphically the variation of the function: $x \rightarrow a^x$ according to a .
2.1.3.3.iii.	→ Compare graphically the two functions: $x \rightarrow x^n \text{ where } n \text{ is a positive integer}$ and $x \rightarrow a^x \text{ where } a \text{ is a positive real number.}$

Codes	<i>Math Curriculum for the LH track at the Secondary School Level</i>
2.2.	Mathematical Models for Economics and Social Sciences
2.2.1.	Simple interest, compound interest
2.2.1.1.	Calculate the simple interest or the compound interest returned by a capital placed at a given rate for a given duration.
2.2.1.2.	Find an element among the four elements concerned by the calculation of interest knowing the other three.
2.2.1.2.i.	→ Know the terminology: capital, simple interest, compound interest, interest rate, period of placement, actual value, acquired value.
2.2.1.2.ii.	→ Know and apply the relation linking the capital, rate, duration and interest.
2.2.1.2.iii.	→ Know and apply the formula linking the acquired value, capital, interest rate and duration.
2.2.1.2.iv.	→ Know and use the formulas of annuity.
3	STATISTICS AND PROBABILITY
3.1.	Statistics
3.1.1.	Measures of central tendency and measures of variability of a distribution of one (continuous or discrete) variable
3.1.1.1.	Calculate the measures of central tendency and measures of variability and know how to interpret them.
3.1.1.1.i.	→ Recognize the median class.
3.1.1.1.ii.	→ Recognize the modal class(es).
3.1.1.1.iii.	→ Identify and calculate analytically and graphically (if it can be done) the median and the mode(s).
3.1.1.1.iv.	→ Identify and determine the range.
3.1.1.1.v.	→ Identify and calculate the mean, mean deviation, variance and standard deviation.
3.1.1.1.vi.	→ Compare and interpret two distributions of the same mean and of different standard deviations.
3.2.	Probability
3.2.1.	Conditional probability: definition, independence of two events
3.2.1.1.	Define and calculate the probability of an event A , knowing that an event B is achieved.
3.2.1.1.i.	→ Calculate $P_B(A)$ by the formula $P_B(A) = P(A/B) = P(A \cap B) / P(B)$.

Codes	<i>Math Curriculum for the LH track at the Secondary School Level</i>
3.2.1.1.ii.	→ Calculate $P(A \cap B)$ by the formula: $P(A \cap B) = P(A/B) \times P(B) = P(B/A) \times P(A)$ where A and B are two non-impossible events.
3.2.1.2.	Define two independent events:
3.2.1.2.i.	→ Recognize two independent events A and B by the fact that $P(A/B) = P(A)$.

APPENDIX H

Quantitative Analysis for Model Test 2 (LHM2)

Code of the Details of Contents of the LH track at Grade 12	Mathematics Framework - TIMSS Advanced 2008 - Cognitive Domains			Mathematics Model Test 2 (LHM2) Test items
	Knowing	Applying	Reasoning	
1.2.1.1.i.	2/3			II.i. , II.ii.
1.2.1.1.ii.			2/3	II.i. , II.ii.
1.2.1.3.i.	1/3	1/3		II.i. , II.ii.
2.1.1.1.iv.		1		III.3.i.
2.1.1.1.v.	4			III.3.ii. , III.3.iii. , III.3.iv. , III.3.v.
2.1.1.1.iiix.	1			III.4.
J		2	1	III.1. , III.2.iii. , III.2.iv.
2.1.2.2.vi.	2			III.2.i. , III.2.ii.
2.1.2.2.vii.	2			III.5.i. , III.5.ii.
2.1.2.2.iiix.		1		III.6.
3.2.1.1.	1/2	1/2		I.
Total	10 1/2	4 5/6	1 2/3	17

J refers to the test items addressed in the model tests and the official exams that relate to the curriculum content studied at grade levels preceding Grade 12 LH track.

J: Given $f(x)$ in terms of a, b, c find a, b, c

APPENDIX I

Quantitative Analysis for the Official Exam LH042

Code of the Details of Contents of the LH track at Grade 12	Mathematics Framework - TIMSS Advanced 2008 - Cognitive Domains			Mathematics Official Exam (LH042) Test items
	Knowing	Applying	Reasoning	
1.1.3.2.	3/4	$\frac{3}{4}$		II.1.d. , II.1.e.
1.1.3.2.i.	1	1		II.1.a, II.1.b. , II.1.c. , II.1.e.
1.1.3.2.ii.	3/4	$\frac{3}{4}$		II.1.a, II.1.b. , II.1.c.
1.1.3.2.v.	1			II.2.
2.1.1.1.iiix.	1			I.6.a.
E		1		I.6.b.
G	4			I.5.i. , I.5.ii. , I.5.iii. , I.5.iv.
2.1.2.2.ii.		1		I.2.
2.1.2.2.v.	4			I.1.i. , I.1.ii. , I.1.iii. , I.1.iv.
2.1.2.2.vii.	2			I.3.i. , I.3.ii.
2.1.2.2.iiix.		1		I.4.
2.2.1.1.	1	1		III.1. , III.2.
L	1			III.3.
Total	16 1/2	6 ½	0	23

E, G, and L refer to the test items addressed in the model tests and the official exams that relate to the curriculum content studied at grade levels preceding Grade 12 LH track.

E: Write the equation of the tangent to the graph of the function at the point (a, f(a))

G: Graphically, determine if $f'(2)$ is > 0 , < 0 , or $= 0$

L: Find earned interest (new amount - old amount)

APPENDIX J

Document Given By Interviewee

SV

Mathématiques Table of compétences

1ere session 2007

N°		Domaine 1				Domaine 2			Domaine 3					
		1.1	1.2	1.3	1.4	2.1	2.2	2.3	3.1	3.2	3.3	3.4	3.5	3.6
I	1a													
	1b													
	1c													
	2a													
	2b													
	2c													
II	1a													
	1b													
	2a													
	2b													
III	1a													
	1b													
	2a													
	2b													
	3a													
	3b													
IV	1a													
	1b													
	1c													
	2													
	3a													
	3b													
	4													
	5a													
	5b													
	6													

Table of competencies

Domains	Competencies
Calculation processes	1.1 Use properties of a binary operation to identify a group. 1.2 Perform different types of calculation (algebraic, complex, trigonometric, combinatorial, statistical, vectorial, analytic, etc.) 1.3 Use the basic principles of probability to solve 1.4 Solve systems of equations.
Numerical functions (Calculus)	2.1 Apply the concepts of continuity and differentiability to functions. 2.2 Study functions (variations, graphic representation, etc.) 2.3 Exploit the integral calculation.
Problem Solving and Communication	3.1 Extract relevant information from different sources. 3.2 Describe, represent and analyze situations of different natures or shift from one mode of representation to 3.3 Conduct different types of mathematical reasoning. 3.4 Choose the adequate model to solve a problem. 3.5 Validate, explain and interpret a result. 3.6 Make, formulate and verify conjectures.

APPENDIX K

Frozen Themes and Details of Contents of the Mathematics Curriculum

Retrieved from:

وزارة التربية والتعليم العالي، والمركز التربوي للبحوث والانماء (2001). *المحاور والدروس المطلوب تعليق العمل بها (للعام الدراسي 2001 - 2002)*. تعميم رقم 59 / م / 2001. تاريخ 2001/9/11. لبنان: وزارة التربية والتعليم العالي والمركز التربوي للبحوث والانماء.

Ministry of Education and Higher Education & Educational Center for Research and Development (2001). *Themes and lessons required to suspend them (for the academic year 2001-2002) – Circular No. 59 / M / 2001 – Date 11/09/2001*. Lebanon: Ministry of National Education, Youth and Sports & National Center of Educational Research and Development.

THIRD YEAR – LITTEATURE AND HUMANITIES SECTION

ALGEBRA

CONTENT	OBJECTIVES
1.1. Binary operation.	<ol style="list-style-type: none">1. Identify a binary operation.2. Recognize the properties of a binary operation.3. Recognize certain particular elements.
1.2. Structure of group.	<ol style="list-style-type: none">1. Define a group.
1.3. Exponential growth and exponential function.	<ol style="list-style-type: none">1. Calculate a^x for a real positive number a in the two cases $a > 1$ and $0 < a < 1$.2. Know and use the properties: $a^x \cdot a^y = a^{x+y}$. $(a^x)^y = a^{xy}$.

APPENDIX L

Qualitative Analysis of the Model Tests and Official Exams

Table 1

Occurrences of Test Items on Different Math Topics in the Model Tests and Official Exams of the LH Track at Grade 12

The Codes of the Math Topics	Model Tests			Official Exams of the LH Track at Grade 12																			
	LHM1	LHM2	LHM3	2001		2002		2003		2004		2005		2006		2007		2008		2009		2010	
				Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2		
1. ALGEBRA																							
1.1.3.			X				X				X												
1.2.	X	X	X		X	X		X		X		X	X	X	X	X	X	X	X	X	X		
2. CALCULUS (Numerical Functions)																							
2.1.	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
2.2.1.						X			X		X											X	
3. STATISTICS AND PROBABILITY																							
3.1.					X		X					X		X				X		X			
3.2.	X	X			X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	

1.1.3. Propositional Calculus ; 1.2. Equations & Inequalities ; 2.1. Definitions & Representations of Rational Functions ; 2.2.1. Simple Interest, Compound Interest ; 3.1. Statistics ; 3.2. Probability

Table 2

Distribution of Grades by Math Topics in the Model Tests and Official Exams of the LH Track at Grade 12

The Codes of the Math Topics	Model Tests			Official Exams of the LH Track at Grade 12																			
	LHM1	LHM2	LHM3	<u>2001</u>		<u>2002</u>		<u>2003</u>		<u>2004</u>		<u>2005</u>		<u>2006</u>		<u>2007</u>		<u>2008</u>		<u>2009</u>		<u>2010</u>	
				Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2
1. ALGEBRA																							
1.1.3.			6				4			5													
1.2.	9	6	8		3	4		4		4		4	5	4	4	5	5	5	5	5	5	5	5
2. CALCULUS (Numerical Functions)																							
2.1.	7	11	6		8	10	11	10	11	10	10	10	10	11	10	10	10	10	10	10	10	10	10
2.2.1.							5			4		5											5
3. STATISTICS AND PROBABILITY								6					6		6	5		5	5				
3.1.					7																		
3.2.	4	3			5	7			5	6	6		5	5		5	5			5	5	5	5
1.1.3. Propositional Calculus ; 1.2. Equations & Inequalities ; 2.1. Definitions & Representations of Rational Functions ; 2.2.1. Simple Interest, Compound Interest ; 3.1. Statistics ; 3.2. Probability																							

Table 3

Occurrences of Test Items on the Math Topic “Propositional Calculus” in the Model Tests and Official Exams of the LH Track at Grade 12

Test Items on Propositional Calculus	Model Tests			Official Exams of the LH Track at Grade 12													
	LHM1	LHM2	LHM3	<u>2001</u>	<u>2002</u>	<u>2003</u>	<u>2004</u>	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>				
				Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2		
-Translate from English to symbolic language					X		X										
-Translate from symbolic language to English					X												
-Indicate which propositions are equivalent							X										
-general problem on logic			X														

Table 4

Occurrences of Test Items on the Math Topic “Equations & Inequalities” in the Model Tests and Official Exams of the LH Track at Grade 12

Test Items Equations Inequalities	on &	Model Tests			Official Exams of the LH Track at Grade 12																			
		LHM1	LHM2	LHM3	<u>2001</u>		<u>2002</u>		<u>2003</u>		<u>2004</u>		<u>2005</u>		<u>2006</u>		<u>2007</u>		<u>2008</u>		<u>2009</u>		<u>2010</u>	
					Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2
-equations			X	X		X	X		X		X		X	X	X	X	X	X	X	X	X	X	X	
-inequalities		X																						

Table 5

Occurrences of Test Items on the Math Topic “Rational Functions” in the Model Tests and Official Exams of the LH Track at Grade 12

			Model Tests		Official Exams of the LH Track at Grade 12																		
Test Items on Rational Functions	LHM1	LHM2	LHM3	<u>2001</u>		<u>2002</u>		<u>2003</u>		<u>2004</u>		<u>2005</u>		<u>2006</u>		<u>2007</u>		<u>2008</u>		<u>2009</u>		<u>2010</u>	
				Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2
-domain of definition					X			X		X		X	X		X							X	
-find f(1)		X		X		X									X	X						X	
-determine f' (-1)				X											X					X		X	
-compare f(2) and f(3)							X					X						X	X				
-compare f ' (0) and f ' (1)																			X				
-prove that I(2, 3) is center of symmetry														X									
-write equation of tangent line at point A					X		X	X	X		X		X	X		X		X		X		X	X
-determine the intersection of f(x) and a line												X		X					X				X
-find lim f(x) as x ->	X	X					X	X		X	X	X				X	X			X	X	X	X

[illegible]

asymptotes

-determine # of solution of $f(x)=3$ (table)

-determine # of solution of $f(x)=0$ (graph)

-solve graphically
 $f(x) = 1$

-solve graphically $f'(x)=0$

-solve graphically f'
(x) > 0

-given table of variation, solve $f(x) < 0$

-solve graphically
 $f(x) > 7$

-solve graphically
 $f(x) < \text{any line}$

-discuss $f(x) = m$

Table 6

Occurrences of Test Items on the Math Topic “Interest Problems” in the Model Tests and Official Exams of the LH Track at Grade 12

Test Items on Interest Problems	Model Tests			Official Exams of the LH Track at Grade 12											
	LHM1	LHM2	LHM3	<u>2001</u>	<u>2002</u>	<u>2003</u>	<u>2004</u>	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>	<u>2009</u>	<u>2010</u>		
				Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2
-find new amount using simple interest					X										
-find new amount using compound interest					X	X	X						X		
-compare which choice is more profitable					X								X		
-find earned interest (new - old amount)						X	X								

Table 7

Occurrences of Test Items on the Math Topic “Statistics” in the Model Tests and Official Exams of the LH Track at Grade 12

			Model Tests			Official Exams of the LH Track at Grade 12																			
Test Statistics	Items on		LHM1	LHM2	LHM3	<u>2001</u>		<u>2002</u>		<u>2003</u>		<u>2004</u>		<u>2005</u>		<u>2006</u>		<u>2007</u>		<u>2008</u>		<u>2009</u>		<u>2010</u>	
						Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2
-Mode						X		X							X					X					
-Median						X		X												X					
-Center						X																			
-Range								X																	
-Mean						X		X					X		X		X			X					
-standard deviation						X																			
-new mean if						X																			
-use graph to complete table:																						X			
classes/freq./ICF																									
-complete table																			X					X	

Table 8

Occurrences of Test Items on the Math Topic “Probability” in the Model Tests and Official Exams of the LH Track at Grade 12

Model Tests				Official Exams of the LH Track at Grade 12																					
Test Items on Probability	LHM1	LHM2	LHM3	<u>2001</u>		<u>2002</u>		<u>2003</u>		<u>2004</u>		<u>2005</u>		<u>2006</u>		<u>2007</u>		<u>2008</u>		<u>2009</u>		<u>2010</u>			
				Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2	Session-1	Session-2		
P(A)	X	X		X	X				X	X	X		X	X	X		X		X	X	X	X			
P(A and B)				X	X			X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		
P(A or B)					X					X						X	X			X		X	X	X	
P(A/B)				X	X				X	X	X		X	X	X	X	X	X	X	X	X	X	X		
Are A and B independent events ?								X																	
P(... < > ...)										X						X					X	X			
P(A then B) with no replacement (knowing that)													X										X		X

APPENDIX M

Quantitative Analysis of the Model Tests and Official Exams

Table 1

Distribution of Percentages of Test Items by Math Topics and Cognitive Domains in the Model Tests and the Official Exams of the LH Track at Grade 12 – Extracted from Table Mod and Table OffEx

The Topics of the Math Curriculum of the LH Track at Grade 12	Sum of Model Tests				Sum of Official Exams			
	K %	A %	R%	Total	K %	A %	R %	Total
1.1.3. Propositional Calculus	0.00	0.00	12.24	12.24	0.75	1.40	0.00	2.15
1.2. Equations & Inequalities	10.20	13.61	2.72	26.53	5.51	2.83	2.80	10.34
2.1. Rational Functions	38.78	16.32	2.04	57.14	35.56	14.22	5.60	55.38
2.2.1. Simple & Compound Interest	0.00	0.00	0.00	0.00	1.94	0.86	0.00	2.80
3.1. Statistics	0.00	0.00	0.00	0.00	9.75	0.81	0.00	10.56
3.2. Probability	1.02	3.06	0.00	4.08	13.85	4.90	0.00	18.75
Total	50.00	32.99	17.01	≈100	67.37	24.23	8.41	≈100

K = Knowing

A = Applying

R = Reasoning

The sum of Totals is approximately equal to 100 because the percentages are rounded.

Table 2

Distribution of Percentages of Test Items by Math Topics and Cognitive Domains in the Model Tests, and the Official Exams of the Years 2001-2005 and 2006-2012 of the LH Track at Grade 12 – Extracted from Table Mod, Table OffEx1-5, and OffEx6-10

The Topics of the Math Curriculum of the LH Track at Grade 12	Sum of Model Tests				Sum of 2001-2005 Official Exams				Sum of 2006-2010 Official Exams			
	K %	A %	R%	Total	K %	A %	R %	Total	K %	A %	R %	Total
1.1.3. Propositional Calculus	0.00	0.00	12.24	12.24	1.63	3.02	0.00	4.65	0.00	0.00	0.00	0.00
1.2. Equations & Inequalities	10.20	13.61	2.72	26.53	3.72	1.40	1.86	6.98	7.06	2.58	3.61	13.25
2.1. Rational Functions	38.78	16.32	2.04	57.14	37.67	13.02	4.65	55.35	33.73	15.26	6.43	55.42
2.2.1. Simple & Compound Interest	0.00	0.00	0.00	0.00	3.26	1.40	0.00	4.66	0.80	0.40	0.00	1.20
3.1. Statistics	0.00	0.00	0.00	0.00	9.19	0.12	0.00	9.31	10.24	1.41	0.00	11.65
3.2. Probability	1.02	3.06	0.00	4.08	13.26	5.81	0.00	19.07	14.36	4.12	0.00	18.48
Total	50.00	32.99	17.01	≈100	68.72	24.77	6.51	≈100	66.20	23.76	10.04	≈100

K = Knowing

A = Applying

R = Reasoning

The sum of Totals is approximately equal to 100 because the percentages are rounded.

Table 3

Distribution of Percentages of Test Items by Math Topics and Cognitive Domains in the Model Tests, and the Session-1 and Session-2 Official Exams of the LH Track at Grade 12 – Extracted from Table Mod, Table OffEx1, and OffEx2

The Topics of the Math Curriculum of the LH Track at Grade 12	Sum of Model Tests				Sum of Session-1 Official Exams				Sum of Session-2 Official Exams			
	K %	A %	R %	Total	K %	A %	R %	Total	K %	A %	R %	Total
1.1.3. Propositional Calculus	0.00	0.00	12.24	12.24	0.00	0.00	0.00	0.00	1.60	2.97	0.00	4.57
1.2. Equations & Inequalities	10.20	13.61	2.72	26.53	6.43	2.55	2.86	11.84	4.49	1.45	2.74	8.68
2.1. Rational Functions	38.78	16.32	2.04	57.14	35.10	13.06	4.49	52.65	36.07	15.53	6.85	58.45
2.2.1. Simple & Compound Interest	0.00	0.00	0.00	0.00	1.22	0.41	0.00	1.63	2.74	1.37	0.00	4.11
3.1. Statistics	0.00	0.00	0.00	0.00	13.16	1.53	0.00	14.69	5.94	0.00	0.00	5.94
3.2. Probability	1.02	3.06	0.00	4.08	14.29	4.90	0.00	19.18	13.36	4.91	0.00	18.26
Total	50.00	32.99	17.01	≈100	70.20	22.45	7.35	≈100	64.19	26.22	9.59	≈100

K = Knowing

A = Applying

R = Reasoning

The sum of Totals is approximately equal to 100 because the percentages are rounded.