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PISA 2015
NATIONAL REPORT

Program For International Student Assessment

National Project Manager
- Dr. Nada OWEIJANE

National Project Coordinator
- Mr. Bassem ISSA

Consultant and Reader
- Prof. Karma EL- HASSAN

Educational Coordinator and Researcher
- Mrs. Rana ABDALLAH

Educational Reader and Reviewer
- Dr. Rita NASRALLAH

Scientific Literacy
- Mrs. Rana ABDALLAH
- Mr. Fady OWEIJANE
- Mr. Akram SABEK

Mathematical Literacy
- Dr. Houssam EL-KASTI

Reading Literacy
- Mrs. Samia ABOU HAMAD
- Mrs. Badria REFAI

Educational Statistician
- Dr. Raymond BOU NADER
- Mrs. Brigitte KADDOUM (Assistant)

Designer
- Mrs. Rebecca EL HADDAD

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PREFACE

Educational tests are considered the means to signify the level of the learning achievement in the target subject matter. Thus, the analysis of its results requires taking corrective and perhaps structural decisions, which may include developing the subject matter curricula, amending its objectives, and updating its methods of teaching and evaluation. This continues until we are able to link these elements with the programs and curricula of preparing teachers of basic as well as secondary education so that development would be comprehensive and harmonious, and able to serve the purpose for which it was found.

This documented study, which dealt with the national and international tests in which Lebanon participated, places in our hands – as personnel who are involved in educational planning and educational management – scientific means and detailed research results. Such means and results could be added to the database reached by the Center for Educational Research and Development through studies, research statistics and analysis of the results of the official examinations. These in turn could be our reference in the workshop of developing, reforming, modernizing and restructuring the educational curricula in a way that is compatible with the interactive digital age, which uses technology and digital media in all aspects of life.

We are working very hard with all partners in the public, private and university educational sectors to improve the performance of the educational system and consequently to increase the learners' preparations in order to make their skills and competencies suitable for the requirements of international and national tests. In this way, we maintain Lebanon's regional and international rank and improve our techniques, curricula and methods to compete countries that have made successful educational leaps and formed educational systems that can be referred to as exemplary models in facilitating education and in preparing creative learners who are not bound by the burdens that impede their abilities or inhibit their aspirations to shine in studying and in the job market.

I congratulate those who participated in this study, and I call for continuing the research and testing approach so that we could achieve the desired educational progress, according to the scientific standards.

The Acting President of the Center for
Educational Research and Development
Dr. Nada OWEIJANE

Executive Summary

The average scores that were obtained by students, in Lebanon, were below the minimum level of proficiency-level 2- which is required for today's 15-year-old students to be able to be savvy and literate citizens in science, math, and reading.

Lebanon's report was written with the purpose of understanding why the general average scores were in the lowest quadrant. As such, CERD decided to go over the Lebanese curriculum to compare it to the PISA framework, and in addition its contents include a closer look on performance per grade, per gender, per region, and per sector.

The general curriculum comparison shed light on content areas that are required by PISA but are not part of the Lebanese curriculum. It was also noticed that in all three literacy areas, the students in Lebanon are weak when it comes to evaluation and reflection.

Additionally, even when the scores of the participating grades were detailed, the scores of 1st Secondary students, in science, were still below proficiency level 2. In math, the scores of the 1st Secondary students shifted to level 2. In reading, the scores were very low. The males performed better in science and math, but the females did better than the males in reading literacy. Moreover, in science, math, and French reading literacy, the students who represent Mount Lebanon (Beirut suburbs) scored the highest amongst the other participating regions; in English reading literacy, students from the North obtained the highest score. And lastly, the performance of private school students was better than those belonging to the public sector in all literacy areas.

At the attitude level, students' motivation towards learning science increases when the students are involved in student cantered activities that are based on inquiry (Intrinsic motivation) and when they believe that discovering science related issues helps them in solving their daily life problems (extrinsic motivation). Moreover, concerning the students' attitudes towards seeking their future jobs, most of them choose their future career the in the field of sciences rather than in the digital field and in the field of humanities.

All in all, the low scores are due to several issues. The political unrest in the country played its role; the fact that the test was conducted, in silence, without being a national priority had its impact on how serious the students were about the test. Plus, the test was taken in English or French which means that the language proficiency of students influenced what they understood and how they dealt with this test. Further, the test included topics that the students were not familiar within all literacy areas. The level of familiarity varied between literacy areas as explained in the report.

The end result was the reality that the scores were low on this international test, and if Lebanon wants to improve its PISA scores, it has to consolidate its efforts towards achieving this goal and updating its curriculum to encompass the skills required of students throughout the world, and this dictates a major shift in more than one area including the teaching methods.

Report Content

Chapter 1
Introduction

In this introductory chapter, an overview of the PISA 2015 test will be covered along with all the necessary information that is required for the general audience reader to understand all the facets that are related to this assessment.

1.1 What is PISA?

The Programme for International Student Assessment (PISA) is an international test meant to assess students' performance on a global scale. It is managed by the Organization for Economic Co-operation and Development (OECD)[1] . The OECD subscriber states and other government associates created PISA to evaluate and equate the calibre, fairness, and effectiveness of their schools on a regular basis, to assess students near the completion of obligatory schooling. They chose the age of 15 because it symbolises the last phase of schooling, universally speaking. With time, they fine-tuned this test to accommodate for the rapid socio-economic transfiguration that resulted from the digital age and its accompanying demands. And these changes imposed drastic dilemmas when it comes to the purpose of education and testing (Schleicher, 2017). The first round started in the year 2000 where the emphasis was on reading literacy skills, and since that time, it has been administered every 3 years. It provides a snapshot of what 15 year old pupils, in many countries, exhibit in terms of knowledge and skills in science, math, and reading when they take this test (OECD, 2016). "PISA assesses both subject matter content knowledge, on the one hand, and the capacity of individuals to apply that knowledge creatively, including unfamiliar contexts, on the other" (Schleicher, 2017, p. 116). In 2015, around 540000 students, from seventy-two countries (refer to Table 1.1), did this test. Besides the assessment, additional data was collected, via questionnaires, to provide further contextual information about students' characteristics and school practices (OECD, 2016).

1. The OECD is an international organization composed of the industrialized countries, as members, and other partner countries. This organization works on policies that are meant to improve the lives of people socially and economically.

Table 1.1 Countries[2] participating in PISA 2015

Albania	**Estonia**	Lebanon	Russia
Algeria	**Finland**	Lithuania	**Scotland**
Argentina+	**France**	**Luxembourg**	Singapore
Australia	Georgia	Macao	**Slovakia**
Austria	**Germany**	Macedonia	**Slovenia**
Belgium	**Greece**	Malaysia+	**Spain**
Brazil	Hong Kong	Malta	**Sweden**
Bulgaria	**Hungary**	**Mexico**	**Switzerland**
Canada	**Iceland**	Moldova	Taiwan
Chile	Indonesia	Montenegro	Thailand
China	**Ireland**	**Netherlands**	Trinidad and Tobago
Colombia	**Italy**	**New Zealand**	
Costa Rica	**Japan**	**Northern Ireland**	Turkey
Croatia	Jordan	**Norway**	United Arab Emirates
Cyprus+	Kazakhstan+	Peru	**United States**
Czech Republic	**South Korea**	**Poland**	Uruguay
Denmark	Kosovo	**Portugal**	Vietnam
Dominican Republic	**Latvia**	Qatar	**Wales**
England		Romania	

1.2 What is the purpose of this report?

The purpose behind this report is twofold. The first aim is to have an idea about how the students, in Lebanon, performed on this test as it was their first time. The second goal is to analyse those results and to conclude with lessons that can be invested practically in the upcoming curriculum reform endeavour. Curriculum design and development are one of the responsibilities of the Center for Educational Research and Development (CERD) that is currently working on preparing the curriculum reform plan. CERD is the national educational think tank that has been established, as an independent body, to provide support to the Ministry of Education and Higher through the Minister of Education. It has been operating since the year 1971. It performs different functions (for further information about its functions see Appendix A) including research, and as such it was the entity in charge of the PISA 2015 test in Lebanon.

1.3 How does the Lebanese schooling system function?

In Lebanon, there are two types of schools: public and private; the private sector is more developed than the public one (Kobeissi, 1999). The public schools are operated by the government and they are free of charge. The private ones are either religious or secular, and they charge fees in varying degrees depending on the services that are offered by the school. As well, there are some private schools that are buttressed by the government too; they charge minimal fees for they receive financial aid from the government, and they may be secular or religious (Lebanon-Education system, 2005). Lebanese pupils join school at the age of three. Education is considered to be compulsory

2. Table includes all countries participating in PISA 2015. Members of the OECD are highlighted in bold. + indicates limitations with the data meaning exclusion from the report. Although there are 35 members of the OECD, 38 countries are in bold as the United Kingdom is split into four separate countries. * China refers to the four Chinese provinces that participated (Beijing, Guangdong, Jiangsu and Shanghai). Arab countries are in red.

for the first six years of schooling (Yaacoub, & Badre, 2012) and nowadays till the age of 15. Parents choose the schools that their kids go to. The language of instruction varies depending on the school. Some schools focus on French as the first foreign language, others focus on English, and a few focus on both; nevertheless, in all cases, students study math and science either in French or in English and not in Arabic. These features render the Lebanese system unique. This is why comparing it to other educational systems, including neighbouring countries, becomes challenging.

The number of students enrolled in Lebanese schools, for the academic year 2015-2016, was 1, 003,634. Those studying in the public sector constituted around 31% whilst the private sector attendees were approximately 69% (CERD, 2016).

Lebanon used to be a leader in education when compared to the neighbouring countries, before the 1975 war. Once the war started, the education sector got affected, similar to all other sectors, and with time the system suffered the consequences especially that the country was not able to change its curriculum except in 1997 (Kobeissi, 1999), and no genuine reform attempts were initiated since then; today, CERD is trying to revamp its role, chiefly when it comes to designing the new curriculum, and this is why this report will highlight how the PISA test may serve as an indicator that there are urgent issues that have to be thought of when designing the new curriculum.

1.4 Why is PISA Important?

PISA is important because it acts as a benchmark that countries can rely on to compare the performance of their students to other countries, and if they continuously participate in this assessment, they will be able to track and compare their students' achievement; even more, in 2015 the assessment, for example, tackled focal issues regarding the scientific literacy of young people and whether they are being prepared by their schools to become life-long learners (OECD, 2016). This springs from the fact that tests leverage priorities by pinpointing to areas that can be ameliorated as far as curriculum and instruction are concerned (Schleicher, 2017). It also concentrates on the quality of the learning settings and how these milieus can be enriched to the benefit of the disadvantaged students. Moreover, it provides policy makers with initial evidence that they can rely on to advance their educational systems, schools, curricula, and teaching-learning processes to the advantage of students (OECD, 2016). However, the results have to be interpreted with caution knowing that "PISA instruments are more comparable across Western countries than they are across Middle Eastern or Asian countries" (Grisay & Monseur, 2007; Grisay et al., 2007; Grisay, Gonzalez, & Monseur, 2009; Kankaras & Moors, 2014 as cited in Hopfenbeck, Lenkeit, El Masri, Cantrell, Ryan, & Baird, 2017, p.13). Nevertheless, there is a general agreement that PISA results have an "informative value" for countries whether nationally or internationally (Hopfenbeck, Lenkeit, El Masri, Cantrell, Ryan, & Baird, 2017).

1.5 What does PISA Measure?

PISA measures three major literacy areas. Every three years, they focus on a specific literacy area besides the other two. In 2015, the principal area was **scientific literacy**. "PISA assesses not only whether students can reproduce knowledge, but also whether they can extrapolate from what they have learned and apply their knowledge in new situations. It emphasizes the mastery of processes, the understanding of concepts, and the ability to function in various types of situations" (OECD, 2016, p. 11). Box 1.5 presents the meanings of each literacy area, which will be revisited in detail in chapters 2, 3, and 4.

Box 1.5 Definitions of literacies

Scientific literacy: the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to:

- ⇨ explain phenomena scientifically – recognise, offer and evaluate explanations for a range of natural and technological phenomena.
- ⇨ evaluate and design scientific enquiry – describe and appraise scientific investigations and propose ways of addressing questions scientifically.
- ⇨ interpret data and evidence scientifically – analyse and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions.

Mathematical literacy: an individual's capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognise the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens.

Reading literacy: an individual's capacity to understand, use, reflect on and engage with written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society.

(OECD, 2016, p.13)

1.6 What has to be known about the PISA 2015 test?

In 2015, the PISA test was administered for the first time via computers, in all literacy areas, but not in Lebanon where assessment was paper-based[1]. The computer based test lasted 2 hours and had 66 test forms unlike the paper-based one, which also lasted two hours; nonetheless, it had 30 different forms; even so, the framework remains the same. Once the tests are over, they are corrected and scored based on scales and not grades. The coding system turns students' answers into an average score of 500 for all of the three literacy areas where the standard deviation is 100. Further, there was a problem solving skills test which was distributed to students for the first time, but Lebanon did not participate in it.

As for the scores in all literacy areas, Lebanon fell in the 65th place when it came to science literacy (mean 386); in other words only 5 countries scored lower than the Lebanese one, and they are Tunisia, FYROM, Kosovo, Algeria, and the Dominican Republic. Here, it is important to note that only Algeria and Kosovo, out of the previously listed countries, did the paper based assessment similar to Lebanon; however, comparing paper based and computer based scores is valid since OECD did not separate, in its international report, the narrated information into two separate entities because the objectives of both tests are the same. Moreover, Singapore had the highest mean score in science (556) followed by Japan (538), Estonia (534), Chinese Taipei (532), and Finland (531). A closer look on these scores, in all three literacy areas, will be handled in this report.

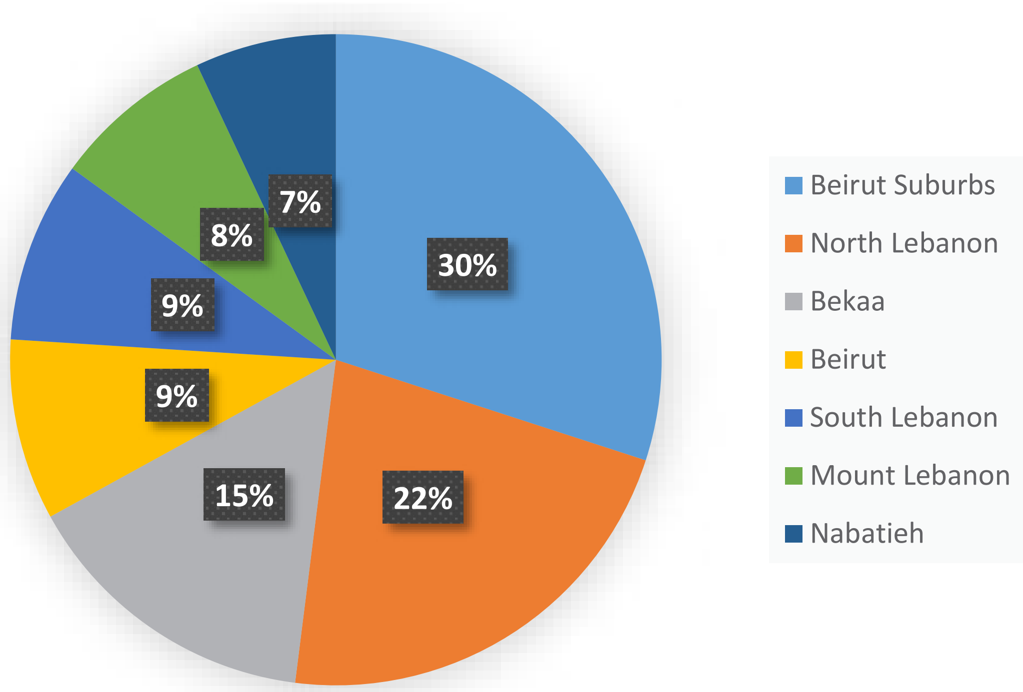
1. Fifteen countries opted for the paper based assessment. They are Albania, Algeria, Argentina, Georgia, Indonesia, Jordan, Kazakhstan, Kosovo, Lebanon, Macedonia, Malta, Moldova, Romania, Trinidad and Tobago, and Vietnam.

1.7 How was PISA administered in Lebanon?

Before dealing with how was PISA administered in Lebanon, it is worth mentioning that Lebanon, as a country, has passed and is still passing through wars, turmoil, economic deterioration, and political unrest since the year 1975. On top of that, there came the war in Syria and with it, Lebanon had to deal with the influx of Syrian refugees into the country (Obeid, 2015). All of the previously mentioned elements weakened the Lebanese governmental system including the education sector, knowing that now the educational system has to cater to both Lebanese and non-Lebanese students, especially the Syrian ones. Amidst all of those challenges, there came the PISA test with its results to convey to the Lebanese audience a snapshot of where we stand in scientific, math, and reading literacies as compared to other neighbouring countries and international ones.

In Lebanon, the PISA Coordinator, on behalf of CERD, provided the PISA Team with the information that they requested about Lebanese schools. Based on that information, the PISA team selected their sample out of 317,090 students enrolled in grades 7 till 12, according to CERD's statistics for the academic year 2015-2016. Their random stratified sample represented 4546 students enrolled in 273 schools that are both public (43%) and private (57%); the females constituted 54% of the overall sample, and the males added up to 46%. The schools represented the different regions as seen in Figure 1.7; the students who were selected to do the assessment belonged to grades 7 till 12 as long as their age was 15. Within each school, a simple random sample of 25 students was chosen to take the test.

Figure 1.7 Distribution of schools based on regions as represented in the Sample



Once the sample was specified, CERD members invited the assigned schools that agreed to join the assessment to introduce them to the PISA framework and all the related procedures, but there were no efforts in this regard at the national level to promote PISA 2015 and its importance as a benchmarking tool.

Besides the test, each school principal filled out a questionnaire and the students filled out another one; the aim of these questionnaires was to gather "contextual information". The "Principal Questionnaire" provides data about the overall school performance, and the "Student Questionnaire" supplies information about students' backgrounds. All in all, the data collection process took about one month and a half. During that period, around twenty-five students in each school were tested. The test lasted two hours; only 5 minutes were given as break to students during the test. Each student was tested via a different booklet. Each booklet contained various questions that either covered two of PISA's subjects or all three of them. The test items were a combination of multiple choice questions (simple and complex) and constructive response questions (closed and open). The tests were administered for all three literacy areas either in French or in English, depending on the school, but not in Arabic. So, the capacity of students to understand the content of the exam questions played its role in the assessment based on their foreign language comprehension skills.

Moreover, the content and the competencies related to the test items were something that the students, in Lebanon, were not familiar with, in varying degrees, as explained later in each literacy area. Such discrepancies interfered for sure with the test scores. Hence, the PISA results confirmed what the education stakeholders already know. The system of education needs reform, and the Lebanese curriculum has to be revisited with a critical eye in order to reform and update every single area of it, if Lebanon wants its youth to become more competent in the global environment and subsequently market, and because CERD has already started working on this endeavour, it has been decided to benefit from this report to shed light on whatever an international citizen is supposed to have based on the PISA perspective as opposed to the topics that our students are familiar with. Moreover, since this PISA round focused on sciences, this report will also concentrate, in Chapter 2, on detailing the comparison between the PISA framework and the sciences' curriculum. In Chapters 3 and 4 the comparison will be simpler and broader.

1.8 In general, how was the performance of students in all literacy areas?

Figure(1.8) Snapshot of performance in science, reading and mathematics

(dark purple)	Countries/economies with a mean performance/share of top performers **above** the OECD average Countries/economies with a share of low achievers **below** the OECD average
(grey-blue)	Countries/economies with a mean performance/share of top performers/ share of low achievers not significantly different from the OECD average
(light blue)	Countries/economies with a mean performance/share of top performers **below** the OECD average Countries/economies with a share of low achievers **above** the OECD average

		Mean score in PISA 2015			**Share of top performers in at least one subject (Level 5 or 6)**	**Share of low achievers in all three subjects (below Level 2)**	**Remark:** (order of the means of other countries within the same colored zone)
		Mean			**%**	**%**	
		Sc	REA	MAT			
Compared to OECD mean	OECD mean	**493**	**493**	**490**	**15.3**	**13.0**	
1	Singapore	556	535	564	39.1	4.8	8 to 25: Viet Nam ,Hong Kong (China), B-S-J-G (China) , Korea , New Zealand , Slovenia, Australia, United Kingdom, Germany, Netherlands, Switzerland, Ireland, Belgium, Denmark , Poland , Portugal , Norway
2	Japan	538	516	532	25.8	5.6	
3	Estonia	534	519	520	20.4	4.7	
4	Chinese Taipai	532	497	542	29.9	8.3	
5	Finland	531	526	511	21.4	6.3	
6	Macao (China)	529	509	544	23.9	5.1	
7	Canada	528	527	516	22.7	5.9	
26	USA	496	497	470	13.3	13.6	29 to 32: Sweden , Czech Republic, Spain, Latvia
27	Austria	495	485	497	16.2	13.5	
28	France	495	499	493	18.4	14.8	
33	Russia	487	495	494	13.0	7.7	34 to 47: Luxembourg, Italy, Hungary, Lithuania, Croatia, CABA (Argentina), Iceland, Malta, Slovak Republic, Greece, Chile, Bulgaria
48	UAE	437	434	427	5.8	31.3	49 to 50 **Uruguay , Romania**
51	Cyprus	433	443	437	5.6	26.1	52 to 53 **Moldova Albania**
54	Turkey	425	428	420	1.6	31.2	55 to 57 Trinidad and Tobago, Thailand and Costa Rica
58	Qatar	418	402	402	3.4	42	59 to 62: Colombia, Mexico, Montenegro Georgia
63	Jordan	409	408	380	0.6	35.7	64 to 66: Indonesia Brazil Peru
67	**Lebanon**	**386**	**347**	**396**	**2.5**	**50.7**	
68	Tunisia	386	361	367	0.6	57.3	69 to 70 : FYROM Kosovo
71	Algeria	376	350	360	0.1	61.1	72 Dominican Republic

The following is a snapshot of performance in science, reading, and mathematics

The mean score for a domain for OECD countries is the benchmark against which each country's domain performance is compared. The easiest way to summarize student performance and compare countries' relative standing in domain performance is through the mean performance score of students in each country.

Level 2 is considered to be the baseline level of the domain proficiency that defines the level of achievement, on the PISA scale, at which students begin to demonstrate the domain competencies that will enable them to participate effectively and productively in life situations.

Comparison of the mean score of science, reading, and mathematics, in Lebanon with the OECD average mean score is as follows (see Figure 1.8):

- The difference between Lebanon's mean score in scientific literacy and the OECD average mean score in science is (493- 386) = 107
- The difference between Lebanon's mean score in reading literacy and the PISA mean score in reading literacy is (493- 347) = 146
- The difference between Lebanon's mean score in math literacy and the PISA mean score in math literacy is (490- 396) = 94.

So, the students' performance was the highest in mathematical literacy followed by scientific literacy, and it was the least in reading literacy.

Comparison of the high and low performers in Lebanon to that of OECD in general and different countries in specific.

- 2.5% of the students in Lebanon achieved level 5 or 6 (best performers) in one of the subjects. This is less than the average percentage of OECD students which is 15.3%. (The results are higher than Turkey 1.6%, Jordan and Tunisia 0.6%, and Algeria 0.1%, but lower than UAE 5.8%, Cyprus 5.6%, and Qatar 3.4%).

According to the **International PISA Report** (OECD, 2016), less than 0.5 % of the students are top performers in Science. Approximately 2.5% of the high performers in PISA 2015, in Lebanon, earned those grades in reading and math (less than 1% in the reading domain and approximately 2% in the mathematics domain) (Figure 1.8).

- **However**, 50.7% of the students, in Lebanon, proved to be low achievers in all of the three subjects, i.e. below proficiency level 2. The percentage of these low achievers, compared to OECD average, is more than those in UAE 31.3%, Turkey 31.2%, Cyprus 26.1 % Jordan 35.7 %, but less than Tunisia 57.3% and Algeria 61.1%.

1.9 What will the rest of the report contain?

Chapter 2 will be about the performance of students, in Lebanon, in science literacy; it starts with introducing this literacy area; after that, this scientific literacy will be compared to the scientific component as found in the Lebanese curriculum. Then, the science scores of students will be shared, in general, and compared to neighbouring countries after which the students' scores will be scrutinized per grade, gender, region, and school type. Next, students' attitudes towards science will be visited. The chapter will end with remarks concerning this literacy area. As a reminder, this chapter is the one that has been elaborated the most because the PISA 2015 test focused on sciences.

Chapter 3 will be about the performance of students in math literacy; similar to

Chapter 2, the meaning of math literacy and its elements will be discussed; moreover, the math literacy framework will be compared to the math component in the Lebanese curriculum. At that point, the scores of students will be shared in general and compared to neighbouring countries after which the students' scores will be scrutinized per grade, gender, region, and school type. This will be followed by a thorough exploration of results.

Chapter 4 will be about the performance of students in reading literacy. When it comes to this literacy area and after introducing it, the framework will be compared to the content of this component in both English and French, since students were tested according to the first foreign language that they are being taught at school. This distinction will mark this whole chapter as the performance of students is discoursed, in general, and compared to neighbouring countries after which the students' scores will be scrutinized per grade, gender, region, and school type. Similar to the previous chapters, this part will conclude with inspecting the achieved results in light of all the challenges that affected this literacy area.

Chapter 5 will be a concise conclusion meant to inform the public and the policy makers about what can be done to thrust the education sector forward towards a student centred approach that can empower the youth in a constantly changing world.

The following chapters will address each literacy area on its own whilst highlighting curriculum related areas that might be taken into consideration in the imminent official Lebanese curriculum.

Chapter 2

Students' performance in science literacy

Science education in primary and secondary schools should ensure that by the time students leave school, they can understand and engage in discussions about the science and technology-related issues that shape our world.

Most current curricula for science education are designed on the premise that an understanding of science is so important that the subject should be a central feature in every young person's education (OECD, 2016b).

The latest PISA assessment in 2015 focused on science as discipline. The skills and knowledge are examined through students' responses on test items, but the students' attitudes, beliefs, and values are examined through students' responses to questions in the student questionnaire.

This chapter is intended to answer the following questions.

2.1 What is meant by science literacy?

2.2 How does the scientific literacy framework compare to the scientific component of the Lebanese curriculum?

2.3 What were the scores of the students, in Lebanon, in this literacy area?

2.4 What were the attitudes of students concerning science?

2.5 What are the major remarks?

2.1 Scientific literacy introduction

Through the PISA lens, scientific literacy is "the ability to engage with science related issues, and with the ideas of science, as a reflective citizen" (OECD, 2016, p.13). Therefore from what precedes, today's youth are expected to be savvy in both science and technology in order to accompany the continuous changes affecting how humans are reasoning, reflecting, and living. As such, scientific literacy emerges as one of the pillars that shapes how the young people understand and make use of science in their daily lives to achieve higher goals (Rychen, & Salganik, 2003, as cited in OECD, 2016). And this was the focal literacy area in the 2015 test, as said before.

For this literacy area to become a reality in students' lives, they have to acquire certain competencies like being able to explain any situation scientifically while evaluating and designing a scientific scheme built on enquiry at the cognitive level. This will allow them to interpret information based on sound scientific evidence.

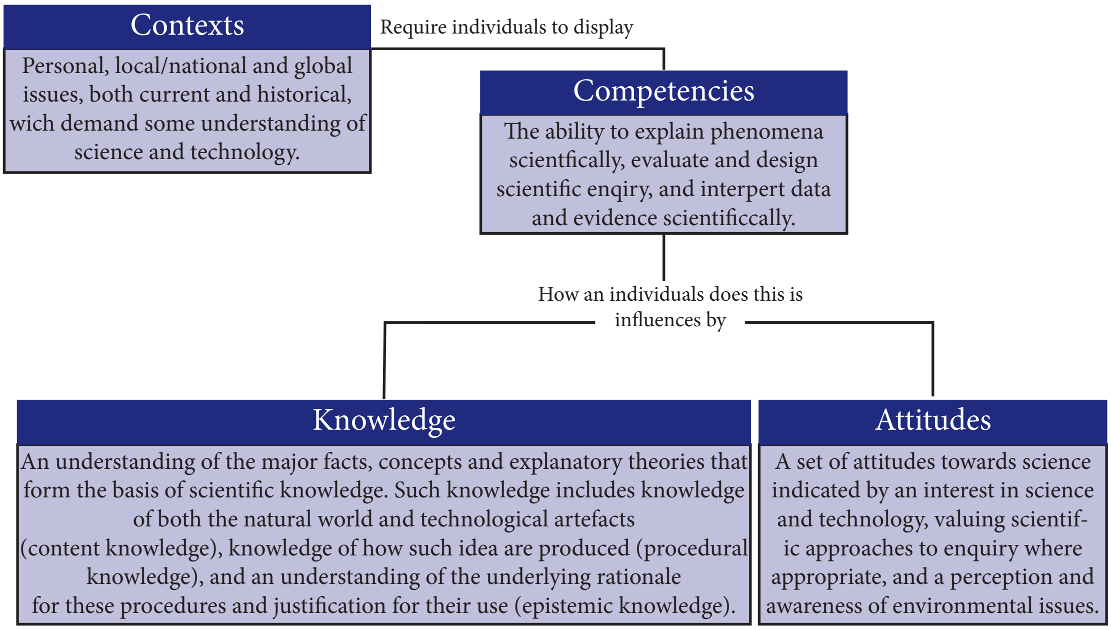
Once students acquire the previously mentioned competencies, they will interpret this in their attitudes and knowledge. In other words, they will become more interested in science and scientific approaches, and they will subsequently develop "environmental awareness". As for their knowledge, it will expand beyond content to become applicable in everyday life via procedures, and this will enhance their theoretical knowledge as well.

Henceforth, this is what scientific literacy is about. Figure 2.1 summarizes the already mentioned scientific literacy aspects and Figure 2.1a clarifies the interrelation among those aspects (OECD, 2016).

Figure 2.1 Aspects of the scientific literacy assessment framework for PISA 2015

Contexts	Personal, local/national and global issues, both current and historical, wich demand some understanding of science and technology.
Knowledge	An understanding of the major facts, concepts and explanatory theories that form the basis of scientific knowledge. Such knowledge includes knowledge of both the natural world and technological artefacts (content knowledge), knowledge of how such idea are produced (procedural knowledge), and an understanding of the underlying rationale for these procedures and justification for their use (epistemic knowledge).
Competencies	The ability to explain phenomena scientfically, evaluate and design scientific enqiry, and interpert data and evidence scientificcally.
Attiudes	A set of attitudes towards science indicated by an interest in science and technology, valuing scientific approaches to enquiry where appropriate, and a perception and awareness of environmental issues.

Figure 2.1a Aspects of the science assessment framework for PISA 2015



After this scientific progression, students will manifest what they have acquired in their personal, local, national, and global contexts. PISA claims that they assess knowledge contexts that are relevant to the national curricula of participating countries; however, as far as Lebanon was concerned this was not the case. Figure 2.1b represents the "scientific literacy" contexts reflected in the assessment.

Figure 2.1b Contexts in the Pisa 2015 scientific literacy assessment

	Personal	Local/National	Global
Health and disease	Maintenance of health, accidents, nutrition	Control of disease, social transmission, food choices, community health	Epidemics, spread of infectious diseases
Natural resources	Personal consumption of materials and energy	Maintenance of human populations, quality of life, security, production and distribution of food, energy supply	Renewable and non-renewable natural systems, population growth, sustainable use of species

	Personal	Local/National	Global
Environ-mental quality	Environmentally friendly actions, use and disposal of materials and devices	Population distribution, disposal of waste, environmental impact	Biodiversity, ecological sustainability, control of pollution, production and loss of soil/biomass
Hazards	Risk assessments of lifestyle choices	Rapid changes (e.g. earthquakes, severe weather), slow and progressive changes (e.g. coastal erosion, sedimentation), risk assessment	Climate change, impact of modern communication
Frontiers of science and tech-nology	Scientific aspects of hobbies, personal technology, music and sporting activities	New materials, devices and processes, genetic modifications, health technology, transport	Extinction of species, exploration of space, origin and structure of the universe

Further, PISA 2015 split the scores of students in science into proficiency levels to provide a clearer scale that participating countries can refer to as found in Figure 2.1c.

Figure 2.1c Scientific literacy proficiency levels (OECD, 2016, pp. 42-43)

Proficiency levels and scale scores	Task description
Level 6 Score > 707.93	At Level 6, students are able to use content, procedural and epistemic knowledge to consistently provide explanations, evaluate and design scientific enquiries, and interpret data in a variety of complex life situations that require a high level of cognitive demand. Level 6 students consistently demonstrate advanced scientific thinking and reasoning requiring the use of models and abstract ideas and use such reasoning in unfamiliar and complex situations. They can develop arguments to critique and evaluate explanations, models, interpretations of data and proposed experimental designs in a range of personal, local and global contexts.
Level 5 633.33 < score < 707.93	At Level 5, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a variety of life situations in some but not all cases of high cognitive demand. Level 5 students show evidence of advanced scientific thinking and reasoning requiring the use of models and abstract ideas and use such reasoning in unfamiliar and complex situations. They can develop arguments to critique and evaluate explanations, models, interpretations of data and proposed experimental designs in some but not all personal, local and global contexts.

Proficiency levels and scale scores	Task description
Level 4 **558.73 < score < 633.33**	At Level 4, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a variety of given life situations that require mostly a medium level of cognitive demand. Level 4 students show evidence of linked scientific thinking and reasoning and can apply this to unfamiliar situations. Students can also develop simple arguments to question and critically analyse explanations, models, interpretations of data and proposed experimental designs in some personal, local and global contexts.
Level 3 **484.14 < score < 558.73**	At Level 3, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in some given life situations that require at most a medium level of cognitive demand. Level 3 students show some evidence of linked scientific thinking and reasoning, usually applied to familiar situations. Students can develop partial arguments to question and critically analyse explanations, models, interpretations of data and proposed experimental designs in some personal, local and global contexts.
Level 2 **409.54 < score < 484.14**	At Level 2, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in some given familiar life situations that require mostly a low level of cognitive demand. They are able to make a few inferences from different sources of data, in few contexts, and can describe simple causal relationships. They can distinguish some simple scientific and non-scientific questions, and distinguish between independent and dependent variables in a given scientific enquiry or in a simple experimental design of their own. They can transform and describe simple data, identify straightforward errors, and make some valid comments on the trustworthiness of scientific claims. Students can develop partial arguments to question and comment on the merits of competing explanations, interpretations of data and proposed experimental designs in some personal local and global contexts.
Level 1a **334.94 < score < 409.54**	At Level 1a, students are able to use a little content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a few familiar life situations that require a low level of cognitive demand. They are able to use a few simple sources of data, in a few contexts and can describe some very simple causal relationships. They can distinguish some simple scientific and non-scientific questions, and identify the independent variable in a given scientific enquiry or in a simple experimental design of their own. They can partially transform and describe simple data and apply them directly to a few familiar situations. Students can comment on the merits of competing explanations, interpretations of data and proposed experimental designs in some very familiar personal, local and global contexts.

Proficiency levels and scale scores	Task description
Level 1b 260.54 < score < 334.94	Students can use basic or everyday scientific knowledge to recognize aspects of familiar or simple phenomenon. They are able to identify simple patterns in data, recognize basic scientific terms and follow explicit instructions to carry out a scientific procedure. At Level 1b, students demonstrate a little evidence to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a few familiar life situations that require a low level of cognitive demand. They are able to identify straightforward patterns in simple sources of data in a few familiar contexts and can offer attempts at describing simple causal relationships. They can identify the independent variable in a given scientific enquiry or in a simple design of their own. They attempt to transform and describe simple data and apply them directly to a few familiar situations.

Therefore and from what precedes, the students, in Lebanon, were being assessed according to certain criteria that have never been applied before in the Lebanese context. The following comparison further elucidates this issue.

2.2 Science literacy framework vis-à-vis the scientific component in the Lebanese curriculum

The PISA 2015 framework views the scientifically literate learner as a person endowed with a set of skills whereby he/she is influenced by both by: the knowledge of science and the attitudes towards science, and all these are utilized to solve problems related to real life situations that mainly impact the citizens' economic and social lives at the individual and national levels, as well as at the global level, such as taking medications, adopting a healthy life in terms of nutrition and exercising, leading a hygiene oriented existence devoid of parasites, intelligently selecting equipment that is friendly to the environment, and making other wise choices in different life aspects that clearly show that science is pervasive in all aspects in our lives; science even interferes in personal issues, such as maintaining a healthy diet, to local issues, such as how to manage waste in big cities, to more global and far-reaching issues, such as the costs and benefits of genetically modified crops, or how to prevent and mitigate the catastrophic consequences of global warming.

So, Science education in primary and secondary school should ensure that by the time students leave school they can understand and engage in discussions about science and technology-related issues that shape our world (OECD, 2016b).

The national science curriculum, as presented by Curriculum decree n⁰ 10227 date 08-05-1997, views the scientific learner as a researcher who is capable of constructing his/her personal knowledge in a world characterized by rapid expansion of science and technology. This curriculum aimed at providing the learner with chances to build their understanding of the main concepts and scientific principles and its relation to every day's life at the global level in the domains of health, environment, technology and ethics. These concepts and scientific principles should be mastered by following the scientific method pedagogy, the techniques of communication, and the transfer of knowledge.

So, both visions aim at preparing citizens who are able to relate what they acquire in sciences to real life situations in a rapidly changing world, and both are after promoting life-long learning.

However, unlike PISA2015

- the Lebanese sciences curricula are limited to the learner as a constructor of his/her knowledge and barely approach attitudes related to solving problems that influence his/her economic and social life at the individual level;
- moreover, the Lebanese sciences curricula approach only the concepts and scientific principles at the global level.

And unlike the sciences national curricula, PISA2015

- doesn't limit or imprison sciences in the science classrooms and labs (not just test tubes, periodic tables, genetic codes,…), but it originates from real life contextual problems that proceed from how to interact and manage the use of daily tools and how to take wise decisions that protect us in our daily lives in real life contexts;
- doesn't consider the learner as a producer of scientific knowledge like the scientist, but rather it envisions the learner as an/a:
- inquirer who "thinks like a scientist" to weigh the situations facing him/her and to be able to collect evidence and come up with decisions while being aware that the "truth" may change over time, due to the rapid changes in society, and this requires greater understanding of this changing world that is influenced by the natural forces and technology's capacities and limitations.
- literate citizen who likes to be informed about scientific knowledge and can be a critical user of this knowledge.

2.2.1 Goals of teaching and assessment of sciences in PISA 2015 vs. sciences in the national curriculum

PISA 2015 aims not only at assessing what students know in sciences, but also what they can do with what they know and how they can creatively apply scientific knowledge to real-life situations (OECD, 2016). The PISA framework's design presents the interaction between four aspects (see Figure 2.1a) that form the matrix for constructing test items tackling real life problem situations at the personal, local/national, or even at the global level in different contexts which demands understanding in science and technology. These contexts are: health and diseases, natural resources, environmental quality, hazards, as well as frontiers of science and technology. This is different from the national sciences curriculum that owns a thematic based design (Appendix B).

As found in Figure 2.1, the framework of scientific literacy shows that for students to be able to answer the set of questions included in these items successfully, they should be competent in utilizing a set of competencies which are to:

- explain phenomena scientifically,
- evaluate and design scientific inquiry,
- interpret data and evidence scientifically.

Furthermore, students' performance in these competencies is affected by:

- students' knowledge at the content, procedural, and epistemic level;

- students' attitudes towards learning sciences such as their interest in sciences, valuing the scientific approaches to inquiry, and their environmental awareness.

On the other hand, the national sciences curricula, as presented in decree n⁰ 10227 date 8-05-1997, were not clear enough in presenting the relationship between the general objectives of science education, the themes and their corresponding content knowledge in the scope and sequence document, and later on in the educational material that described the content of the subjects' curricular objectives and their relation with the assessment system description presented in circular 45/M/98 and the accompanying assessment guide elaborated in 1999. The scope and sequence in each of the science subjects were built in a thematic way, considering pure scientific concepts rather than real life contexts, and the sequence showed interruptions of different themes away from constructivism in cycle 3 and the secondary cycle.

At the level of the goals of the National Curriculum, the discrepancy lies in the fact that when probing into the general objectives of the national sciences curricula, one can realize how much they are advanced concerning the targeted knowledge, skills, and attitudes in such a way that they approach the twenty first century demands at the cognitive level as well as at the affective level, similar to what is tackled in the PISA 2015 framework; this means that, **the introduction of the national sciences curricula in 1997 considered the same under-assumptions regarding the needs of citizens in the developing world, as mentioned previously in the vision, as those considered by PISA 2015 framework.** From this perspective, the new international and global tendencies towards science teaching have been the main inspiration during the preparation of the national science curriculum since 1997, in Lebanon, and that called for adopting pedagogical innovations that favor the mastering of the scientific method, the techniques of communication, and the transfer of knowledge where all should be aligned with the assessment. But did this happen? **Were the sciences curricula able to develop inquirers and long life learners as they were intended?**

Therefore, a comparison of what is intended by the general objectives in the Lebanese national sciences curricula can be made in view of the four aspects of the PISA framework in order to explore the underlying assumptions that might be behind the low performance of the learners in PISA 2015 whilst revealing the gaps for the sake of bridging them during the development of national sciences curricula and sciences education in the right way.

By probing the general objectives of science education in the sciences curricula (Appendix C), one can realize the intentions or aims of scientific literacy, as described in PISA2015, which are not very far from those intended in the national sciences curricula. However, are all these general objectives mirrored in the final teaching-learning material adopted in schools?

- By reviewing the content of the science books, it is obvious that objectives 4, 5, 6, and 7 were well mirrored and explicitly covered in the sciences national text books.

- Other general objectives were handled with less rigor, in the national science books, and teachers focused only on the explanation of theories and phenomena with shy attempts to relate them to real life situations; besides that, the students did not even practice effectively in the lab or in any other context. These objectives were 1 and 9.

- The rest of the objectives (9 objectives) are barely covered in the science text books and might appear as examples at the end of the chapter or in the introduction of chapters without being emphasized. Most of these objectives are related to students' attitudes and ethics towards the aim of learning sciences and its relation to society.

At the level of assessment approach, the approach, as clarified in the circular 45/M/98, aimed not only at focusing on the grade (mark) as an indicator to appraise students' performance, but it also targeted the acquisition of skills and attitudes relevant to certain situations as two inseparable complementary entities that go hand in hand during the teaching learning process. The evaluation system, at that time, was a significant step in developing the new curricula by not only assessing information, but it went beyond that to use information and invest it for further knowledge building to attain the required competencies in different domains. However, the interpretation of transversal competencies, in the different domains/ subjects/ disciplines, are different. For example, a competency might belong to one domain in one subject but to a different domain in another subject. The requirements, or descriptions, or indicators for the acquisition of different competencies vary from one subject to another. We can see different domains and different distribution of competencies in Life Sciences on one hand, and in Physics and Chemistry on the other hand (Appendix D). Moreover, the domain including competencies related to the lab activities is suspended and not assessed in the official exam, based on the **decision n⁰666 date 2000**. Since the assessment of lab work is suspended in official exams, the students are not developing many of the competencies related to it in in all sciences and especially in life sciences.

When comparing the competencies related to PISA 2015 and those related to different domains of assessment in the national sciences assessment system (Appendix D: Tables 1, 2, and 3), we found that the scientific competencies adopted by PISA 2015 are presented along with the measurable descriptions of the kinds of performances expected to be displayed by students. These competencies are written in a measurable way (in the form of action verbs) since they reflect science as a group of life skills and social and epistemic practices that can be performed by learners, which are common across all sciences (National Research Council, 2012).

By comparing the competencies recommended in PISA to those recommended in the national assessment system in Life Sciences, Physics, and Chemistry, we can deduce the following:

- for the competency, "**explain phenomena scientifically**", the students in Lebanon are trained in all sciences to recall and apply appropriate scientific knowledge and to make and justify appropriate predictions. However, they are not trained to explain the potential implications of scientific knowledge for society, and they are barely trained to offer explanatory hypotheses in text books as well as national exams. Additionally, in physics and chemistry they are more trained on the use and generation of explanatory models and representations than in Life sciences;
- for the competency, "**evaluate and design scientific enquiry**", the learners in Lebanon are trained on how to identify the question explored in a given scientific study covered in life science but not in physics and chemistry. They are trained somehow on how to propose a way of exploring a given question

scientifically and how to describe and evaluate a range of ways that scientists use to ensure the reliability of data and the objectivity and generalizability of explanations in physics and chemistry, but not in life sciences. However, in all science subjects they are not trained on how to distinguish questions that can be scientifically investigated, and they are neither skilled in evaluating ways of exploring a given question scientifically nor well trained on distinguishing different types of measurement (qualitative and quantitative, categorical and continuous). Likewise, they are not trained on treating data associated with differing degrees of certainty, depending on the nature and quantity of empirical evidence that has accumulated over time;

- for the competency, "**interpret data and evidence scientifically**", the students in all subjects, life science, physics, and chemistry, are trained on how to transform data from one representation to another, how to analyse and interpret data, and how to draw appropriate conclusions and identify the assumptions, evidence, and reasoning in science-related texts. Nevertheless, they are not well trained on how to distinguish between arguments which are based on scientific evidence and theory and those based on other considerations. The students are barely trained on how to evaluate scientific arguments and evidence from different sources (e.g. newspaper, internet, journals) in life sciences, but they do not do so in physics and chemistry.

So, we can consider that the competencies intended in PISA 2015, which were not in all 3 science subjects in Lebanon, are 5 out of 15:

- explain the potential implications of scientific knowledge for society,
- distinguish between arguments which are based on scientific evidence and theory and those based on other considerations;
- evaluate scientific arguments and evidence from different sources (e.g. newspaper, internet, journals);
- distinguish questions that are possible to investigate scientifically;
- evaluate ways of exploring a given question scientifically;

The competencies which are poorly covered are 3 out of 15, and they are mostly present in the domains of experimental work in the Lab and in relation to real life situations and attitudes. These are:

- identify, use, and generate explanatory models and representations;
- offer explanatory hypotheses;
- propose a way of exploring a given question scientifically.

2.2.2 Comparison of the required knowledge in the sciences national curricula and that required by PISA2015 in the different contexts

Three types of knowledge are considered by the framework of PISA2015 which are content knowledge, procedural knowledge, and epistemic knowledge.

Content knowledge

The content knowledge to be assessed in PISA 2015 belongs to the systems: physics, chemistry, biology, earth and space sciences. Content knowledge here is limited to the understanding of the major explanatory ideas, theories, and phenomena in the natural world, such as our understanding of the history and scale of the universe, the particle model of matter, and the theory of evolution by natural selection, and their application, and these have to be acquired by the age of 15. The targeted scientific phenomena are those that are related to real life situations and aligned with the cognitive level of the 15 year old child. They are tackled at the personal, local/ national, and global contexts. As mentioned previously, the citizens have to understand concepts from different contexts that require physical and life sciences and earth and space sciences, where the elements of knowledge are interdependent or interdisciplinary. As explained previously, this is different from what is adopted in the Lebanese curriculum which is based on thematic content in separate domains of sciences: physics, chemistry, and life science where there is minimal content of earth and space science.

In spite of this, it is worth it to compare the content knowledge required in PISA 2015 to that present in the national science curricula (Appendix F: Tables 1, 2, 3 and 4). The content knowledge required by PISA is highly represented in the chemistry and physics curricula text books, but not in the contexts defined by PISA, as previously mentioned. So, the students are familiar with concepts related to these subjects. Conversely, the content related to life science which includes environmental science is less alligned with that required by PISA, especially when talking about the environmental issues related to population and demography. When comparing the content related to the six different contexts of scientific literacy adopted by PISA, in the three domains biology, earth and space science, and physical sciences, it is realized that the content related to environmental quality, hazards, and frontiers of science and technology is poorly covered in life science and physics and chemistry, except that the quality of the environment is tackled in chemistry by a number of objectives, yet they were all suspended in 2016. Natural resources are well covered in life science and chemistry, but the objectives related to them were suspended in life science till 2016, and re- suspended in chemistry in 2016. Also, due to time constraints, students are not taught the aforementioned material. This means that 50% of the content required in sciences is barely covered by the curriculum, and therefore reflected in the national science books. The health and disease context is covered at the level of the living system and immunology and nutrition; the latter was reintegrated into the curriculum in 2016, and only a few ideas are discussed about the spread of epidemic diseases in the community like populations, ecosystems, and biosphere related topics.

Procedural knowledge

Procedural knowledge (Appendix G) is the knowledge of the standard procedures used by scientists to obtain reliable and valid data. It undertakes scientific enquiry and engages in critical review of evidence that might be used to support particular claims. Procedural knowledge allows students to know that scientific knowledge is not absolute but can be fallible, and further it has differing degrees of certainty associated with it especially when it comes to the confidence that accompanies the measurement of data. Nevertheless, it is not covered in the sciences curriculum, in Lebanon, except for the steps of the scientific method.

Epistemic knowledge

Epistemic knowledge (Appendix H) goes beyond the content already prepared and the empirical inquiry standards followed during procedural knowledge to expand the horizon of students' thoughts through critical thinking questions. Such types of knowledge are very weakly reflected in the science curriculum, textbook, and assessment tasks.

So, the most prominent feature that imprints the PISA 2015 framework is that it shows no limits between the three domain specific competencies and the three types of knowledge. The national science curricula in the domain of reasoning in Life Science and in Life and Earth Subjects inhibited the usage of knowledge acquired by students, and limited only the students' answers to the information and data given in the exercise. However, this is not the case in physics and chemistry. Moreover, the knowledge domain focused on content knowledge only, with little attention given to procedural and minimal attention given to epistemic knowledge.

This shows that the national sciences curricula don't clearly show this harmony between the competencies and the required knowledge. The decree n^{0} 10227 date 8-05-1997 focused on the content that has to be included in all subjects following thematic organization. This decree was followed later on by the decision 666/m/2000 which is about the organization of school assessment throughout the academic years, in accordance with the new curricula, in public schools.

In conclusion, the PISA science assessment assesses competencies and knowledge in specific contexts (OECD, 2016); whereas, the Lebanese curriculum presents a set of independent cognitive objectives that focus on content regardless of context, and this is where efforts should be invested. These objectives are translated into activities in the book which emphasize content and procedural knowledge with shy attempts of practical implications.

What is more, the assessment in PISA does not just ascertain whether students can reproduce knowledge; it also examines whether students can extrapolate from what they have learned and can apply that knowledge in unfamiliar settings, both inside and outside of school. This approach reflects the fact that modern economies reward individuals not for what they know but rather for what they can do with this knowledge. On the other hand, the Lebanese assessment approach focuses more on content (more at the level of physics and chemistry rather than in biology which tends to contextualize the knowledge a step further as compared to physics and chemistry).

2.3 Students' achievement in science literacy

2.3.1 Comparison by countries' averages

The mean score of OECD is 493.5, in the range of proficiency level 3, while that of Lebanon is 386 which is 1a proficiency level and 107 points lower than OECD average. UAE scored the closet score to OECD's average with a difference of 56 points, and it lies at proficiency level 2 which is the base line of scientific proficiency, and its median is at 431 which means that 50% of students in UAE got scores lower than 431 which is 6 points less than average. Then, comes the mean scores of Cyprus (433) and Turkey (425) that are lower than that of OECD's average by 60 and 68 respectively, and both countries also lie in the range of the proficiency level 2. Next, there is Qatar with a mean score that is 75 points less than OECD's average with level 2 proficiency; it is followed by Jordan. Its mean score is 84 points less than OECD's average where the proficiency level is 1a. Finally, Lebanon and Tunisia have similar scores; in other words they are 107 points below the OECD average which is the farthest from OECD's average, and their proficiency is level 1a. So, Jordan, Lebanon and Tunisia's average lie below the baseline of proficiency in science (Figure 2.3.1).

Figure 2.3.1 The mean score and variation in science performance in some neighbouring countries

	Mean Score	Standard deviation	Percentile						
			5th	10th	25th	Median 50th	75th	90th	95th
Singapore	556 (1.2)	104 (0.9)	373 (3.7)	412 (2.8)	485 (2.2)	564 (1.6)	631 (1.8)	683 (2.2)	712 (3.1)
OECD Average	493 (0.4)	94 (0.4)	336 (1.3)	368 (0.6)	426 (0.6)	495 (0.5)	561 (0.5)	615 (0.5)	645 (0.6)
UAE	437 (2.4)	99 (1.1)	284 (3.3)	312 (2.8)	364 (2.8)	431 (3.1)	505 (3.2)	571 (3.2)	608 (3.0)
Cyprus	433 (1.4)	93 (1.2)	286 (2.9)	314 (2.5)	365 (2.1)	429 (2.0)	497 (2.2)	557 (2.8)	590 (4.1)
Qatar	418 (1.0)	99 (0.7)	268 (1.9)	295 (1.8)	344 (1.3)	410 (1.4)	486 (2.1)	554 (1.9)	589 (2.4)
Turkey (OECD)	425 (3.9)	79 (1.9)	301 (3.8)	325 (3.5)	368 (3.7)	421 (4.9)	482 (5.5)	532 (6.1)	560 (5.7)
Jordan	409 (2.7)	84 (1.6)	268 (5.2)	299 (3.8)	351 (3.4)	410 (3.1)	468 (3.0)	517 (3.4)	544 (3.5)
Lebanon	386 (3.4)	90 (1.8)	249 (4.6)	276 (3.9)	322 (3.6)	379 (4.2)	446 (5.1)	511 (4.9)	545 (5.2)
Tunesia	386 (2.1)	65 (1.6)	287 (3.1)	306 (2.6)	341 (2.2)	382 (2.5)	428 (2.5)	472 (3.8)	500 (5.3)
Algeria	376 (2.6)	69 (1.5)	268 (3.4)	291 (3.3)	329 (2.5)	373 (2.5)	419 (3.2)	465 (4.5)	496 (6.1)

legend	P.L <1b	P.L 1b	P.L 1a	P.L 2	P.L 3	P.L 4	P.L 5	PL6	

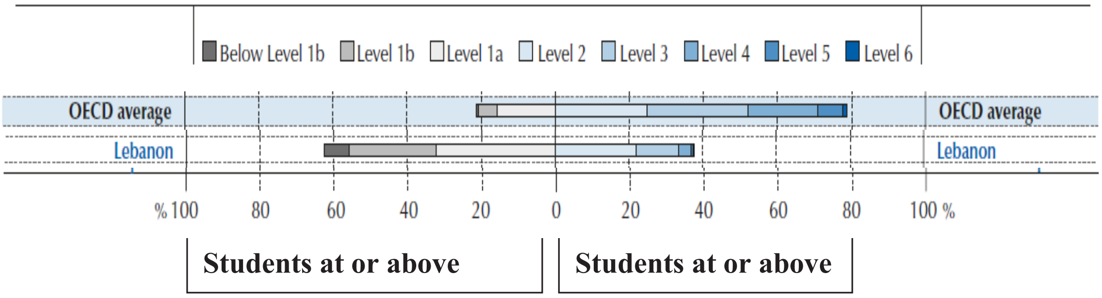
Figure 2.3.1 reveals that:

- The percentage of students that exceeded **the science proficiency base line** (P.L.2) are found in:
  - Singapore (90%) or 412 points above OECD average,
  - OECD countries (75%); they scored higher than 426,
  - UAE, Qatar, Jordan, Cyprus, and Turkey (50%) got scores higher than 431, 410, 410, 429, and 421 respectively,
  - Lebanon, Tunisia, and Algeria (25%) got scores higher than 446, 428, and 419 respectively.
- Only in Lebanon's case, the data revealed that 5% of its students scored below 276, and thus below level b.
- Only Singapore has 10% of its students who are high performers; they obtained scores between 683 and 712 (P.L 5 and P.L 6 respectively). In contrast, 10 % of OECD's students scored between 615 and 645 (P.L 4 and P.L 5) respectively, and they did not reach P.L. 7. Other countries in the table did not include high performers.
- As far as UAE is concerned, 90% of its students scored lower than 571 (P.L4), 75% lower than 505 (Level 3), 50% lower than 431 (Level2); thus only 10% in UAE reached level 4.
- Cyprus, Qatar, and Turkey (90%) scored below 557, 554, and 532 (P.L3) , and 95% of students in Cyprus, Qatar, and Turkey, scored lower than 590, 589, and 560(P.L4). All in all, 10% of the population reached P.L.3 with 5% of them reaching PL4.
- Only 10% of students in Jordan and Lebanon scored higher than 517 and 511 respectively, and thus 10% of the population reached P.L.3.
- Only 5% of students in Tunisia and Algeria scored higher than 500 and 495 respectively, and thus 10% of the population reached P.L.2, with 5% of them reaching P.L 3.
- In Lebanon, 62.7% of students performed poorly in scientific literacy (6.8% scored below level 1 b; 23.6% were at level 1b, and 32.3 % scored at level 1 a).

Moreover, **Figure 2.3.1a reveals Lebanon's results as compared to OECD and which are summarized in the following table:**

Proficiency Level	Range	Lebanon%	OECD%	
<1b	<261	7		63% Below proficiency level
1b	261 <335	24	5	
1a	335 <410	32	16	
2	**410 <484**	**22**	**25**	**38% Above proficiency level**
3	484 < 559	12	27	
4	599 < 633	3.3	19	
5	633 < 708	0.4	7	
6	> 708	0	1.1	

Figure 2.3.1 Students' proficiency in science



This means that in Lebanon:

- **6.8 % of students were low performers or below level 1b** (scored less than 261 points). These students may have acquired some scientific notions, but based on the tasks included in the PISA test, their ability can only be described in terms of what they cannot do.

- **23.6% of students** scored at proficiency **level 1b** (scored greater than 261 but lower than 335 points), **which is higher than 4.9% of** students in OECD countries. As an inference, they can use common content knowledge to recognize aspects of simple scientific phenomena. They can identify simple patterns in data, recognize basic scientific terms, and follow explicit instructions to carry out a scientific procedure.

- **32.3% of students** performed at **level 1a** (scored higher than 335 but lower than 410 points), **which is greater tha**n 15.7% of students **of OECD countries**. These students can use common content and procedural knowledge to recognize or identify explanations of simple scientific phenomenon. With support, they can undertake structured scientific enquiries with no more than two variables. They can identify simple causal or correlational relationships and interpret graphical and visual data that require a low level of cognitive ability. Students at level 1a can select the best scientific explanation for given data in familiar personal, local, and global contexts.

- **38% of students performed above the literacy baseline** (22% at level 2, 11.6% at level 3, 3.3 % at level 4, 0.4% at level 5, and 0% at level 6).

This means that:

- **22% of these students** performed **at proficiency level 2** (scored higher than 410 but lower than 484 points) which is slightly less than the OECD average percentage (24.8%), and this proficiency level is considered the baseline level of scientific literacy that is required to engage in science-related issues as a critical and informed citizen. Indeed, the baseline level of proficiency defines the level of achievement on the PISA scale at which students begin to demonstrate the science competencies that will enable them to participate effectively and productively in life situations related to science and technology.

- **11.6% of these students scored at proficiency Level 3 (scored higher than 484 but lower than 559 points) which** is less than the OECD average percentage (27.2%). These students can use moderately complex content knowledge to identify or construct explanations of familiar phenomena. In less familiar or more complex situations, they can construct explanations with relevant cueing or support. They can deploy elements of procedural or epistemic knowledge to carry out a simple experiment in a constrained context. Level 3 students are able to distinguish between scientific and non-scientific issues and identify evidence supporting a scientific claim.

3.3 % of students scored at proficiency Level 4 (scored higher than 559 but lower than 633 points) which is less **than** the OECD average percentage (19%). At Level 4, students can use more sophisticated content knowledge, which is either provided or recalled, to construct explanations of more complex or less familiar events and processes. They can conduct experiments involving two or more independent variables in a constrained context. They can justify an experimental design, drawing on elements of procedural and epistemic knowledge. Level 4 students can interpret data drawn from a moderately complex data set or less familiar contexts and draw appropriate conclusions that go beyond the data and provide justifications for their choices.

- **0.4% of students scored at proficiency level 5** (scored higher than 633 but lower than 708 points) **which is less than** the OECD average percentage (6.7%). At level 5, students can use abstract scientific ideas or concepts to explain unfamiliar and more complex phenomena, events, and processes. They can apply more sophisticated epistemic knowledge to evaluate alternative experimental designs, justify their choices, and use theoretical knowledge to interpret information or make predictions. Students, at this level, can evaluate ways of exploring a given question scientifically and identify limitations in interpretations of data sets, including sources and the effects of uncertainty in scientific data.

- **0 % of students scored at proficiency level 6** (scored higher than 708 points) **which is less than** the OECD average percentage (1.1%). Students at Level 6 on the PISA science scale can successfully complete the most difficult items in the PISA science assessment. They can draw on a range of interrelated scientific ideas and concepts from the physical, life, and earth and space sciences and use procedural and epistemic knowledge to offer explanatory hypotheses of novel scientific phenomena, events, and processes that require multiple steps or making predictions. In interpreting data and evidence, they can discriminate between relevant and irrelevant information and can draw on knowledge external to the normal school curriculum.

- They can distinguish between arguments that are based on scientific evidence and theory and those based on other considerations. Level 6 students can evaluate competing designs of complex experiments, field studies or simulations, and justify their choices.

2.3.2 Comparison by grade

Table 2.3.2 reveals that the highest percentage of students was from grade 10 (62.32%), and it is approximately four times that present in grade 9 (16.59%) and approximately 8 times that present in grade 8 (8.29%) and in grade 11(8.98%).

Only 3.71 % belong to grade 7 and a very low percentage of respondents are enrolled in grade 12 (0.13%). The highest mean score is achieved by students in grade 10 (409.32) which barely reached proficiency level 2. This score is greater than that achieved by students in grade 9 by a mean difference of 61.71, and those in grade 8 by a mean difference of 98.8, and those in grade 7 by a mean difference of 113.94, and those in grade 12 by a mean difference of 34.5 and all these differences are statistically significant. However, the mean difference between grade 10 students and grade 11 students is minimal (1.60). This similarity in the latter two mean scores doesn't show any statistical significance.

Most of the knowledge (content knowledge) that is common with the PISA framework is covered by grade 10. Moreover, the students in grade 10 passed the official exams of grade 9 and have been well prepared to answer the questions belonging to different competencies, part of which are common with the PISA competencies, so these competencies get developed year after year. This explains the increase in the mean score from grade 7 to grades 10 and 11. In grade 11, the topics which are covered by the students don't fit with the context and themes covered in PISA 2015 (Molecular Biology, Physics, and Chemistry). The same thing is applicable in grade 12.

Table 2.3.2 Mean score students by grade level

Grade	% of students	Mean Score	Mean Difference	t-value (Refgroup grade 10)
7	3.71	295.39	-113.94	-13.32
8	8.29	310.48	-98.84	-14.61
9	16.59	347.61	-61.71	-9.52
10	**62.32**	**409.32**	**0.00**	-
11	8.98	407.72	-1.60	-0.62
12	0.13	375.08	-34.5	-1.73
Note: bold t-value indicates that the difference is statistically significant.				

2.3.3 Comparison by gender

Table 2.3.3 shows that males performed better than females, at the level of the OECD average (495 mean score of males greater than 491 mean score of females), in science with a gender difference of 4 points, and this difference is statistically significant (OECD, 2016). Similarly, in Lebanon and Tunisia the mean scores of males (388) are greater than that of females (386) and 385 respectively, but this difference is not statistically significant for Lebanon, but it is for Tunisia (OECD, 2016). Yet, in Turkey the mean score of males (422) is less than that of females (429), with no statistical significance. In Algeria, Cyprus, Jordan, Qatar, and the UAE, the mean scores of males are less than females- respectively 369, 424, 389, 406, and 424 less than that of females 383, 441,428, 429, and 449 with statistical significance. (OECD, 2016).

Table 2.3.3 Mean score of males and females	Males	Females	Gender difference (males and females)
OECD Average	**495***	491	4
Turkey	422	429	-6
Algeria	369	**383***	-14
Cyprus	424	**441***	-17
Jordan	389	**428***	-39
Lebanon	388	386	2
Qatar	406	**429***	-33
Tunisia	**388***	385	4
Note: bold font along with a* indicates that the mean score is significantly different from OECD at the five percent level (OECD, 2016).			

2.3.4 Comparison by region

Table 2.3.4 shows that the highest mean score in science is in Mount Lebanon (Beirut suburbs), which is 425.80 and it exceeds proficiency level 2. Since students' performance is the highest in Mount Lebanon Beirut Suburbs, and they achieved proficiency level 2 (OECD, 2016), we will compare their performance to those students in the other regions to find out how far the other regions are from achieving this level. Moreover, the highest percentage of the PISA target population lies in grade 10.

Table 2.3.4 shows that the highest mean score in science is in Mount Lebanon, Beirut suburbs which is 425.8 and it exceeds proficiency level 2. The highest difference in scores exists between Mount Lebanon, Beirut suburbs and that of South (-68.89) and North Lebanon (-67.11) followed by Nabataea (-58.98) and Beqaa (55.65) regions. All these differences are statistically significant.

This difference decreases to become -21.66 when compared to the mean score of schools in Mount Lebanon, without Beirut suburbs (-21.66) and the least when compared to that in Beirut (-20.01) with no statistical significance for both. This gives an indication that students from Beirut Suburbs are achieving the highest mean score with no statistical significance when comparing these differences with Beirut and Mount Lebanon without Beirut suburbs, but with statistical significance when compared to North, Beqaa, South, and Nabataea.

Table 2.3.4 Mean score by regional differences

School Region	Mean Score	Mean Difference	t-value (Ref- group Mount Lebanon -Beirut suburbs)
Beirut	405.78	- 20.01	-1.13
Mount Lebanon (Beirut Suburbs)	425.80	0.00	-
Mount Lebanon (away from Beirut)	404.14	-21.66	-1.51
North	358.69	-67.11	**-7.60**
Beqaa	370.15	-55.65	**-5.90**
South	356.90	-68.89	**-4.19**
Nabataea	366.82	-58.98	**-5.35**
Note: bold t-value indicates that the difference is statistically significant.			

2.3.5 Comparison by educational sector

Table 2.3.5 shows that students in private schools performed much better (418.30) than those in the public schools (353.75), with a mean difference of 64.55 points, and this difference is statistically significant. Moreover, the mean score of private schools reached proficiency level 2 (409.54 < score < 484.14).

Table 2.3.5 Mean score by educational sector

Educational Sector	Mean Score	Mean Difference	t-value (Ref- group private schools)
Public	353.75	64.55	**10.04**
Private	418.30	0	-
Note: bold t-value indicates that the difference is statistically significant.			

When probing more into the data of public and private schools in the different regions in Lebanon Table (2.3.5a) and Table (2.3.5b), it is shown that:

Table 2.3.5a The Mean Score of PISA Population in Lebanon in Public Sectors in Different Regions

School Regions	Mean Score	Mean Difference	t-value (Ref- group Mount Lebanon-without Beirut suburbs)
Beirut	353.75	-28.27	-1.61
Mount Lebanon (Beirut suburbs)	358.94	-23.07	-1.38
Mount Lebanon (without Beirut suburbs)	382.02	0.00	-
North	**339.00**	-43.01	**-2.82**
Beqaa	355.04	-26.98	-1.32
South	356.96	-25.06	-1,64
Nabataea	357.81	-24.21	-1.39
Note: bold t-value indicates that the difference is statistically significant.			

Table 2.3.5b The Mean Score of PISA Population in Lebanon in Private Sectors in Different Regions

School Region	Mean Score	Mean Difference	t-value (Ref- group Mount Lebanon -Beirut suburbs)
Beirut	433.25	-14.48	-0.62
Mount Lebanon (Beirut suburbs)	447.73	0.00	-
Mount Lebanon (without Beirut Suburbs)	427.71	20.02	-0.99
North	395.73	-52.00	**-3.43**
Beqaa	388.14	-59.60	**-5.12**
South	356.82	-90.91	**-2.58**
Nabataea	386.55	-61.18	**-5.47**
Note: bold t-value indicates that the difference is statistically significant.			

- The highest mean score of public schools in Mount Lebanon (without Beirut Suburbs) is 382.02 which is much higher than that of Beirut by 328.72 points, and that of Mount Lebanon, Beirut Suburbs by 23.07, and that of Bekaa by 26.98, and that of the south by 25.06, and that of Nabatieh by 24.21 points, but all these differences are not statistically significant. Still, the difference is much higher between Mount **Lebanon (without Beirut Suburbs) and North Lebanon by 43.01, with statistical significance.**
- **The highest mean score of private schools is in Mount Lebanon (Beirut suburbs) is 447.73 which is** slightly higher than that of private schools in Beirut (433) by 14 points, and those in Mount Lebanon without Beirut suburbs (427), by 20 points. All these differences are with no statistical significance. However, the mean score of private schools in Mount Lebanon (Beirut suburbs) is much higher, with statistical significance, than those in the north (395) by 52 points, and those in Beqaa (388) by 59 points, and those in Nabataea (386) by 61, and those in the south (356) by 91 points.

Almost all of the private schools in Lebanon performed higher than the highest public schools except in the South.

This shows that on average, only the students of the private schools found in Beirut and Mount Lebanon, with suburbs and without suburbs exceeded proficiency level 2, (base line of Scientific Literacy), but they did not reach proficiency level 3.

2.3.6 Comparison by language of study for the scientific literacy test

Table 2.3.6 shows that students who sat for the scientific literacy test in English (394.75) performed higher than students who sat for the scientific literacy test in French (381.58), with a mean difference of 13.16 points, and this difference is statistically significant.

Table 2.3.6 Mean score of students as per the scientific literacy test language

Test Language	Mean Score	Mean Difference	t-value (Ref- group English)
French	381.58	-13.16	**-2.16**
English	394.75	0.00	-
Note: bold t-value indicates that the difference is statistically significant.			

So, based on this, the students performed lower when the language of study was French in scientific literacy. This leads us to think that the reading comprehension skills are affecting students' performance in science.

The Pearson correlation test ($r=0.81$; $p < 0.05$) shows that there is a significant positive correlation between reading and science. This means that as the score of reading increases, the score of science increases.

2.3.7 Analysis of the results of constructive student items achieved by Lebanon versus the international ones.

The items in PISA 2015 Scientific Literacy are classified based on systems, knowledge type, response type, cognitive demand, and contexts as well as competencies (Figure 2.3.7). The percentage of distribution of items are presented in Figures 2.3.7a and 2.3.7b.

Figure 2.3.7 Categories describing the items constructed for the PISA 2015 science assessment

Reporting categories			Further categories to ensure a balanced assessment		
Scientific competencies	**Knowledge types**	**Content areas**	**Response types**	**Cognitive demand**	**Contexts**
Explain phenomena scientifically	Content	Physical systems	Simple multiple choice	Low	Personal
Evaluate and design scientific enquiry	Procedural[1]	Living systems	Complex multiple choice	Medium	Local/ National
Interpret data and evidence scientifically	Epistemic[1]	Earth and space systems	Constructed response	High	Global

Note: while distinct from a theoretical point of view, the procedural and epistemic knowledge categories form a single reporting category.

Figure 2.3.7.a Target distribution of score points for knowledge

	Systems			
Knowledge types	**Physical**	**Living**	**Earth & Space**	**Total over systems**
Content	*20-24%*	*20-24%*	*14-18%*	***54-66%***
Procedural	*7-11%*	*7-11%*	*5-9%*	***19-31%***
Epistemic	*4-8%*	*4-8%*	*2-6%*	***10-22%***
Total over knowledge types	***36%***	***36%***	***28%***	***100%***

Figure 2.3.7b Target distribution of score points for scientific competencies

Scientific Competencies	% of score points
Explaining phenomena scientifically	*40-50%*
Evaluating and designing scientific enquiry	*20-30%*
Interpreting data and evidence scientifically	*30-40%*
TOTAL	**100%**

The following tables show the performance of the Lebanese PISA 2015 population relative to the percentage of International PBA countries in constructive response questions, in reference to different parameters considered in PISA. Figures 2.3.7c, 2.3.7d, and 2.3.7e show the results with respect to the different competencies.

Fig 2.3.7c Competency: Interpret data and evidence scientifically

ITEM	Knowledge:	Context	Proficiency level	Level of difficulty	PBA International % correct	PBA Lebanon %		
						Correct	Partial correct	Incorrect
S498Q04 Experimental Digestion (grade 9)	Procedural; Living	Local/National; Frontiers	3	moderate	41.38	55.67	16.50	27.83
S326Q01 Milk	Procedural; Living	Local/National; Health and Disease	3	moderate	42.31	30.83	-	69.17
S326Q02 Milk			2		34.96	34.21	-	65.79
S131Q02 Good Vibrations	Procedural; Living	Personal; Health and Disease	3	moderate	32.46	41.43	-	58.57
S495Q03 Radiotherapy	Procedural; Living	Local/National; Frontiers	4	moderate	23.55	20.17	-	79.83
S519Q01 Airbags	Procedural; Physical	Personal; Frontiers	5	High	21.99	26.67	19.07	54.26

For this competency, "Interpret data and evidence scientifically", the following cases need to be considered.

Case 1: Item S498Q04 (Experimental Digestion) is a question of moderate difficulty that focuses on in vitro digestion of a piece of bread which is a traditional question and one of the easiest questions in life and earth science in grade 9. So, the students are familiar with the context and content. The performance of students in Lebanon was relatively the highest (55.6% of students answered correctly and 16.50% answered it partially). The latter did not compare the data before reaching the conclusion; a step is required during interpretation by using evidence. Moreover, 55.6% of the Lebanese population answered this question fully as compared to the international PBA (41.38). Moreover, this question was an open question and not a closed one; that is, it required expressive writing skills.

Similarly, with respect to item S413Q06 (Plastic Age), it is a question of moderate difficulty that is a very common question in physics and chemistry in the Lebanese Curriculum in the theme related to density. So, the students are familiar with the context and content. It is a closed question requiring only to fill in with + sign and – sign in a table without the need of using any writing skills. However, the % of students who solved it correctly was less than the previous item 33.27%. Moreover, the percentage of students who solved it correctly was higher than those in other PBA countries (25.39%). Here, a question arises: do the students lack the skills of interpreting text and conceptualizing in terms of symbols and codes?

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Case 2: We compared two test items which show similarity in different aspects

<table>
<tr><td colspan="2">The features of Item S326Q02 (Milk) and Item S131Q02 (Good Vibrations) show that both:
have moderate levels of difficulty, are of proficiency level 3, belong to the Living System, belong to the context health and disease, target the competency: Interpret data and evidence scientifically, and represent the procedural type of knowledge. However, the concepts tackled in item S326Q02 (Milk) are covered in the Lebanese Life and Earth Science curriculum in grade 9; meanwhile, the concepts tackled in item S131Q02 (Good Vibrations) are covered in the Lebanese Physics curriculum in grade 8.</td></tr>
<tr><td>For the Item S326Q02 (Milk): the percentage of students who answered this question fully, in Lebanon, is 30.83% which <u>is less than</u> that of the PBA International percentage (42.3%). 69.17 % were not able to solve this question in Lebanon.</td><td>For the item S131Q02 (Good Vibrations): the percentage of students who answered this question fully in Lebanon is 41.43% which <u>is greater than</u> that of the PBA International (32.46%). 58.57 % were not able to solve this question in Lebanon.</td></tr>
<tr><td>The item focused on the chemical constituents of milk (proteins, lipids, and carbohydrates) and the students have to use the data represented in the table to compare the milk wolf to that of humans to prove a certain old story that talks about babies fed on wolf milk in ancient times. The chemical constituents of different foods are covered in Life and Earth Science curriculum in grade 9 in the chapter of digestion and the chapter of nutrition. So, the scientific terms used in the stimulus of the test item are familiar to students. The data is presented in tables which the students should use to compare and this representation of data is also familiar to students. Also, the students are asked to verify if this myth is correct or not based on data and this is also a familiar question in life and earth science. Yet, the students' performance in this question was very low. The context of the question is not familiar to the students since it approaches the organic food molecules from the nutrition approach and not from the chemical digestion approach. The latter was suspended and resumed initially.</td><td>The item focused on the range of the frequency of audible sound waves and those of high vibrations which show bad influence on the sense of hearing. It also focused on how the scientists prove that some animals use the direction of sound waves to locate a certain target and move towards it. These topics (sound waves, frequency, audible range, and direction of sound waves) are core topics in the physics subject curriculum in grade 8 in Lebanon, but the system and context (living system, animal behavior) in which the question is introduced is not familiar in physics curriculum, mainly in books and in assessment. It introduces an experiment integrating animal behavior and sound vibrations. The students require their reasoning skills to be able to answer it. In this situation, the students have to interpret data and to draw out new information in a way which is similar to the type of questions that are usually covered in life and earth science in Lebanon, based on reasoning. The result was somehow good for the Lebanese students and this indicates that they somehow performed well in reasoning skills in new contexts.</td></tr>
</table>

Case 3: We compared two test items which consist of similar stimulus (a text introducing a study and the data of the study are presented in a graph showing two curves. For the Item three variables are studied together in the airbags whereas two variables are studied together in radiotherapy (S495Q03). Radiotherapy and S519Q01 Airbags.

<table>
<tr><td colspan="2">The features of Item S495Q03 (radiotherapy) and Item S519Q01 (airbags) show that both have moderate levels of difficulty, belong to the Living System and the context frontiers, target the competency: Interpret data and evidence scientifically, and rely on the procedural type of knowledge. However, item S495Q03 (radiotherapy) is of proficiency level is 3 while item S519Q01 (airbags) is of proficiency level 5. Moreover, the concepts tackled in item S495Q03 (radiotherapy) and tumor and radiotherapy are barely covered in the Lebanese Life and Earth Science curriculum; meanwhile, the concepts tackled in item S519Q01 (airbags), which are force, speed, forms of energy, and kinetic and potential energy, are covered in the unit of mechanics in the Lebanese Physics curriculum in grade 8.</td></tr>
<tr><td>For the item S495Q03 (radiotherapy): the percentage of students who answered this question fully in Lebanon is 20.17% which <u>is less than</u> that of the PBA International percentage (23.55 %). 79.83 % were not able to solve this question in Lebanon.</td><td>For the item S519Q01 (airbags): the percentage of students who answered this question fully in Lebanon is 26.67 % which <u>is greater than</u> that of the PBA International percentage (21.99 %). 19.07% solved this question partially and 54.26% were not able to solve this question in Lebanon.</td></tr>
<tr><td>The item focused on the effects of the different types of therapy on the cure of certain tumors, in a way which doesn't harm the neighboring tissues. The scientific term, the tumor, used in the stimulus of the test item is not familiar to the students, before grade 11- Science section and no reference at all to any mean of therapy. The data collected in the study are represented in two curves. The students should compare the variation in the two curves to justify their decision about the best treatment and this is familiar to students especially in life science. Yet, the students' performance in this question was very low. In general, the performance of students is usually weaker in such types of questions which belong to the reasoning domain in the life science system of assessment. Moreover, the context here is not familiar to the students and may be this can explain their low performance.</td><td>The item focused on the physics concepts related to force, time, energy, and speed which are covered in grade 8 (note: now the topics related to force and energy are suspended). However, the context of the question is not familiar to the students. Here, the students in this question have to compare the data represented in two curves and relate it to the data of the threshold value in order to decide on the safe techniques while driving. 19.07% of students got the partial grade indicating that they have drawn out new information based on the comparison of two curves without comparing these to the threshold value in the graph. 26.67% of students (4.7% higher than the international percentage) compared the two curves and related their comparison to threshold value for safety. The analysis and comparison of values represented in graphs is more common in the reasoning domain in the life science subject in the Lebanese curriculum. Students used the reasoning skills to answer a physics test item which may be a familiar concept (suspended from the physics curriculum now). Moreover, the proficiency level of this question is 5 compared to the other one which is 4, and therefore the former requires higher order thinking as compared to the latter, yet the students performed much better in the former one. Here comes the question: why were the students better in treating the data in a physics item which is more complicated than a life science item? Does the familiarity of concepts play a role here? Yet, there is no doubt that the performance in this physics item which requires reasoning skills is also low.</td></tr>
</table>

Fig 2.3.7d Competency: Evaluate and design scientific enquiry.

ITEM	Knowledge:	Context	Proficiency level	Level of difficulty	PBA International % correct	PBA Lebanon %		
						correct	partial correct	Incorrect
S519Q03 Airbags	Epistemic; Living Physical Science	Personal; Frontiers	5	High	19.62	15.35	-	84.65
S438Q03 Green Parks	Epistemic; Physical	Local/ National; National Resources	4	Moderate	21.52	21.30		78.70
S425Q04 Penguin Island (repeat experiment for validity)	Epistemic; Living	Global; Environmental Quality	5	High	17.69	12.17		87.83
S131Q04 Good Vibrations (what idea is formulated in the experiment)	Procedural; Living	Local/ National; Health and Disease	4	Moderate	18.25	20.20		79.80

The competency related to evaluation and designing of scientific enquiry is barely covered in the science books, although the general objectives of science considered it. Moreover, in the official exams, this competency in the way it is described by PISA is poorly assessed in all sciences. So, the students are not trained on such types of questions where they should use epistemic knowledge and procedural knowledge at higher levels of thinking in evaluating and designing experiments. This is why the students' percentage of correct items (on average is less than 20%) is very low compared to incorrect items (on average greater than 75%); and it is lower than the international percentage of correct items in PBA countries except for the test item S131Q04. Also relatively speaking, the percentage of PBA internationally correct items is low too.

Fig 2.3.7e Competency: Explain phenomena scientifically

ITEM	Knowledge:	Context	Proficiency level	Level of difficulty	PBA International % correct	PBA Lebanon %		
						correct	partial correct	Incorrect
S269Q01 Earth's Temperature	Content: Earth and Space	Global; Environmental Quality	3	Moderate	34.93	30.31		69.79
S269Q03 Earth's Temperature (present grade 10)	Content: Living	Global; Environmental Quality	4	Moderate	29.40	34		65.38
S408Q03 Wild Oat Grass	Content; Living	Local/National Natural Resources	5	High	26.56	21.94		78.76
S425Q03 Penguin Island	Content; Living	Local/National Environmental Quality	4	Moderate	35.19	33.09		66.91
S428Q05 Bacteria in Milk	Content; Living	Global; Health and Disease	3	Moderate	26.48	22.31		77.69
S514Q02 Development and Disaster	Content; Physical	Local/ National; Environmental Quality	1a	Relatively low	50.11	50.70		49.30

The competency "explain phenomena scientifically" is very familiar in all science subjects in Lebanon. If we consider the item S269Q03 Earth's Temperature, it focused on the greenhouse gas carbon dioxide and its role in inducing global warming. If we consider the item S269Q03 (Earth's Temperature), it focused on a very familiar idea (trees are the lungs of the cities) which is fully covered and in the same context in the Life and Earth Science subject in grade 7 and in Life Science subject in grade 10, and it is considered as a very easy concept. What is astonishing here is the relatively low performance of students in this question especially that the majority of students sitting for PISA are in grade 10. The same thing applies to the test item S408Q03 (wild oat grass) which covers the cross hybridization and the life cycle of seed plants, which are covered in grades 6, 7, and 10. Likewise, in the other test items the students performed relatively low, and this tends to raise a question, to what level are the students able to explain a familiar scientific content?

In conclusion, the students performed somehow better in constructive response questions belonging to the competency "Interpret data and evidence scientifically", of the same level of difficulty, especially in the physical science questions compared to life science questions. For these questions, they did much better in this competency than in the competency related to "Explain phenomena scientifically", although this latter competency requires skills at lower levels of thinking than the former. For the competency "Evaluate and design scientific enquiry", the learners performed the least.

In some test items, the lack of content from the curriculum or its suspension affected the percentage of correct items, especially the content related to human health, the environment and the earth and space science. Also, the context of the questions calls for integrated information from the different science subjects, and this is not very familiar to students in the Lebanese case.

Finally, the students performed better in physical science system related questions than in life science system related questions, especially in the competency related to "Interpret data and evidence scientifically" as shown in cases 2 and 3.

Here, the following questions emerge: are the students more motivated when studying physical sciences than when studying life science? Does the curriculum of Life and Earth Sciences allocate less time than required which makes it had to extend the learner's learning to real life contexts? What about the teachers' self-esteem and confidence while teaching the different science subjects?

2.4 Students' attitudes towards science

This part focuses on students' engagement with science, and their attitudes towards science as measured through students' responses to the PISA background questionnaire, which examines differences in students' career expectations and intrinsic and extrinsic motivation for learning science.

Studying science in school is useful to students' future lives and careers. Expectations of future careers in science are positively related to performance in science and to enjoyment of learning science, even after accounting for performance. The relationship with enjoyment is stronger among higher-achieving students than among lower-achieving students

2.4.1 Science-related career expectations

Many 15-year-old students do not have clear decisions about their future careers. They either give more than two options or no options at all, and this reflects their insufficient knowledge about careers.

Table 2.4.1 Students' career expectations
Percentage of students who expect to work in science-related professional and technical occupations when they are 30

	Science and engineering professionals	Health professionals	Information and communication technology professionals	Science-related technicians and associate professionals
OECD average	8	13	3	2
Lebanon	17	21	1	1
Source: OECD, PISA 2015 Database, Table I.3.10a. http://dx.doi.org/10.1787/888933432284				

The data in Table 2.4.1 shows that on average, across OECD countries, 26% of students reported that they expect to work in an occupation that requires further science training beyond compulsory education, and mainly:

- 8.8% of students expect to work as professionals who use science and engineering training (e.g. engineer, architect, physicist or astronomer);
- 11.6% of students expect to work as health professionals (e.g. medical doctor, nurse, veterinarian, physiotherapist);
- 2.6% of students expect to work as ICT professionals (e.g. software developer, applications programmer);
- 1.5% of students expect to work as science-related technicians and associate professionals (e.g. electrical or telecommunications engineering technician)

However in Lebanon, almost double the percentage of students (40%) reported that they expect to work in an occupation that requires further science training beyond compulsory education and mainly:

- 17% of students expect to work as professionals who use science and engineering training (e.g. engineer, architect, physicist or astronomer);
- 21% of students expect to work as health professionals (e.g. medical doctor, nurse, veterinarian, physiotherapist);

- 1% of students expect to work as ICT professionals (e.g. software developer, applications programmer), and 1% as science-related technicians and associate professionals (e.g. electrical or telecommunications engineering technician);
- 1% of students expect to work as science-related technicians and associate professionals.

In almost all countries/economies, the expectations of pursuing a career in science is strongly related to proficiency in science.

Table 2.4.1a Students' career expectations, by proficiency level in science
Percentage of students who expect to work in science-related professional and technical occupations when they are 30

	Low achievers in science (students performing below Level 2)	Moderate achievers in science (students performing at Level 2 or 3)	Strong achievers in science (students performing at Level 4)	Top achievers in science (students performing at or above Level 5)
OECD average	13	23	34	42
Lebanon	30	54	65	-

The data in Table 2.4.1a shows that on average, across OECD countries, only 13% of students who score below PISA proficiency Level 2 in science hold such expectations, but that percentage increases to 23% for those scoring at Level 2 or 3, to 34% among those scoring at Level 4, and to 42% among top performers in science (those who score at or above Level 5). In all countries and economies that have more than 1% of students who score at or above Level 5, these students are most likely to expect that they will work in science-related occupations.

In Lebanon, the share of students who are expected to work in science related and technical related occupations when they are 30 is 30%, and this is more than double the OECD average (13%) for the students who score below PISA proficiency Level 2 in science. this percentage increases to 54% for those scoring at Level 2 or 3, and it reaches 65% among those scoring at Level 4 in Lebanon. It is always higher than that of OECD countries.

This shows that students' expectations about their future work partly reflect their academic successes and skills; however, the variation in results between the average of OECD countries and Lebanon for the same proficiency level, reflects the fact that the opportunities and support available to students and the social vision about certain careers, in their country and in their local environment, might turn an aspiration to a reality. Since in Lebanon most of the parents push their children towards such careers, the students have to perform very well in science subjects to achieve their parents' aspirations. However, in OECD countries other factors play a role in career selection; that is the individual skills and likes and dislikes are not the sole factors for pursuing a career in science-related fields, but this also depends on the social and economic resources available to students and on employers' current and future demand for science professionals and technicians. This, in turn, depends on the wider economic context, including a country's level of development and strategic policies which expand beyond their education policy (OECD, 2016).

Motivation for learning science

Basic knowledge is not enough to engage students with complex scientific issues. In fact, motivation nurtures students' engagement with science, so school systems need to provide students with a climate of interest and motivation to ensure in their engagement.

PISA distinguishes between two forms of motivation to learn science: students may learn science because they enjoy it (intrinsic motivation) and/or because they perceive learning science to be useful for their future plans (instrumental motivation). These two constructs are central in expectancy-value theory (Wigfield & Eccles, 2000) and in self-determination theory, which emphasises the importance of intrinsic motivation (Ryan & Deci, 2009).

Intrinsic motivation to learn science

When learners do the activity as a consequence of the joy resulting from the activity itself, this is referred to as intrinsic motivation. Students are intrinsically motivated to learn science when they want to do so not to pursue the acquisition of new science concepts, but because they find learning science and working on science problems enjoyable (Ryan & Deci, 2009). This enhances students' willingness to spend more time and exert more effort in science-related activities. It also affects their choice of subjects, their self-image, and the type of careers they aspire to and choose to pursue (Nugent et al., 2015).

Moreover, enjoyment of science has been found to predict participation in science-related activities among young children, whereas the opposite is not true; more opportunities to learn about science do not, in themselves, stimulate enjoyment of science (Alexander, Johnson & Kelley, 2012). Generally, students' enjoyment of science declines from elementary to high school (Archer et al., 2010). This is because with age students' interests become increasingly differentiated and specialized, and the teacher's attitude regarding the teaching strategies and techniques she practices in class tends to decrease the duration of students' enjoyment and natural motivation to learn science (Hampden-Thompson & Bennett, 2013; Krapp & Prenzel, 2011; Logan & Skamp, 2013)

Table 2.4.1b Students' enjoyment of learning science
Percentage of students who reported that they "agree" or "strongly agree" with the following statements

Average	A	B	C	D	E
OECD	64	51	55	67	64
Lebanon	70	65	71	80	79

A: I generally have fun when I am learning science topics
B: I like reading about Science
C: I am happy working on Science topics
D: I enjoy acquiring new knowledge in Science
E: I am interested in learning about Science

As Table 2.4.1b shows, across OECD countries, 67% of students enjoy acquiring new knowledge in Science; 64% generally have fun when learning Science topics, and also 64% are interested in learning about Science. Fewer students, 55%, feel happy when working on Science topics, and 51% like reading about Science.

Lebanon shows a similar pattern of variation like OECD concerning the attitudes towards learning science but with higher motivation towards each of the aspects. Eighty percent of the learners, in Lebanon, enjoy acquiring new knowledge in science; 79% are interested in learning about science. Fewer learners (71%) feel happy about working on science topics, and 70% generally have fun when studying science topics. A smaller number (65%) likes reading about science.

Extrinsic factors: students' instrumental motivation to learn science

Instrumental motivation to learn science refers to the drive to learn science because students perceive it to be useful to them and to their future studies and careers (Wigfield & Eccles, 2000). PISA measures the extent to which students feel that science is relevant to their own study and career prospects through students' responses ("strongly agree", "agree", "disagree" or "strongly disagree") to statements that affirm that the effort they exert in learning science is worthwhile, because it will help them in their future work, and what they want to do in the future, and to get good job in the desired field, and improve their career prospects.

Table 2.4.1c Students' instrumental motivation to learn science
Percentage of students who reported that they "agree" or "strongly agree" with the following statements

Average	A	B	C	D
OECD	69%	64	67	61
Lebanon	83	81	80	77

A- Making an effort in my science subjects is worth it because this will help me in the work I want to do later on.
B- What I learn in my science subjects is important for me because I need this for what I want to do later on.
C- Studying my science subjects is worthwhile for me because what I learn will improve my career prospects
D- Many things I learn in my science subjects will help me to get a job.

Table 2.4.1c shows that on average, across OECD countries, 69% of students agreed or strongly agreed that making an effort in science subjects at school is worth it because it will help them in the work they want to do later on; 67% of students agreed that studying science subjects at school is worthwhile because what they learn will improve their career prospects. 64 % agreed that learning science subjects is important because they need this for what they want to do later on. 61% agreed that many things they learn in their science subjects will help them get a job. In Lebanon, a higher percentage of students agreed on these drivers than the average across OECD countries; 83 % of students in Lebanon agreed or strongly agreed that making an effort in science subjects, at school, is worth it because it will help them in the work they want to do later on; 80 % of students agreed that studying science subjects at school is worthwhile because what they learn will improve their career prospects. 81 % agreed that learning science subjects is important because they need this for what they want to do later on. 77 % agreed that many things they learn in their science subjects will help them get a job.

2.5 Remarks

Although career awareness and linking it to science education is one of the general objectives in Science curriculum in Lebanon, yet they are not very much emphasized in the learning resources and during the teaching-learning process. But what is obvious here is the students' attitudes towards seeking their future jobs in the field of sciences rather than in the digital field and the humanities field. This might relate to the Lebanese culture and families most of which orient their children towards becoming either doctors or engineers, being for them first class jobs. So, here it is important to integrate career guidance in the teaching-learning process so that students would have more diversified options which would better match the needs of society and its environment.

Concerning students' motivation towards learning science , it is obvious that when the instructional strategies and plans follow the inquiry based approach and are student centred, they will give the chance to the students to enjoy learning (intrinsic motivation) and discover that science learning solves many of their life problems (extrinsic motivation). While planning the curriculum development or any unit plan in any subject, it is very important to take into consideration the intrinsic as well extrinsic inducing motivation activities. This will enhance students' performance.

The profound analysis of the scientific literacy performance of students leads us to:

1- **Conclude:**

Different variables led to this low performance of students in Lebanon. These are related to the lack of different types of knowledge on one hand, and to the lack of well-developed competencies related to the reasoning domain and practical laboratory work on the other hand. Moreover, the ambiguity of concepts and skills related to assessment put the students in a conflict when answering the science questions related to different systems (Life Science, Physical Science, Earth and Space Sciences, Environmental Science). Also, the weakness of students in English/French proved to be a barrier, and the way of presenting many questions was not familiar to the students in the Lebanese context.

2- **Recommend**:

At the level of curriculum development:

- The science curriculum should be motivating and differentiated to cater to the interests of students. It should take into consideration two target populations of students: the inquirers who are the scientists and the consumers who want to make use of science concepts and skills to solve their life problems.
- The sciences curricula should be richer in Earth and Space Science topics.
- More integration between the different science subject matter should take place.
- There is a need to clarify the existing assessment framework in science subjects because reasoning skills are not well defined and clear for the science teachers.
- The assessment framework must go hand in hand with other curriculum components while designing the curriculum.

- There should be emphasis on scientific activities that emerge from real life contexts.
- The lab work and its assessment should become focal in the curriculum, and this can't be achieved if this part remains excluded from official assessment in official exams.
- The instructional strategies should be student centred. It should help students achieve proficiency Level 6 in PISA. Students should be able to use content, procedural, and epistemic knowledge to consistently provide explanations, evaluate, design scientific enquiries, and interpret data in a variety of complex life situations that require high levels of cognition. They should consistently demonstrate advanced scientific thinking and reasoning requiring the use of models and abstract ideas and use such reasoning in unfamiliar and complex situations. They should develop arguments to critique and evaluate explanations, models, interpretations of data, and proposed experimental designs in a range of personal, local, and global contexts (OECD, 2016).

At the level of teacher professional development:

There is a need for programs to tackle:

- Assessment in a coherent way among the different subjects as well as in the same subject. (Note: use the curriculum as reference to any type of assessment)
- PISA assessment framework and types of questions.
- Classroom management and the art of posing effective questions (techniques or ways).
- Laboratory work for the investigation and explanation of science principles and concepts.
- Preparation of creative activities to stimulate gifted students who want to become scientists, and other activities have to target students who want to be proficient in science to solve their problems.
- The curriculum and inquiry strategies need to be deployed along with planning to prepare class periods that will give the students the chance to conduct experiments.

At the level of universities:

- Introduce obligatory courses related to earth and space sciences for candidates of Sciences Bachelors.
- Enforce taking education courses for students who will become teachers.
- Make use of the national assessment framework especially by Education Departments at universities to provide a comprehensive pre-service teachers' preparation. This implies that all pre-service preparation programs for teachers should take into consideration the national curriculum to train their students accordingly.
- Emphasize the importance of lab work courses and their respective assessment means.

Chapter 3

Students' performance in math literacy

Mathematics in PISA 2015 was assessed as a minor domain. For Lebanon, it was the first PISA contribution, a quick look at the results reveals that:

- Students, who participated in the PISA test in Lebanon, scored, on average, 396 on the PISA 2015 mathematics test which is approximately 100 points lower than the general average (490) and 160 points lower than the highest grade Singapore (564).
- Their mean score in mathematics was more than Algeria (360), Tunisia (367), and Jordan (380) but less than Qatar (402), UAE (427) and Cyprus (437).
- Sixty percent of the students scored below level 2 (on a 6-level scale) in mathematics similar to Qatar but better than Algeria (80%), Tunisia (78%), and Jordan (70%).
- There were gender differences; the mean score achieved by males exceeded the females' mean score by more than 15 points. Also, more females scored below level 2 (64.4%), when compared to males (55.5%), and a few females scored (1.2%) above level 5 compared to males (2.9%).
- Grade 10 students did better than grade 7 to 12 students; Mount Lebanon students, including Beirut suburbs, did better than students from other governorates; private school students did better than public school students; French school students did better than English school students.
- Students, in Lebanon, scored more than the average in the open-ended questions when compared to the countries who have used the Paper Based (PB) PISA test.

To dwell further on the results, this chapter is intended to answer the following questions:

3.1 What is meant by math literacy?

3.2 How does the math literacy framework compare to the math component of the Lebanese curriculum?

3.3 What were the scores of students in this literacy area?

3.4 What are the major remarks?

3.1 Math literacy introduction

When we read the word 'mathematics literacy' what comes to mind is the minimal, or low-level, knowledge and skills a student should learn in mathematics. But for PISA 2015 (OECD, 2016), this construct means the student's capacity to formulate, employ, and interpret mathematics in a variety of contexts. The difference is vast and it means that it is not enough for a student to know some factual and procedural mathematics to be considered as 'mathematically literate' but rather he/she should use those facts and procedures in a variety of contexts. For the 'variety of contexts', PISA selected four domains: personal, occupational, societal, and scientific.

- **Personal –** problems classified in the personal domain include (but are not limited to) those involving food preparation, shopping, games, personal health, personal transportation, sports, travel, personal scheduling and personal finance.
- **Occupational –** problems classified in the occupational category may involve (but are not limited to) such things as measuring, costing and ordering materials for building, payroll/accounting, quality control, scheduling/inventory, design/architecture and job-related decision making.
- **Societal –** problems classified in the societal category involve (but are not limited to) such things as voting systems, public transport, government, public policies, demographics, advertising, national statistics and economics.
- **Scientific –** problems classified in the scientific category might include (but are not limited to) such areas as weather or climate, ecology, medicine, space science, genetics, measurement and the world of mathematics itself.

In summary, for the purposes of PISA 2015, mathematical literacy is defined as follows:

> Mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged, and reflective citizens (OECD, 2016, p. 65).

As for content knowledge, PISA 2015 mathematics covers evenly four categories in six difficulty levels; the four categories are:

1) Change and relationships (25%)
2) Space and shape (25%)
3) Quantity (25%)
4) Uncertainty and data (25%)

The list of mathematical concepts assessed is: functions, algebraic expressions, equations and inequalities, representation and description of data, relationships within and among geometrical objects in two and three dimensions, measurement, numbers and units, arithmetic operations, percent, ratios and proportions, counting principles, estimation, data collection, representation and interpretation, data variability and its description, samples and sampling, chance and probability.

The questions are distributed over six difficulty levels or proficiency levels and the types of questions are multiple choice, true or false, short answer, and explanatory. In addition, the questions are distributed as follows in terms of skills: (1) formulating situations mathematically (25%), (2) employing mathematical concepts (50%): facts, procedures, and reasoning, (3) interpreting, applying, and evaluating mathematical outcomes (25%).

The difficulty levels are from level 1 to level 6 (6 being the hardest) as explained in Figure 3.1.

Figure 3.1 Math literacy proficiency levels (OECD, 2016, p. 77)

Proficiency levels and scale scores	Task description
Level 6 Score > 669	At Level 6, students can conceptualize, generalize and utilize information based on their investigations and modelling of complex problem situations and can use their knowledge in relatively non-standard contexts. They can link different information sources and representations and flexibly translate among them. Students at this level are capable of advanced mathematical thinking and reasoning. These students can apply this insight and understanding, along with a mastery of symbolic and formal mathematical operations and relationships, to develop new approaches and strategies for attacking novel situations. Students at this level can reflect on their actions, and can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments, and the appropriateness of these to the original situation.
Level 5 607 < score < 669	At Level 5, students can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Students at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriate linked representations, symbolic and formal characterizations, and insight pertaining to these situations. They begin to reflect on their work and can formulate and communicate their interpretations and reasoning.
Level 4 545 < score < 607	At Level 4, students can work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic ones, linking them directly to aspects of real-world situations. Students at this level can utilize their limited range of skills and can reason with some insight, in straightforward contexts. They can construct and communicate explanations and arguments based on their interpretations, arguments and actions.
Level 3 482 < score < 545	At Level 3, students can execute clearly described procedures, including those that require sequential decisions. Their interpretations are sufficiently sound to be a base for building a simple model or for selecting and applying simple problem-solving strategies. Students at this level can interpret and use representations based on different information sources and reason directly from them. They typically show some ability to handle percentages, fractions and decimal numbers, and to work with proportional relationships. Their solutions reflect that they have engaged in basic interpretation and reasoning.
Level 2 420 < score < 482	At Level 2, students can interpret and recognize situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic algorithms, formulae, procedures or conventions to solve problems involving whole numbers. They are capable of making literal interpretations of the results.
Level 1 Score>358	At Level 1, students can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They can perform actions that are almost always obvious and follow immediately from the given stimuli.

3.2 Math literacy framework vis-à-vis the math component in the Lebanese curriculum

In terms of content, all the PISA mathematical knowledge is covered in the Lebanese curriculum by grade 10 except for counting, chance, and probability which are studied in grade 11. In terms of types of questions, we do have multiple choice, true or false, short answer, and explanatory questions in our Lebanese official exam which is very different from the style of items deployed by PISA.

Moreover, as far as competencies are concerned, The competencies in the Lebanese curriculum for the first secondary (15 year old students) are divided into four main domains:

1) Algebraic and numeric processes
2) Numeric functions
3) Geometric activities
4) Problem solving and communication

For the first three domains, the competencies are content related whereas for the problem solving and communication, the competencies are general for any content. The competencies for this fourth domain are:

1) Make use of information from different sources (text, table, diagram, graph, formulas, theorems, rules, etc.) to solve a problem.
2) Use a variety of mathematical representations to model a certain situation (algebraic formula, equation, inequality, table of values, graph, histogram, circular diagram, oral, written, symbolic, or pictorial form).
3) Conjecture, formulate, verify, and determine the validity domain.
4) Distinguish between valid and invalid arguments.
5) Demonstrate using different types of reasoning and mathematical methods (deductive, by induction, inductive, by contradiction…).
6) Validate results and explain solutions.

To compare these competencies with PISA 2015, we can only compare them in this domain (Problem solving and communication) because the competencies in PISA 2015 are not content related.

For purposes of the assessment, the PISA 2015 definition of mathematical literacy can be analysed in terms of three interrelated aspects:

- The mathematical processes that describe what individuals do to connect the context of the problem with mathematics and thus solve the problem, and the capabilities that underlie those processes.
- The mathematical content that is targeted for use in the assessment items.
- The contexts in which the assessment items are located.

(OECD, 2016, p. 68)

Figure 3.2 Relationship between mathematical processes and fundamental mathematical capabilities (OECD, 2016, pp. 71-72).

	Forlmulating situations mathematically	Employing mathematical concepts, facts, procedures and reasoning	Interpreting, applying and evaluating mathematical outcomes
Communicating	Reads decode, and make sense of statements, questions, tasks, objects or images, in order to form a mental model of the situation	Ariculate a solution, show the work involved in reaching a solution and/or summarise and present inermediate mathematical results	Construct and communicate explanations and arguments in the context of the problem
Mathematising	Identify the underlying mathematical variables and structures in the real world problem, and make assumptions so that they can be used	Use an understanding of the context to guide or expedite the mathematical solving process e.g. working to a context-appropriate level of accuracy	Understand the extent and limits of a mathematical solution that are a consequence of the mathematical model employed
Representation	Create a mathematical representation of the real-world information	Make sense of, relate and use a variety of representations when interacting with a problem	Interpert mathematical outcomes in a variety of formals in relation to a situaton or use; compare or evaluate two or more representation in relation to a situaton
Reasoning and argument	Explain, defend or provide a justifcation for the identified or devised representation of a ral-world situation	Explain, defend or provide a justifcation for the processes and procedures used to determine a mathematical result or solution Connect pieces of information to arrive at a mathematical solution make generalisations or create a multi-step argument	Reflect on mathematical solution and create explanations and arguments that support, refute or qualify a mathematical solution to a contextualised problem
Devising strategies for solving problems	Select or devise a plan or strategy to mathematically reframe contextualised problems	Activate effective and sustained control mechansisms across a multi-step procedure leading to a mathematical solution, conclusion or generalisation	Devise and implement a strategy in order to interpert, evaluate and validate a mathematical solution to a contextualised problem
Using symbolic, formal and technical language and operations	Use appropriate variables, symbols, diagrams and standard models in order to represnt a real-world problem using symbolic/formal language	Understand and utilise formal constructs based on definitions, rules and formal systems as well as employing algorithms	Understand the realationship between the context of the problem and representation of the mathematicalsolution. Use this understanding to help interpert the solution in contextand gauge the feasibility and possible limitations of the solution
Using mathematically tools	Use mathematical tools in order to recognise mathematical structrures or to portray mathematical realationships	Know about and be able to make appropriate use of various tools that may assist in implementing processes and procedures for determining mathematical solutions	Use mathematical tools to ascertian the reasonableness of a mathematical solution and any limits and consstraints ti that solution, given thecontext of the problem

By comparing both the Lebanese and PISA competencies, it is obvious that both are similar but the PISA competencies are more detailed. When it comes to official exams, the real differences between PISA mathematics items and the Lebanese official exams are three-fold:

1) in the question style that requires a great amount of reading;
2) in applying mathematics in a 'variety of contexts';
3) in the competencies tested in the questions.

First, all PISA test questions require a greater amount of reading. This results in two obstacles for students. The first impediment arises from language deficiency; to illustrate, if a student has some weakness in the English language, this surely will be a limiting factor in answering the mathematics question. The second difficulty results from the questioning style where too many things need to be read, understood, selected, and then answered, and this has never been used by local teachers, so the students, at any level, do not have the potential to deal with such items, and that will add to the trouble of the questions.

Second, in reference to PISA 2015 assessment and analytical framework, it has been mentioned that it is of utmost importance to prepare students for applying mathematics in the diverse contexts; they specified:

> The construct of mathematical literacy, as defined for PISA, strongly emphasizes the need to develop students' capacity to use mathematics in context, and it is important that they have rich experiences in their mathematics classrooms to accomplish this (OECD, 2016, p. 64).

Unfortunately, students have no experience what so ever with such kinds of questions.

Moreover, the United States National Council of the Teachers of Mathematics NCTM (Collins, 2011) defines four levels of cognitive assessment questions: memorization (knowledge), procedures without connections (procedural), procedures with connections (conceptual), and doing mathematics knowledge (problem solving).

The Lebanese official exams questions are mainly of the 'procedural knowledge without connection' type, whereas the PISA 2015 assessment mathematics questions cover all types except memorization items.

An example that explains the difference between a procedural and conceptual question is:

- Multiply 24 by 8 (Procedural).
- In your head, multiply 24 by 8. Explain your method. Try to find another method that works (Conceptual).

From the Lebanese official exam grade 9 (2010 first session) here is a statistics question:

200 people are surveyed about their favorite football team. The following table represents the results of this survey.

Team	Italy	Brazil	Spain	Algeria	Total
Frequency	60	40	a	30	200
% relative frequency	30	b	c	d	100
Central angle	e	f	126°	g	360°

1) Calculate a, b, c, d, e, f and g .
2) Draw the bar graph of frequencies.
3) Construct the corresponding circle graph.

A similar question in statistics similar to PISA 2015 questions might look like this:

A survey was conducted among a randomly chosen sample of U.S. citizens about U.S. voter participation in the November 2012 presidential election. The table below displays a summary of the survey results.

Reported Voting by Age (in thousands)				
	Voted	Did Not Vote	No Response	Total
18- to 34-year-olds	30,329	23,211	9,468	63,008
35- to 54-year-olds	47,085	17,721	9,476	74,282
55- to 74-year-olds	43,075	10,092	6,831	59,998
People 75 years old and over	12,459	3,508	1,827	17,794
Total	132,948	54,532	27,602	215,082

According to the table, for which age group did the greatest percentage of people report that they had voted?

Select an Answer

(A) 18- to 34-year-olds

(B) 35- to 54-year-olds

(C) 55- to 74-year-olds

(D) People 75 years old and over

View Correct Answer

The first question (Grade 9 Lebanese official exam) asks to calculate, to draw, to find, and to construct… Such questions are pure procedures without connections (procedural). Whereas in the PISA example, the question needs reading, understanding and comparing; this is considered to be procedures with connections (conceptual).

Hence, it can be deduced that the students who took the PISA Math test were at a disadvantage based on what was previously explained.

3.3 Students' achievement in math literacy.

3.3.1 Comparison by countries' averages

In mathematics literacy, the students, in Lebanon, did better than Algerian, Tunisians, and Jordanian students, but their performance was behind their counterparts from Qatar, Turkey, and U.A.E. (Table 3.3.1).

Table 3.3.1. Mean score, across 8 countries, in decreasing order

Mathematics		
Country	**Mean Score**	**Difference from OECD Average (490)**
Cyprus	437	53
United Arab Emirates	427	63
Turkey	420	70
Qatar	402	88
Lebanon	396	94
Jordan	380	110
Tunisia	367	123
Algeria	360	130

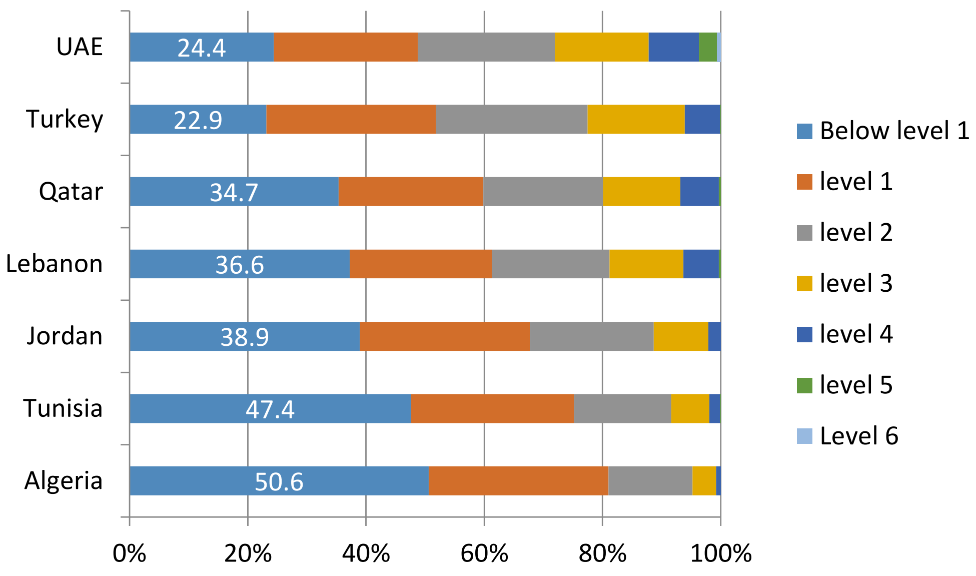
Figure 3.3.1 shows the position of Lebanon's average compared to the OECD average in mathematics literacy and the highest score achieved by Singapore. Lebanon's average falls way behind our real abilities.

Figure 3.3.1. The position of the Lebanese PISA 2015 mathematics average.

But how did the students do in terms of the proficiency levels and how was that compared to the neighbouring countries?

In Lebanon, more than third of students scored below level 1; 60% scored below level 2, and only 3 out of 1000 students scored in level 5. No one scored in level 6 (Figure 3.3.1a). Whereas in U.A.E, for example, 25% of students scored below level 1; 50% scored below level 2, and 31 out of 1000 scored in level 5, and 6 out of 1000 scored in level 6.

Figure 3.3.1a Percentage of students in each of the mathematics proficiency levels in each of the neighbouring countries.



3.3.2 Comparison between Lebanon's percentage of correct answers in the open ended questions for both English and French and the international ones, as far as the open ended (PB) questions are concerned.

PISA 2015 test was done in two forms, computer based (CB) and paper based (PB), as mentioned in Chapter 1. Most countries participated in the CB and only some participated in the PB form. The most accurate comparison can only be done among the countries that have used the same form, but because the framework is the same, the overall scores can be compared. What follows is a detailed comparison in terms of content, process, and level. In Table 3.3.2, a thorough comparison was made between the percentages of correct responses given by students for open-ended questions with the international percentages of correct answers for the same questions.

Table 3.3.2. Comparison between Lebanon's percentages of correct open-ended questions versus the international ones

Content	Process	Number of questions	Level	Number of questions	Lebanon % Correct Full credit	PBA International % Correct
Quantity	Employing Mathematical Concepts, Facts and Procedures	6	Level 2	2	38 %	27 %
			Level 3	1		
			Level 4	1		
			Level 5	1		
			Level 6	1		
	Interpreting, Applying and Evaluating Mathematical Outcomes	2	Below level 1	1	48 %	42 %
			Level 4	1		
	All	8			41 %	31 %

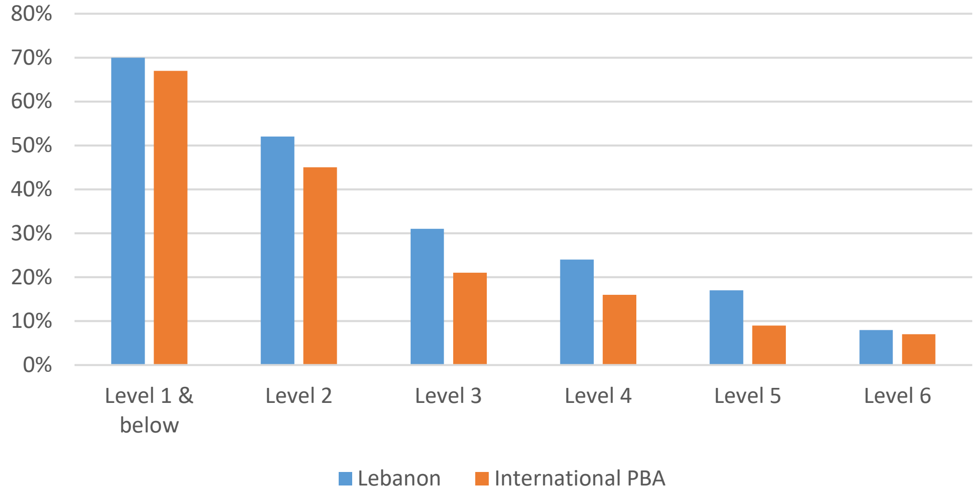
Content	Process	Number of questions	Level	Number of questions	Lebanon % Correct Full credit	PBA International % Correct
Change and Relationships	Employing Mathematical Concepts, Facts and Procedures	6	Level 2	3	42 %	27 %
			Level 4	1		
			Level 5	1		
			Level 6	1		
	Interpreting, Applying and Evaluating Mathematical Outcomes	3	Level 2	1	39 %	27 %
			Level 3	1		
			Level 4	1		
	Formulating Situations Mathematically	4	Level 2	2	23 %	19 %
			Level 6	2		
	All	13			35 %	25 %
Uncertainty and Data	Employing Mathematical Concepts, Facts and Procedures	3	Below level 1	1	54 %	42 %
			Level 3	1		
			Level 5	1		
	Interpreting, Applying and Evaluating Mathematical Outcomes	1	Level 4	1	36 %	24 %
	Formulating Situations Mathematically	1	Level 4	1	11 %	8 %
	All	5			42 %	32 %
Space and Shape	Employing Mathematical Concepts, Facts and Procedures	2	Level 4	1	10 %	8 %
			Level 6	1		
	Formulating Situations Mathematically	7	Level 1	1	17 %	17 %
			Level 4	1		
			Level 5	3		
			Level 6	2		
	All	9			16 %	15 %

From this table, and other detailed data not shown in the table, it can be concluded that,

1. in terms of content, students did better than the OECD international PBA averages. The difference was more than 10% for each of the three content areas (quantity, change and relationship, and uncertainty and data), but it was the same in space and shape;
2. in terms of the level of the questions, no significant difference was found between the percentages scored in Lebanon and the other PBA percentages;
3. in terms of the process, no significant difference was found. It is worth mentioning that when it comes to process the 'formulating situations mathematically', the difference was less than the other processes.

In Figure 3.3.2 a comparison was made according to the question level.

Figure 3.3.2. Comparison between Lebanon's percentage of correct responses and the international ones.



In each of the levels, Lebanon's percentage of correct answers was more than the international percentages, but the difference was less than 10% except in level 3, where the difference was at its maximum of 10% in favour of Lebanon.

3.3.3 Comparison by grade

The sample in Lebanon was 4546 students from all over Lebanon selected in the following way: grade 10 (2892 making 62.3 %), grade 9 (716 making 16.6 %), and the others are from grades 7 and 8 (11.9%); from grade 11 (9%) and from grade 12 only 9 students took the test and that makes 0.2 %.

The highest score for mathematics literacy in Lebanon was in grade 10 (1st Secondary), as shown in table 3.3.3 whereas the lowest score was in grade 7.

Applying the t-test (comparing the mean score between the Lebanese grades) taking grade 10 as a reference group shows that grades 7, 8, and 9 the difference was significant while for grade 11 and 12 it was not significant.

Table 3.3.3 Mean score of the students by grade level

Grade	% of students	Mean Score	Mean Difference	t-value (Refgroup grade 10)
7	3.71	292.03	130.55	**15.14**
8	8.29	309.42	113.16	**14.73**
9	16.59	352.33	70.25	**9.21**
10	62.32	422.58	0.00	-
11	8.98	417.45	5.13	0.72
12	0.13	418.23	4.35	0.20
Total		396.49	26.09	
Note: bold t-value indicates that the difference is statistically significant.				

The highest score was in grade 10 because the PISA test is mostly related to this grade, in the Lebanese case. But in mathematics, students are expected to build on their knowledge; it implies that grade 11 and 12 students should do similar if not better than grade 10 students. The number of students from grade 12 that have participated in the PISA (9 students out of 4546) is negligible, and we cannot build on it any conclusion.

The distribution of scores in each grade level was normal except for grades 8 and 12 where there was a slight shift to the left (median was less than the average by 10 points in grade 8 and 20 points less in grade 12).

3.3.4 Comparison by gender

Male students (2451 or 54%) achieved better than female students (2095 or 46%) by 15 more points (t-value 5.6 taking male as a reference group for mean comparison), as shown in Figure 3.3.4.

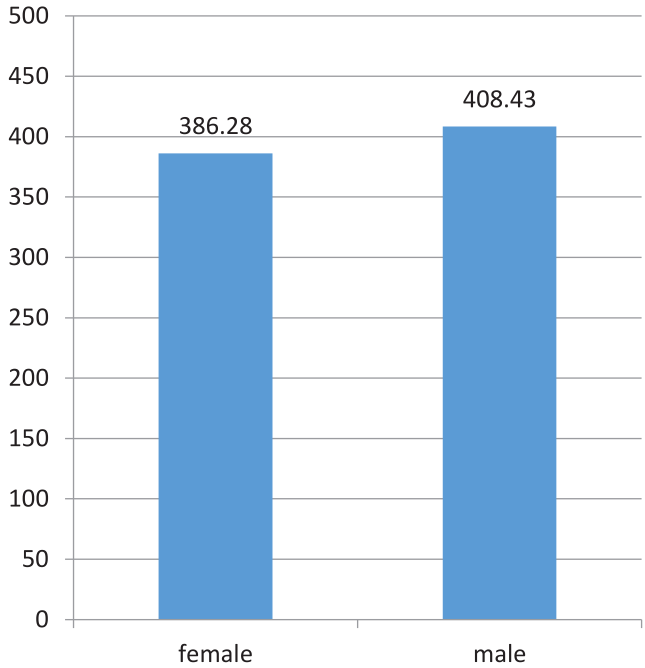


Figure 3.3.4. Mathematics literacy average gender difference

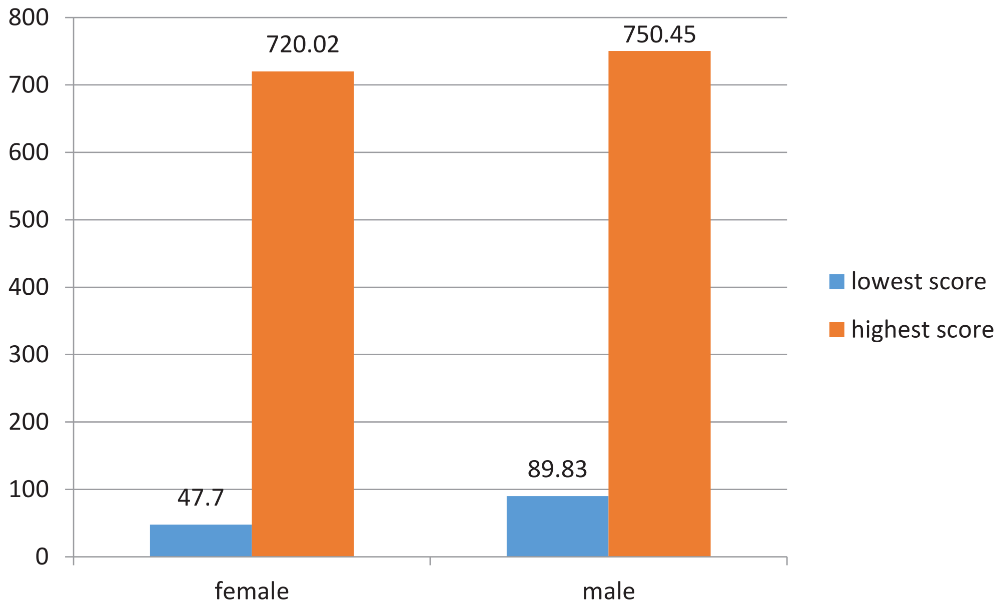


Figure 3.3.4a. Lowest and highest scores in terms of gender.

Also females' lowest score was less than males' lowest score (Figure 3.3.4a). The two curves, for both males and females, were normal with approximately the same standard deviation female (M=386, SD=102) and male (M=408, SD=108).

3.3.5 Comparison by regional differences

Students from Mount Lebanon-Beirut suburbs region scored highest among other regions, whereas students from the south region scored the lowest.

The difference between the averages according to school region was significant for all regions except for Beirut and Mount Lebanon Table 3.3.5.

Table 3.3.5. Mean score by school region (governorate)

School Region	Mean Score	Mean Difference	t-value (Mount Lebanon - Beirut suburbs) (refgroup)
Beirut	415.92	27.65	1.31
Mount Lebanon (Beirut suburbs)	443.57	0.00	-
Mount Lebanon excluding Beirut suburbs	420.40	23.17	1.62
North	362.44	81.13	**8.36**
Bekaa	373.80	69.77	**5.92**
South	361.06	82.51	**4.29**
Nabatieh	378.70	64.87	**5.61**
Note: bold t-value indicates that the difference is statistically significant.			

The highest average and the highest grade was in Mount Lebanon (Beirut suburbs). In general, it can be said that there were no extreme differences among Lebanese regions.

3.3.6 Comparison by educational sector

The participants in the PISA mathematics test were 2581 students where 56.8% belong to the private non-free schools and they represent the official schools (43.2 %).

Not surprisingly students from the private sector scored higher than students from the public sector by approximately 80 points (Table 3.3.6) and that difference was significant.

Table 3.3.6. Mean score by sector

Educational Sector	Mathematics Mean Score	Mean Difference	t-value
Public	361.48	0.00	-
Private	430.05	-68.57	**-9.12**
Note: bold t-value indicates that the difference is statistically significant.			

Both public and private sectors' distribution of grades was normal with less discrepancy in the public sector (SD=88) than in the private one (SD=106).

3.3.7 Comparison by mathematics study language

Table 3.3.7 shows that students who sat for the mathematical literacy test in English (391.03) performed lower than students who sat for the scientific literacy test in French (405.04), with a mean difference of 14.01 points, and this difference is statistically significant.

Table 3.3.7 Mean score of students as per the mathematics literacy test language

Test Language	Mean Score	Mean Difference	t-value (Ref- group English)
French	405.04	14.01	**6.94**
English	391.03	0.00	-
Note: bold t-value indicates that the difference is statistically significant.			

So, based on this, the students performed lower when the language of study was English in mathematical literacy. This leads us to think that the reading comprehension skills are affecting students' performance in mathematics.

In addition, there was a significant correlation (between the mathematics grades and the reading grades and similarly between the scores of science and mathematics This means that students don't have a particular weakness in a specific subject, but they do have problems in their competencies in general.

In summary, in Lebanon approximately 60% of the students scored below level 2 and no student scored in level 6, these results were similar to the neighbouring countries. The highest score was in grade 10. Males did better than females; private school students did better than public school students; French school students did better than English school students, and Mount Lebanon students and Beirut suburbs did better than the other students. The reasons behind all of these results need further investigation. What is really needed is an immediate and applicable strategy for improvement.

3.4 Remarks

It is not a surprise to fall behind in international tests because of our:

1) mathematics curriculum (last update 1997);
2) national books that stress only on procedural knowledge;
3) teaching methods that are more teacher-directed than student-centred.

What should be done is:

1) Reform or design a new national mathematics curriculum in a way to keep its depth whilst adding new and more important topics;
2) make sure our national books contain all kinds of cognitive assessment questions, for better understanding of the mathematical concepts, and at least, try to effectively apply the competencies agreed upon for all the grades;
3) stress more on space ,shape and statistics topics that are neglected totally by teachers, while they are main topics in international curricula;
4) prepare teachers to teach via a student-centred method with or without the use of technology.

Till the above aims are achieved, it is recommended to at least write booklets that contain conceptual and problem-solving questions to be integrated in the current mathematics curriculum, and then gradually change our official exams to include such questions.

Chapter 4

Students' performance in reading literacy

Reading literacy, similar to math literacy, was also a minor domain in PISA 2015 assessment. In Lebanon, and since the test was done either in French or in English, this literacy area will be discussed by referring to the performance of students in each language separately, but before, a rapid look at the outcomes discloses that:

- students, who participated in the PISA test in Lebanon, scored, on average, 347 on the reading literacy which is approximately 146 points lower than the OECD average (493) and 188 points lower than the highest average obtained by Singapore (535).
- the mean score in reading was the lowest amongst the other neighbouring countries (UAE: 434, Jordan: 408, Qatar: 402, Tunisia: 361, Algeria: 350, and Cyprus: 443).
- approximately 70% of the students scored below level 2 (on a 6-level scale) in reading.
- the gender difference between males and females in reading performance was only 14 points in favour of females.

To brood over the results, the following questions will be answered.

4.1 What is meant by reading literacy?

4.2 How does the reading literacy framework compare to the reading component of the Lebanese curriculum, in English and in French?

4.3 What were the scores of students in this literacy area?

4.4 What are the major remarks?

4.1 Reading literacy introduction

PISA reading literacy assessment is essential, on a global scale, to detect how students may be capable of becoming life-long learning members in their societies, for reading requires a wide range of intellectual capabilities, from elementary deciphering, to familiarity with words, syntax and superior linguistic and textual constructions and features, to knowing worldly facts. Based on that, reading literacy is defined as, **"understanding, using, reflecting on and engaging with written texts, in order to achieve one's goals, to develop one's knowledge and potential and to participate in society** (OECD, 2016, p. 49).

The focus in this assessment was related to assuring a broad coverage of reading texts and organizing those texts according to a domain that represents a certain difficulty range. In this regard, two requirements emerge in the construction of tasks. The first has to do with what the students are reading and for what purpose, whether at school or outside of it. The other has to do with how to represent a difficulty scale.

Additionally, this domain has three major attributes: the situation, the text, and the aspect.

Situation refers to the larger goals or settings that trigger reading. Based on the Common European Framework of Reference (CEFR), four settings require reading

(Council of Europe, 1996). They are “personal, public, educational, and occupational” (OECD, 2016, p. 51). In terms of personal, it is based on readers’ interests, and it amounted to 30% of the reading tasks; whereas public situations imply societal issues that are of common concern, and this constituted 30% of the reading. The educational context has to do with instructional texts (25%), and the occupational situation (15%) is rather related to the accomplishment of workplace tasks.

Text denotes the variety of material that is being read. It was split into continuous texts, or sentences and paragraphs that belong to a larger whole and non-continuous ones such as list or matrix where the reading approach must be different. Moreover, different types of texts such as description, narration, exposition, and argumentation were used.

Aspect implies the thinking method that governs how readers interact with written texts. This thinking pattern passes through stages. First, the reader accesses and retrieves information (25%); next, the reader integrates and interprets this information (50%), and finally, the reader reflects and evaluates the written passage (25%).

Furthermore, to report reading proficiency, PISA follows the descriptions found in Figure 4.1 to classify the different test items whether multiple choice, short answer questions, or even open-ended questions. The close ended questions are coded either 0 in case they are false or 1 in case they are correct. On the other hand, the open-ended questions are more flexible when it comes to coding where partial credits are given. This is why each student is given an exam booklet that has all types of questions meant to reflect the various proficiency levels.

Figure 4.1 Reading literacy proficiency levels (OECD, 2016, P. 59)

Proficiency levels and scale scores	Task description
Level 6 Score > 698.32	Tasks at this level typically require the reader to make multiple inferences, comparisons and contrasts that are both detailed and precise. They require demonstration of a full and detailed understanding of one or more texts and may involve integrating information from more than one text. Tasks may require the reader to deal with unfamiliar ideas, in the presence of prominent competing information, and to generate abstract categories for interpretations. “Reflect and evaluate” tasks may require the reader to hypothesise about or critically evaluate a complex text on an unfamiliar topic, taking into account multiple criteria or perspectives, and applying sophisticated understandings from beyond the text. A salient condition for “access and retrieve” tasks at this level is precision of analysis and fine attention to details that are inconspicuous in the texts.
Level 5 625.61 < score < 698.32	Tasks at this level that involve retrieving information require the reader to locate and organise several pieces of deeply embedded information; inferring which information in the text is relevant. Reflective tasks require critical evaluation or hypothesis, drawing on specialised knowledge. Both interpretative and reflective tasks require a full and detailed understanding of a text whose content or form is unfamiliar. For all aspects of reading, tasks at this level typically involve dealing with concepts that are contrary to expectations.

Proficiency levels and scale scores	Task description
Level 4 **552.89 < score < 625.61**	Tasks at this level that involve retrieving information require the reader to locate and organise several pieces of embedded information. Some tasks at this level require interpreting the meaning of nuances of language in a section of text by taking into account the text as a whole. Other interpretative tasks require understanding and applying categories in an unfamiliar context. Reflective tasks at this level require readers to use formal or public knowledge to hypothesise about or critically evaluate a text. Readers must demonstrate an accurate understanding of long or complex texts whose content or form may be unfamiliar.
Level 3 **480.18 < score < 552.89**	Tasks at this level require the reader to locate, and in some cases recognise the relationship between, several pieces of information that must meet multiple conditions. Interpretative tasks at this level require the reader to integrate several parts of a text in order to identify a main idea, understand a relationship or construe the meaning of a word or phrase. They need to take into account many features in comparing, contrasting or categorising. Often the required information is not prominent or there is much competing information; or there are other text obstacles, such as ideas that are contrary to expectation or negatively worded. Reflective tasks at this level may require connections, comparisons and explanations, or they may require the reader to evaluate a feature of the text. Some reflective tasks require readers to demonstrate a fine understanding of the text in relation to familiar, everyday knowledge. Other tasks do not require detailed text comprehension but require the reader to draw on less common knowledge.
Level 2 **407.47 < score < 480.18**	Some tasks at this level require the reader to locate one or more pieces of information, which may need to be inferred and may need to meet several conditions. Others require recognising the main idea in a text, understanding relationships, or construing meaning within a limited part of the text when the information is not prominent and the reader must make low level inferences. Tasks at this level may involve comparisons or contrasts based on a single feature in the text. Typical reflective tasks at this level require readers to make a comparison or several connections between the text and outside knowledge, by drawing on personal experience and attitudes.
Level 1a **score>335**	Tasks at this level require the reader to locate one or more independent pieces of explicitly stated information; to recognise the main theme or author's purpose in a text about a familiar topic, or to make a simple connection between information in the text and common, everyday knowledge. Typically the required information in the text is prominent and there is little, if any, competing information. The reader is explicitly directed to consider relevant factors in the task and in the text.
Level 1b **score>262**	Tasks at this level require the reader to locate a single piece of explicitly stated information in a prominent position in a short, syntactically simple text with a familiar context and text type, such as a narrative or a simple list. The text typically provides support to the reader, such as repetition of information, pictures or familiar symbols. There is minimal competing information. In tasks requiring interpretation the reader may need to make simple connections between adjacent pieces of information.

4.2 Reading literacy framework vis-a-vis the reading component of the Lebanese curriculum, in both English and French.

The objective of this part is to detect the commonalities and differences between the PISA Reading Framework and the Lebanese reading curriculum in order to explain the national results through a logical perspective, which paves the way for future interventions.

The themes that students study are actually precise and predetermined for each cycle, in the national textbooks. So, the students know beforehand that this is the theme that they need to work on in preparation for the official exam, and they are usually exposed to up to 12 themes per year where a related theme may be elaborated in the year that follows. In contrast, the PISA reading test has various themes that students may not know about, especially in Lebanon. Their aim is to measure the capacity of students in reading and comprehending unfamiliar texts because they are after the skill and not the theme.

The situational domains cover, as far as PISA is concerned, day to day situations, educational circumstances, and professional settings all of which may be encountered in real life and cover both what is private and what is public. In contrast, the Lebanese curriculum does not link students' learning to the various situational domains in the first place.

The texts to be read in PISA, particularly in the paper based test, format wise is a combination of continuous texts (60%), non-continuous texts (30%), and a mixture of both (10%). However, students in Lebanon are only familiar with relatively short continuous texts that are either fictitious or factual.

The types of texts are relatively common to both PISA and the Lebanese curriculum. Description, narration, and exposition, are taught in both English and French, while argumentation is taught in French but not in English to 15-year-old students in Lebanon. However, their usage is different: Within the Lebanese French curriculum, students usually identify the text type and its writing requirements, including various indicators. Whereas the PISA test focuses on the text type in relation to its aim, and the issue it addresses.

As for the aspects or the mental strategies involved in reading, the PISA framework denotes three facets. The first and most basic facet is related to accessing and retrieving information from a text, and this amounts to 25% of the questions. The second aspect requires integrating and interpreting coherence in sentences, paragraphs, or multiple texts which is actually 50% of the questions. The third and most elaborated feature requires reflecting on and evaluating the content of the text at hand. Only 25% of the questions fall under this aspect. Conversely, the 15-year-old students are rather familiar with questions that belong to the first two aspects, knowing that when students' answers are assessed, they are assessed as a whole without splitting their answers into aspects. Additionally, the majority of the questions that the students are familiar with require locating and retrieving information and a minor part requires integration and interpretation; nevertheless, it is to be noted that in all the aspects, the difficulty levels may vary from the easiest to the most complicated ones.

Moreover, the PISA questions range from multiple choice, to short response items, to items that require extended responses. As for the Lebanese curriculum, the three ways are mentioned in the official texts, but the multiple choice questions are not utilized, and the open ended responses are rather writings that must follow a certain studied structure like a narrative essay that is made up of approximately 200 words. Here, the students will be evaluated according to their ideas, organization, language, style, tidiness, and handwriting and not for higher order thinking.

Difficulty wise, the PISA framework has a different objective than the Lebanese curriculum. The former is trying to test the cognitive progression of students when the latter seeks to test whether the students have learned what was studied in class, regardless of the cognitive concepts and implications involved in the process where Bloom's taxonomy is a major reference at the understand and apply levels.

A closer look at the grade 9 Lebanese French curriculum, reveals that there is a section entitled "methods and work techniques" where the following verbs are utilized:

- exercising critical thinking
- planning one's work
- consulting an encyclopaedia
- collecting, classifying, and selecting information
- knowing how to use brochures, catalogues, etc…

However, the previously mentioned titles are not interpreted in the required competencies of the discipline and they are not supported by measurable indicators that are supposed to be assessed while in the English language curriculum, critical thinking skills and study skills are listed as learning objectives with specific performance tasks. The PISA test focuses on real life situations which extend beyond teaching a language, and this is different from the way languages are taught in the Lebanese curriculum. The concentration is on teaching the language itself without connecting it to real life situations.

To wrap up this section, it can be observed that there are variances in approaching the reading concept and its insinuations where the PISA assessment views reading as an empowering tool across all disciplines, for it is the key to achieving the diverse learning outcomes in the various disciplines that allow students to become skilled and knowledgeable citizens in today's world. In the Lebanese curriculum, the focus is on the language itself as a first foreign language. Both languages in the Lebanese curricula do not address specific requirements in other disciplines such as science or math.

4.3 Students' achievement in reading literacy

This section will be split into two parts, the first part has to do with the reading literacy results as far as the English language is concerned, and the second part will be about the reading literacy in French. This separation will occur once the overall comparison with other countries takes place and the overview of open-ended questions' results is over i.e. 4.3.1 and 4.3.2. But before proceeding, it is worth mentioning that the students who sat for the reading literacy test in English performed higher (356) than the students who sat for the reading literacy test in French (340.56), with a mean difference of 1.97 points, and this difference is statistically significant as shown in Table 4.3.

Table 4.3. Mean score of students according to the test language

Test Language	Mean Score	Mean Difference	t-value (Refgroup English)
French	340.56	-16.07	**-1.97**
English	356.64	0.00	-
Note: bold t-value indicates that the difference is statistically significant.			

4.3.1 Comparison by countries' averages

What is common though is the fact that 15 year old students in Lebanon scored the lowest, in PISA 2015.The reading mean score (347) in Lebanon was 146 points lower than the OECD average (i.e 493) and 96 points lower than Cyprus whose mean score was the highest among the countries listed in Table 4.3.1. Lebanon's mean score was the least among the 8 countries with a difference of 87 points lower than UAE, 81 points lower than Turkey, 61 points lower than Jordan, 55 points lower than Qatar, 14 points lower than Tunisia and 3 points lower than Algeria.

Table 4.3.1 Mean scores of Lebanon and the neighbouring countries in both English and French

Country	Mean Score	Difference from OECD average (493)
Cyprus	443	50
United Arab Emirates	434	59
Turkey	428	65
Jordan	408	85
Qatar	402	91
Tunisia	361	132
Algeria	350	143
Lebanon	347	146

4.3.2 Comparison between Lebanon's percentage of correct answers in the open ended questions and the international ones as far as the paper based test is concerned in both English and French

The PISA reading literacy framework identifies three aspects for the tasks pertaining to the required cognitive processes. The targeted tasks vary in difficulty ranging between 1 and 6 (whereby 1 is at the lower end of the reading scale and is classified into two sub scales a and b, and 6 is at the high end of the scale). Table 4.3.2 is a detailed comparison as far as the percentage of correct answers is concerned when it comes to open ended questions. The purpose of this table is to highlight the fact that students' correct answers were somehow similar to the international percentages in the case of the open ended responses that were corrected by Lebanese people. In PISA 2015, the tasks are distributed as found in Table 4.3.2.

Table 4.3.2 Comparison between Lebanon's percentages of correct open-ended questions versus the international ones

Aspect	Number of tasks	Proficiency Level	Number of questions	International average of the percentage[1] of correct responses (PBA)	Lebanon's average of the percentage of correct responses (PBA)
Access and retrieve	15	Level 1b Level 2 Level 3 Level 4 Level 5 Level 6	2 5 3 3 - 2	47.73	50.28
Integrate and interpret	17	Level 1b Level 2 Level 3 Level 4 Level 5 Level 6	- 5 5 4 2 1	40.71	34.18

Aspect	Number of tasks	Proficiency Level	Number of questions	International average of the percentage[1] of correct responses (PBA)	Lebanon's average of the percentage of correct responses (PBA)
Reflect and evaluate	18	Level 1b Level 2 Level 3 Level 4 Level 5 Level 6	- 3 5 5 4 1	36.81	35.30

Furthermore, the following percentages of correct responses, for both English and French, were obtained once aspects and levels of difficulty were compared.

Aspect / Level	Percentage of correct responses in the « access and retrieve » category		Percentage of correct responses in the «integrate and interpret » category		Percentage of correct responses in the « reflect and evaluate »category
Level 1b	82.21		--		--
Level 2	56.96	>	47.22	>	45.44
Level 3	53.36	>	34.2		38.67
Level 4	40.80	>	32.48		41.29
Level 5	--		16.88		22.85
Level 6	11.53	>	10.36	>	7.95

Based on the above table, we may conclude the following:

a- Apparently, students were most able to perform in "Access and retrieve" tasks regardless of the level of difficulty.

b- "Integrate and interpret" tasks are easier for students than "Reflect and evaluate" tasks and these are found in proficiency level 2 and in proficiency level 6.

c- "Integrate and interpret" tasks are less accessible than "Reflect and evaluate" tasks at the median levels.

These previous remarks, once compared to the current teaching practices that have been adopted since 1997- the year the official curricula were issued- clearly show that critical thinking and construction of meanings are minimal in students' practices.

4.3.3 Comparison by grade in English reading literacy

After discussing the previous general notions, now a closer look on the scores that were obtained in each grade is a must. Grade 10 students, or the reference group, constituted 61.4% of the overall sample or the highest percentage. But the highest score in reading literacy was obtained in grade 12. However, it is not significant as found when applying the t-test, knowing that grade 12 students constituted 0.15% of the overall reading literacy sample, in English. Nevertheless, the difference was significant in grades 7, 8, and 9. So, the results indicate that the grade 10 mean score reflected the reality of things where the performance is still below proficiency level 2 or the baseline level.

Table 4.3.3 Mean score by grade level in English reading literacy

Grade	% of students	Mean Score	Mean Difference	t-value (Ref group grade 10)
7	2.05	240.84	136.52	**6.50**
8	6.83	264.29	113.07	**10.73**
9	16.67	306.92	70.44	**6.19**
10	61.48	377.36	0.00	-
11	12.83	389.09	-11.74	-1.13
12	0.15	395.19	-17.83	-0.38
Note: bold t-value indicates that the difference is statistically significant.				

4.3.4 Comparison by gender in English reading literacy

There were gender differences between males and females in Lebanon by 19.68 points. Females achieved better than males in reading literacy as shown in Table 4.3.4.

Table 4.3.4 Mean score by gender

Gender	Mean Score	Mean Difference	t-value (Ref group males)
Female	366.55	-19.68	**-3.12**
Male	346.87	0.00	-
Note: bold t-value indicates that the difference is statistically significant.			

4.3.5 Comparison by region in English reading literacy

Students from Mount Lebanon and Beirut suburbs scored the highest among the other regions, and students from the south region scored the lowest where the difference was statistically significant.

Table 4.3.5 Mean score by region in English reading literacy

School Region	Mean Score	Mean Difference	t-value (Ref group Mount Lebanon - Beirut suburbs)
Beirut	355.11	24.69	0.86
Mount Lebanon (Beirut suburbs)	379.80	0.00	-
Mount Lebanon (away from Beirut)	375.17	4.64	0.22
North	402.68	-22.88	-0.56
Bekaa	339.04	40.76	1.99
South	317.59	62.21	**3.24**
Nabatieh	344.31	35.49	2.01
Note: bold t-value indicates that the difference is statistically significant.			

4.3.6 Comparison by educational sector in English reading literacy

Students in the private sector in Lebanese schools did better than students studying in the public sector with a difference of 50.42 points, and this difference is significant.

Table 4.3.6 Mean score by educational sector in English reading literacy

Educational Sector	Mean Score	Mean Difference	t-value (Refgroup public sector)
Public	328.85	0.00	-
Private	379.27	-50.42	**-4.43**
Note: bold t-value indicates that the difference is statistically significant.			

Here is where the English reading literacy part ends and the French literacy part begins.

4.3.7 Comparison by grade level in French reading literacy

The students, in Lebanon, who did the PISA test in French were distributed as found in Table 4.3.7. Grade 7 students constituted 3.7% of the sample; grade 8 were represented by 8.3%; grade 9 students amounted to 16.6% of the sample, and the highest represented percentage was grade 10 (62.3%), or the reference group. Grade 11 were 9% of the overall sample, and those who belonged to grade 12 were only 0.1%. As mentioned earlier, the PISA sample focuses on students aged 15 up until 16 and 3 months of age. As indicated in the table, the lowest mean score was obtained in grade 7, and it is statistically significant. The highest mean score was detected in grade 10, and this is reasonable since grade 10 students represent the majority of the 15 year old students.

Table 4.3.7 Mean score by grade in French reading literacy

Grade	% of students	Mean Score	Mean Difference	t-value (Ref group grade 10)
7	4.69	223.03	153.92	**12.39**
8	9.15	244.45	132.50	**12.73**
9	16.54	289.99	86.96	**6.37**
10	62.81	376.95	0.00	-
11	6.69	337.71	39.24	**3.04**
12	0.12	345.69	31.26	0.79
Note: bold t-value indicates that the difference is statistically significant.				

4.3.8 Comparison by gender in French reading literacy

The mean score of females was 13 points above that of males, but statistically speaking the difference was insignificant. However, the mean score of females is still below the OECD average by 146.72 points. The gender difference gap between males and females is even higher for instance in Jordan, Qatar, and the UAE by more than 50 points in favor of females as compared to Lebanon.

Table 4.3.8 Mean score by gender in French reading literacy

Gender	Mean Score	Difference in mean score between male students and female students	t-value (Refgroup males)
Female	346.28	-12.93	-1.89
Male	333.35	0.00	-

4.3.9 Comparison by region in French reading literacy

The average scores obtained by students who belong to Mount Lebanon and Beirut suburbs were the highest across regions (416.58). The average score found in the North was 121 points less than Mount Lebanon and the suburbs of Beirut, and it is statistically significant. Nabatieh, Bekaa, and the South obtained similar averages around 115 points less than Mount Lebanon and the suburbs of Beirut, with statistical significance. Thus, 121 points separate the highest score from the lowest score which reflects a great disparity amongst regions. According to the OECD, a difference of 100 points is worth 3 schooling years. Hence, this disparity opens the door to questions that are related to equity and resilience in education.

Table 4.3.9 Mean score by regions in French reading literacy

School Region	Mean Score	Mean Difference	t-value (Ref group Mount Lebanon - Beirut suburbs)
Beirut	394.37	22.22	0.67
Mount Lebanon (Beirut Suburbs)	416.58	0.00	-
Mount Lebanon (away from Beirut)	373.61	42.97	1.48
North	295.72	120.86	**8.51**
Bekaa	299.73	116.86	**6.71**
South	296.32	120.26	**3.06**
Nabatieh	308.74	107.84	**6.49**
Note: bold t-value indicates that the difference is statistically significant.			

4.3.10 Mean score by educational sector in French reading literacy

Also in French reading literacy, the performance of private school students was better than the public ones, and this difference is statistically significant.

School Sector	Mean Score	Difference in mean score between students in the public and private sectors	t-value (Refgroup public sector)
Public	292.62	0.00	-
Private	392.31	-99.69	**-8.70**
Note: bold t-value indicates that the difference is statistically significant.			

4.4 Remarks

All in all, it can be said that the English and French curricula have been designed in 1997. At that time, the 21st century skills were not launched, while the PISA exam has been designed accordingly. As a result, the 21st century skills have not been addressed in a well-designed approach in the Lebanese context.

In the reflection process, the following points need to be considered:

- Both Lebanese English and French curricula do not focus their instruction on real life situations and problem solving as presented in PISA which adds to the novelty of the exam items.
- In the Lebanese curriculum, languages are taught for academic achievement, social settings, and cultural enrichment while PISA has adopted (CEFR)'s personal, educational, and occupational settings, leading to a gap regarding this issue. In addition, the types of questions, levels of text complexity, and assessment approaches are not familiar to the 15 year old students in Lebanese schools.
- In the lebanese context, science, math and other disciplines are taught in French or English, called both first foreign languages (despite a different approach in their teaching methodology). But both of them do not address the role / function of the language in teaching math and sciences: they do not recognize and work on the different skills required by achieving sciences or math objectives.

As a final note, reading literacy is the cornerstone that prepares students to become successful in all disciplines. The fact that this literacy area was the weakest for students, rings the alarm bells because the future of students and their chances at succeeding in high school and college later on are jeopardized by the current Lebanese curriculum and the accompanying teacher centred teaching approach.

Chapter 5

Concluding comments

The average obtained by students, in Lebanon, was at the lowest proficiency level or 1. It was even below the baseline or Level 2. Only 29.6% of the students reached or exceeded level 2, as shown in Table 5. Only Algeria and Tunisia scored lower than Lebanon as far as Level 2 is concerned. According to OECD analyses since the year 2000 (OECD, 2016), students who do not reach Level 2 usually face difficulties in pursuing their high school studies, their college studies, and they will even have a hard time in finding a decent job.

Table 5 Proficiency levels attained by students, in Lebanon, as compared to levels of students in neighbouring countries.

Proficiency Levels	< 1b	1b 262,04< score ≤ 334,75	1a 334,75< score ≤ 407,47	2 407,47< score ≤ 480,18	3 480,18< score ≤ 552,89	4 552,89< score ≤ 625,61	5 625,61< score ≤ 698,32	6 Score > 698,32	Percentage of students who attained or exceeded Level 2
Algeria	11	31.2	36.8	17.0	3.7	0.3	0.0	0.0	21
Tunisia	11.1	26.6	33.9	21.0	6.5	0.8	0.1	0.0	28.4
Lebanon	24.1	24.5	21.7	15.8	9.4	3.6	0.7	0.1	29.6
Qatar	11.1	17.7	22.8	22.7	16.8	7.4	1.4	0.1	48.4
Jordan	7.4	13.7	25,2	30.7	18.7	4.1	0.3	0.0	53.8
UAE	5.4	13.2	21.8	25.4	20.5	10.7	2.7	0.3	59.6
Turkey	2.3	10.9	26.8	32.6	21.1	5.7	0.6	0.0	60
Cyprus	4.4	11.4	19.8	27.0	23.0	11.3	2.8	0.2	64.3
OECD Average	1.3	5.2	13.6	23.2	27.9	20.5	7.2	1.1	79.9

Moreover, there are students who were top performers:

a. 2.5 % of students were « top performers » for they reached Levels 5 and 6 in one literacy area out of 3.

b. 0.2% of students were "top performers" in all 3 literacy areas.

c. The top performers in reading comprehension constitute 0.8 %, as opposed to 8.3% as per the OECD average.

Table 5a Top performers

Country	Not top performers in any	Top only science	Top only reading	Top only math	Top science +reading	Top science +math	Top reading +math	Top all 3	Top science and also reading and math
OECD Average	84.7	1.1	2.5	3.9	1.0	2.0	1.1	3.7	46.8
Turkey	98.4	0.1	0.3	0.8	0.0	0.1	0.1	0.1	28.4
Algeria	99.9	0.0	0.0	0.1	0.0	0.0	0.0	0.0	--
Cyprus	94.5	0.3	1.8	1.8	0.3	0.4	0.4	0.6	39.0
Jordan	99.4	0.1	0.2	0.2	0.0	0.0	0.0	0.0	4.2
Qatar	96.6	0.4	0.6	1.0	0.3	0.5	0.2	0.6	33.8
Tunisia	99.4	0.0	0.0	0.5	0.0	0.0	0.0	0.0	--
UAE	94.2	0.6	1.1	1.6	0.4	0.7	0.3	1.1	38.7
Lebanon	97.5	0.1	0.4	1.5	0.0	0.1	0.2	0.2	39.0

Three issues require further attention:

a. 2.5 % of students were « top performers » in one out of 3 literacy areas as opposed to 15% when it comes to the OECD mean score (1/6).

b. 0.2% of students were « top performers » in all 3 literacy areas (1/18).

c. The top performers in reading comprehension constitute 0.8 % in Lebanon, in contrast to 8.3 % based on the OECD mean score.

Table 5b Low achievers

	Not low achiever in any	Low only science	Low only reading	Low only math	Low science +reading	Low science +math	Low reading +math	Low in all 3	Low in science and also reading and math
OECD Average	69.2	2.0	3.0	4.9	2.4	3.8	1.7	13.0	59.2
Turkey	40.7	2.2	3.0	8.8	2.8	8.3	3	31.2	70.1
Algeria	9.3	1	4.8	6.0	3.9	4.7	9.1	61.1	86.4
Cyprus	45.9	4	3.4	6.5	4.1	7.9	2	26.1	62.0
Jordan	26.0	1.8	2.8	15.4	1.8	10.4	6.0	35.7	71.7
Qatar	34.9	1.3	2.9	8	2.2	4.3	4.4	42.0	84.3
Tunisia	16.2	1.0	4.6	6.9	3.3	4.3	6.3	57.3	86.9
UAE	43.4	1.9	3	8.6	2.9	5.7	3.2	31.3	74.9
Lebanon	22.6	2.8	7.4	2.2	7.1	2.1	5.3	50.7	80.9

Further, certain percentages are alarming:

a. 87.4 of students were low achievers in at least one out of three literacy areas, as opposed to 30.8 % as per the OECD mean score which is three times more ;

b. 70.5 % of students were low achievers in reading comprehension, as opposed to 20.1 as per the OECD mean score which is 3 and a half times more.

c. 50.7 % of students were low achievers in all 3 literacy areas, which is 4 times more than the OECD mean score (13 %).

d. The results are better in the neighbouring countries, excluding Algeria and Tunisia.

In conclusion, the low scores that were achieved by students in Lebanon convey that there is a major problem in equity (refer to Table 5c Equity in Education) and fairness. Equity in education implies ensuring that education outcomes are the result of students' abilities, will and efforts, and not the result of their personal circumstances, and this lies at the heart of advancing social justice and inclusion. Fairness refers to the degree to which background circumstances influence students' education outcomes.

Even more, PISA 2015 concentrates on two goals related to equity: inclusion and fairness. PISA defines inclusion in education as ensuring that all students attain essential foundation skills. In this light, education systems where a large proportion of 15-year-olds remain out-of-school and/or has not learned the basic skills needed to fully participate in society, are not considered as sufficiently inclusive. And this is what was observed, in Lebanon, based on the weak scores, and this is opposite to obtaining high scores.

Most high-performing systems also achieve high levels of inclusion; they ensure that the vast majority of 15-year-olds are enrolled in school, and they reduce the number of students who perform poorly.

On average across OECD countries, students' socio-economic status explains about 13% of the variation in student performance in science, reading, and mathematics; in Lebanon, it is 10.

Advantaged students tend to outscore their disadvantaged peers by large margins. On average across OECD countries, a one-unit increase on the PISA index of economic, social, and cultural status is associated with an increase of 38 score points in the science assessment, and in Lebanon, it is 26; so the impact is less.

Table 5c Equity in Education

		Inclusion		Fairness			
	Mean performance in science	Coverage of the national 15-year-old population	Percentage of students performing below Level 2 in science	Percentage of variation in science performance explained by students' socioeconomic status	Score-point difference in science associated with a one-unit increase in the ESCS1	Percentage of resilient students	Percentage of the between-school variation in science performance explained by students' and schools' ESCS
	Mean Score	Index	%	%	Score Difference	%	%
OECD	493	0.89	21	13	38	29	62.9
Lebanon	386	0.66	63	10	26	6	39.9

On average across OECD countries, disadvantaged students are 2.8 times more likely than more advantaged students to not attain the baseline level of proficiency in science. In PISA 2015, 29% of disadvantaged students are "resilient" – meaning that they score among the top quarter of students in all participating countries/ economies despite the odds against them. Disadvantaged students are less likely to expect a career in science and to embrace scientific approaches to enquiry.

Yet, these results have to be interpreted with caution since several studies, as opposed to others, criticize PISA. The first issue has to do with the fact that Lebanon does not belong to a western context; moreover, the "criticism of the PISA sampling frame adopted has been expressed since the early cycles of PISA. Scholars have debated OECD's age criterion as opposed to the grade level criterion" (Hopfenbeck et al., 2017, p. 11), and this was obvious in the students' results where grade 10 students' scores were higher than the scores of those who belonged to the other grades. This confirms what Prais (2004) emphasized that an age related sample will create a sample-level-problem where a significant number of students skipped or failed a class, and this implies that there are major discrepancies when it comes to curriculum exposure.

Additionally, students, in Lebanon, took the test in a foreign language, and this in itself is a challenge and disadvantage to pupils because the national language is different than the test language (Hopfenbeck et al., 2017). This was evident in several places. To illustrate, some of the students who answered items, in English, in the student questionnaire filled information that was different from what the question asked for.

On the whole, the PISA results can be considered as useful, but at the same time "a substantial number of articles in both the critique and impact/policy categories are warning policy-makers and researchers alike to be cautious about using PISA data as a means for valid comparison or informed policy-making" (Hopfenbeck et al., 2017, p.15).

So, in order to benefit from this PISA 2015 experience, it is recommended that education stakeholders in this country decide on prioritizing things. For now, should our major concern be the international tests? If yes, then immediate actions need to be taken to render these tests a targeted national priority which implies that efforts need to be invested at all levels to improve the performance of students; however, Lebanon cannot keep on participating in international tests without any additional hard work because the outcomes would be the same, and this participation would be a false investment.

On the other hand, policy makers can join their efforts to contribute to a drastic curricular change, as CERD intends to do; and such reform attempts cannot become a reality except when they belong to a national educational reform strategy, and this requires a political decision, consolidation of efforts, a task force of experts, and a genuine paradigm shift.

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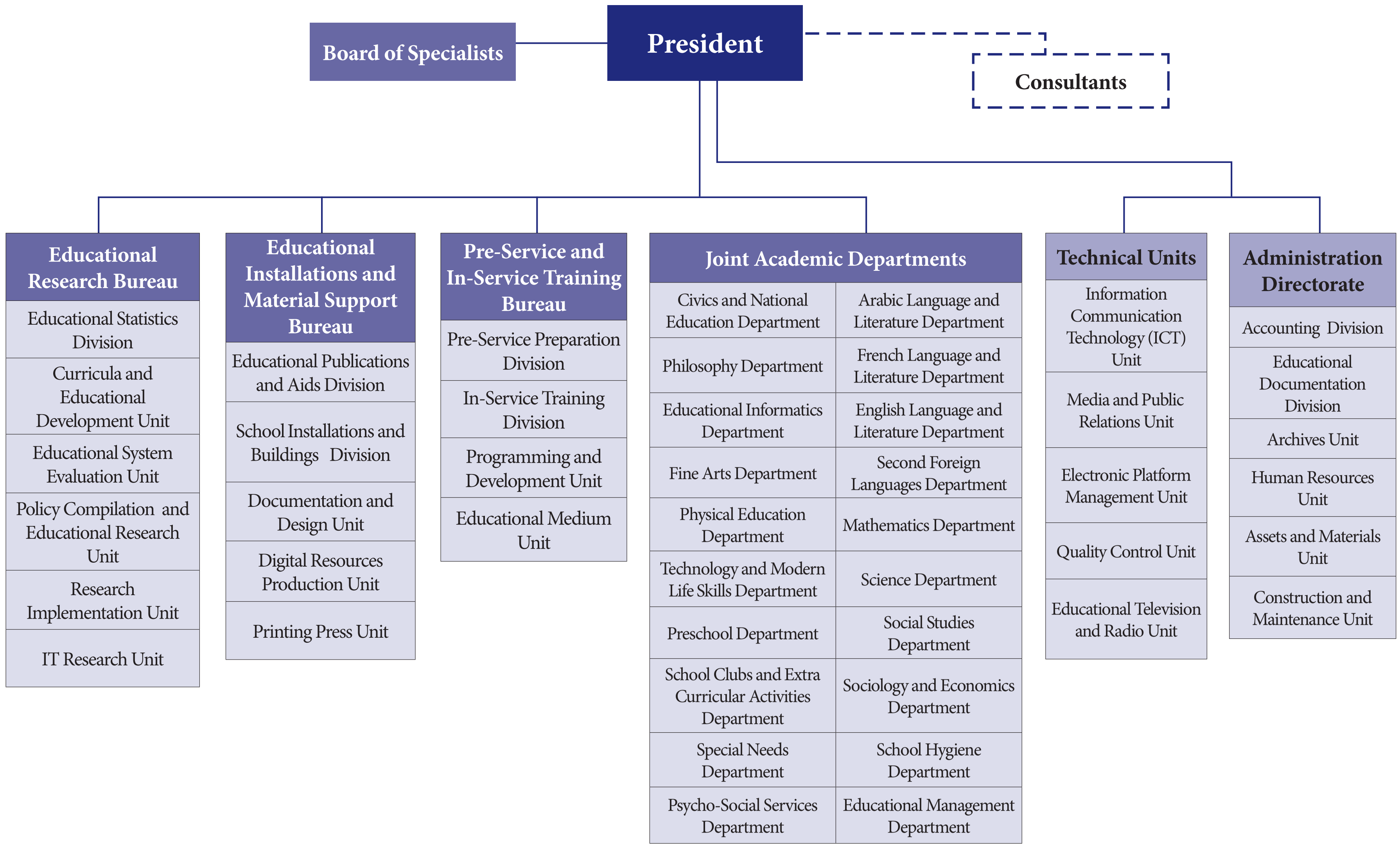
Appendix A

CERD Organizational Chart



Appendix B

Table 1: PISA vs. Physics in the Lebanese National Curriculum

Contexts for the PISA 2015 Scientific Literacy Assessment			Themes covered in the Lebanese National Curriculum			
Context	**Level**	**Content Knowledge**	**Theme**	**Level**	**Description**	**Grade level**
Health and Diseases	**Personal**	Maintenance of health, accidents, nutrition	**Waves**	**Personal**	Sound waves	G8
					Sound waves (Reading)	G11
	Local/National	Control of disease, social transmission, food choices, community health	---	**Local/National**	---	---
	Global	Epidemics, spread of infectious diseases	---	**Global**	---	---
Natural Resources	**Personal**	Personal consumption of materials and energy	**Mechanics**	**Personal**	Work, Power and forms of Energy (Reading)	G8
	Local/National	Maintenance of human populations, quality of life, security, production and distribution of food, energy supply		**Local/National**		
	Global	Renewable and non-renewable natural systems, population growth, sustainable use of species	---	**Global**	---	---
Environmental Quality	**Personal**	Environmentally friendly actions, use and disposal of materials and devices	---	**Personal**	---	---
	Local/National	Population distribution, disposal of waste, environmental impact	---	**Local/National**	---	---
	Global	Biodiversity, ecological sustainability, control of pollution, production and loss of soil/biomass	---	**Global**	---	---
Hazards	**Personal**	Risk assessments of lifestyle choices	**Electricity**	**Personal**	Electric power and energy	G9
					Resistors – Short-circuit and protecting resistor	G10
	Local/National	Rapid changes [*e.g.*, earthquakes, severe weather], slow and progressive changes [*e.g.*, coastal erosion, sedimentation], risk assessment	---	**Local/National**	---	---
	Global	Climate change, impact of modern communication	---	**Global**	---	---
Frontiers of Science and Technology	**Personal**	Scientific aspects of hobbies, personal technology, music and sporting activities	---	**Personal**	---	---
	Local/National	New materials, devices and processes, genetic modifications, health technology, transport	---	**Local/National**	---	---
	Global	Extinction of species, exploration of space, origin and structure of the Universe	**Mechanics**	**Global**	Kepler's laws (Reading)	G11

Table 2: PISA vs. Life/Life and Earth Sciences in the Lebanese National Curriculum

Contexts for the PISA 2015 Scientific Literacy Assessment			Themes covered in the Lebanese National Curriculum			
Theme	**Level**	**Description**	**Theme**	**Level**	**Description**	**Grade level**
Health and Diseases	**Personal**	Maintenance of health, accidents, nutrition	**Nutrition**	**Personal**	Malnutrition diseases	G9
	Local/National	Control of disease, social transmission, food choices, community health	---	**Local**	---	---
	Global	Epidemics, spread of infectious diseases	**Immunology**	**Global**	Transmission of diseases, prophylactic and therapeutic methods	G8
Natural Resources	**Personal**	Personal consumption of materials and energy	---	**Personal**	---	---
	Local/National	Maintenance of human populations, quality of life, security, production and distribution of food, energy supply	---	**Local**	---	---
	Global	Renewable and non-renewable natural systems, population growth, sustainable use of species	**Control and protection of the environment**	**Global**	Pollution, conservation and conservation of fresh water Pollution, conservation and conservation of soil (suspended)	G10
Environmental Quality	**Personal**	Environmentally friendly actions, use and disposal of materials and devices	---	**Personal**	---	---
	Local/National	Population distribution, disposal of waste, environmental impact	---	**Local/National**	---	---
	Global	Biodiversity, ecological sustainability, control of pollution, production and loss of soil/biomass	---	**Global**	Man and the Carbon cycle Energy Flow and the Carbon cycle (suspended in 2002); small part resumed in 2016 but not covered due to shortage of time	Grade 10 and 11
Hazards	**Personal**	Risk assessments of lifestyle choices	---	**Personal**	---	---
	Local/National	Rapid changes [*e.g.*, earthquakes, severe weather], slow and progressive changes [*e.g.*, coastal erosion, sedimentation], risk assessment	**Earth and environment**	**Local**	Earthquakes, volcanoes, circulation of matter on earth(very shallow ideas)	---
	Global	Climate change, impact of modern communication	---	**Global**	---	G8
Frontiers of Science and Technology	**Personal**	Scientific aspects of hobbies, personal technology, music and sporting activities	---	**Global**	---	---
	Local/National	New materials, devices and processes, genetic modifications, health technology, transport	---	**Global**	---	---
	Global	Extinction of species, exploration of space, origin and structure of the Universe	---	**Global**	---	---

Table 3: PISA vs. Chemistry in the Lebanese National Curriculum

Contexts for the PISA 2015 Scientific Literacy Assessment				Themes covered in Chemistry in the Lebanese National Curriculum			
Theme	**Level**	**Description**		**Theme**	**Level**	**Description**	**Grade level**
Health and Diseases	**Personal**	Maintenance of health, accidents, nutrition	212b7e				
	Local/ National	Control of disease, social transmission, food choices, community health					
	Global	Epidemics, spread of infectious diseases					
Natural Resources	**Personal**	Personal consumption of materials and energy		- Organic Chemistry	**Local +National +Global**	Aliphatic Hydrocarbons (overview) Aromatic Hydrocarbons- Esterification (suspended in 2016) Petroleum and Synthetic Materials	G 9
	Local/ National	Maintenance of human populations, quality of life, security, production and distribution of food, energy supply		Water		Obtaining potable water (suspended since 1999)	G 10
	Global	Renewable and non-renewable natural systems, population growth, sustainable use of species		Synthetic polymers		Synthetic polymers (overview)	G 11 (H)
				Organic Chemistry		Hydrocarbons Petroleum and Natural Gas	G 11 Sciences
				- Industrial inorganic chemistry - Metallurgy		- Study of the principles of manufacturing. - Fertilizers, Explosives, Soaps. - Cement and glass - Metals and alloys (parts of them were suspended since 1999)(the rest were suspended in 2016)	G 11 Sciences
Environmental Quality	**Personal**	Environmentally friendly actions, use and disposal of materials and devices		- Matter - Solutions, suspensions, colloids. - Chemical reactions.	**Personal +Local +National +Global**	Environmental Applications: Water purification, Home and industrial filters. Environmental applications: Dilution of toxic wastes.(suspended in 2016) Combustion as one type of chemical Reactions:- Pollution due to combustion reactions/ - Safety (Laboratory, house, forests …)	G 7
				Acids, bases and salts.		Applications: Acid rain- Antacids- Fertilizers (suspended in 2016)	G 8
	Local/ National	Population distribution, disposal of waste, environmental impact		Chemistry and the Environment	**Personal +Local +National +Global**	Pollution in air, water and soil/ Pollutants and their sources Effects of pollution (Greenhouse effect) – Ozone Depletion – Acid Rain – Heavy Metals – Plastic Wastes – Agricultural Wastes) - Addressing pollution problems (some learning objectives were suspended in 1999 and in 2016)	G 9
	Global	Biodiversity, ecological sustainability, control of pollution, production and loss of soil/biomass		**Environment**		Fertilizers- Atmospheric pollution (suspended since 1999)	G 10
				Pollution		Industrial Wastes and their Impact on the environment Household wastes and their impact on the environment Treatment of wastes and fight against pollution.	G 11 Sciences
				- Soaps and detergents - Synthetic polymers - Pesticides		Detergents Pesticides Chemical communication among insects Future strategies	G 11 Humanities

Contexts for the PISA 2015 Scientific Literacy Assessment				Themes covered in Chemistry in the Lebanese National Curriculum			
Theme	Level	Description		Theme	Level	Description	Grade level
Hazards	Personal	Risk assessments of lifestyle choices		---	---	---	
	Local/ National	Rapid changes [e.g., earthquakes, severe weather], slow and progressive changes [e.g., coastal erosion, sedimentation], risk assessment	212b7e	---	---	---	
	Global	Climate change, impact of modern communication		---	---	---	
Frontiers of Science and Technology	Personal	Scientific aspects of hobbies, personal technology, music and sporting activities		---	---	---	
	Local/ National	New materials, devices and processes, genetic modifications, health technology, transport		---	---	---	
	Global	Extinction of species, exploration of space, origin and structure of the Universe		---	---	---	

Appendix C

The General Science Objectives in the National Curriculum

1. Develop the learners' intellectual and practical scientific skills.
2. Deepen the learner's awareness in the ability of humans to understand, invent, and create.
3. Understand the nature of science and technology, their development across history, and their impact on human thought.
4. Ensure that learners have acquired the facts, concepts, and principles necessary to understand natural phenomena.
5. Motivate students to apply basic scientific principles in all sciences.
6. Explain the scientific concepts and principles behind commonly used machines and devices.
7. Acquire knowledge about health, environment, and safety practices and behave accordingly.
8. Realize that some natural resources can be depleted and make the learner aware of the role of science in sustaining these resources.
9. Encourage learners to use scientific knowledge and skills in novel situations especially in everyday life.
10. Emphasize the role of scientists in the advancement of human kind.
11. Encourage learners to be open to the ideas of scientists from different cultures and to their contributions in the advancement of science.
12. Encourage learners to abide by such scientific values as honesty and objectivity.
13. Develop the learners' scientific curiosity and orientation toward scientific research.
14. Encourage learners to work independently and cooperatively in solving scientific problems.
15. Make the learners aware of career possibilities in different science related areas.

Appendix D

Domains and competencies in the assessment framework in the National Curricula (Life Science/Physics/Chemistry)

Subject	Domain	Competencies
Life Science	**Mastering Acquired Knowledge**	• Apply acquired knowledge to a new Situation • Relate acquired knowledge to a new given
	Mastering Communication Techniques	• Use an Adapted Scientific Language • Use the means of scientific representations
	Mastering Experimental Techniques	• Performing an experiment or a dissection by following certain steps/ • Raises or cultivates animals and plants and observe their mode of reproduction
Physics	**Applying Knowledge**	• Apply knowledge specific to… • Distinguish between closely related physical quantities… • Identify… • Interpret daily life physical phenomena related to… • Explain…
	Communication	• Read and interpret a diagram… • Use an appropriate scientific vocabulary in accordance with the different representation modes: written, diagrams, tables, graphs… • Look up information from diversified resources.
	Experimentation	• Use measuring devices… • Assemble… • Verify the laws of… • Follow an experimental conduct in order to… • Determine experimentally the characteristics of…
Chemistry	Applying Knowledge	• Use specific chemistry knowledge. • Identify the characteristics of. • Identify the role of. • Classify chemical species based on their properties. • Distinguish between. • Relate the parameters and / or the variables. • Interpret. • Explain the consequences of chemistry on health, quality of life and environment.
	Mastery - Communicating	• Use accurate scientific vocabulary • Utilize various methods to present information. • Read-up a scientific text. • Make use of a tabulated data. • Interpret a schema and / or a graph • Conduct documentary research.
	Designing an experiment	• Perform experimental activities. • Write report of an experiment. • Build molecular models. • Devise an experimental procedure.

Appendix E

Table 1: Competencies covered in PISA 2015 vs. Competencies covered in L.S. in the National Curriculum)

PISA 2015 Competency with measurable descriptions	**Domains and Competencies in Life and Earth Science/Life Science**		
Explain phenomena scientifically, that is Recognize, offer and evaluate explanations for a range of natural and technological phenomena demonstrating the ability to:	**Mastering Acquired Knowledge:**	**Practicing Scientific Reasoning**	**Mastering Communication Techniques**
• Recall and apply appropriate scientific knowledge;	Apply /relate acquired knowledge to a new Situation/ new given		
• Identify, use and generate explanatory models and representations;			Use an Adapted Scientific Language/ Use the means of scientific representations
• Make and justify appropriate predictions;	Relate information in order to explain		
• Offer explanatory hypotheses;		Formulation of hypothesis	
• Explain the potential implications of scientific knowledge for society.			

Evaluate and design scientific enquiry that is describe and appraise scientific investigations and propose ways of addressing questions scientifically demonstrating the ability to:	**Practicing Scientific Reasoning**	**Mastering Experimental Techniques**
• Identify the question explored in a given scientific study;	Pose a problem/ Formulate a hypothesis	
• Distinguish questions that are possible to investigate scientifically;		
• Propose a way of exploring a given question scientifically;	Test a hypothesis by designing an experiment	Performing an experiment (suspended)
• Evaluate ways of exploring a given question scientifically;		
• Describe and evaluate a range of ways that scientists use to ensure the reliability of data and the objectivity and generalizability of explanations.		

Interpret data and evidence scientifically Analyze and evaluate scientific data, claims and arguments in a variety of representations and draw appropriate conclusions showing the ability to:	**Practicing Scientific Reasoning**	**Mastering Communication Techniques**
• Transform data from one representation to another;		Use the means of scientific representations
• Analyze and interpret data and draw appropriate conclusions;	Deduce by Interpreting results, Elaborate a synthesis, Draw out information by analyzing texts or scientific representations	
• Identify the assumptions, evidence and reasoning in science-related texts;	Perform critical thinking	
• Distinguish between arguments which are based on scientific evidence and theory and those based on other considerations;		
• Evaluate scientific arguments and evidence from different sources (e.g. newspaper, internet, journals).		

Table 2: Competencies covered in PISA2015 vs. Competencies covered in Physics in the National Curriculum

PISA 2015 Specific Domain Competency with measurable descriptions	The Sciences National Curriculum Domains and Competencies in Physics		
Explain phenomena scientifically, that is Recognize, offer and evaluate explanations for a range of natural and technological phenomena demonstrating the ability to:	**Applying Knowledge**	**Communication**	**Experimentation**
• Recall and apply appropriate scientific knowledge;	• Apply knowledge specific to…		• Use measuring devices… • Assemble…
• Identify, use and generate explanatory models and representations;	• Distinguish between closely related physical quantities… • Identify…		• Determine experimentally the characteristics of…
• Make and justify appropriate predictions;	• Interpret daily life physical phenomena related to… • Explain…		• Verify the laws of…
• Offer explanatory hypotheses;			• Follow an experimental conduct in order to…
• Explain the potential implications of scientific knowledge for society.			
Evaluate and design scientific enquiry, that is describe and appraise scientific investigations and propose ways of addressing questions scientifically demonstrating the ability to:	**Applying Knowledge**	**Communication**	**Experimentation**
• Identify the question explored in a given scientific study;			
• Distinguish questions that are possible to investigate scientifically;			
• Propose a way of exploring a given question scientifically;			
• Evaluate ways of exploring a given question scientifically;			
• Describe and evaluate a range of ways that scientists use to ensure the reliability of data and the objectivity and generalizability of explanations.			

PISA 2015 Specific Domain Competency with measurable descriptions	The Sciences National Curriculum Domains and Competencies in Physics		
Interpret data and evidence scientifically Analyze and evaluate scientific data, claims and arguments in a variety of representations and draw appropriate conclusions demonstrating the ability to:	**Applying Knowledge**	**Communication**	**Experimentation**
• Transform data from one representation to another;		• Use appropriate scientific vocabulary in accordance with the different representation modes: oral, written, diagrams, tables, graphs…	
• Analyze and interpret data and draw appropriate conclusions;		• Read and interpret a diagram… • Look up information from diversified resources.	
• Identify the assumptions, evidence and reasoning in science-related texts;			
• Distinguish between arguments which are based on scientific evidence and theory and those based on other considerations;			
• Evaluate scientific arguments and evidence from different sources (e.g. newspaper, internet, journals).			

Table3: Competencies covered in PISA2015 vs Competencies covered in Chemistry in the National Curriculum

PISA 2015 Specific Domain Competency with measurable descriptions	The Sciences National Curriculum Domains and Competencies in Chemistry		
Explain phenomena scientifically, that is Recognize, offer and evaluate explanations for a range of natural and technological phenomena demonstrating the ability to:	**Applying Knowledge**	**Mastery - Communicating**	**Designing an experiment**
• Recall and apply appropriate scientific knowledge;	• Use specific chemistry knowledge.	• Use accurate scientific vocabulary	
• Identify, use and generate explanatory models and representations;	• Identify the characteristics of. • Identify the role of.	• Make use of a tabulated data.	
• Make and justify appropriate predictions;			• Perform experimental activities.
• Offer explanatory hypotheses;	• interpret	• Interpret schema or graph	
• Explain the potential implications of scientific knowledge for society.	• Explain the consequences of chemistry on health, quality of life and environment.	• Conduct documentary research.	
Evaluate and design scientific enquiry, that is describe and appraise scientific investigations and propose ways of addressing questions scientifically demonstrating the ability to:	**Applying Knowledge**	**Mastering Communication**	**Conducting Experiment**
• Identify the question explored in a given scientific study;	• Relate parameters and variables	• Make use of table of data • Interpret a schema or graph	
• Distinguish questions that are possible to investigate scientifically;			
• Propose a way of exploring a given question scientifically;			• Perform experimental activities. • Devise an experimental procedure
• Evaluate ways of exploring a given question scientifically;	• Interpret		
• Describe and evaluate a range of ways that scientists use to ensure the reliability of data and the objectivity and generalizability of explanations.			

PISA 2015 Specific Domain Competency with measurable descriptions	The Sciences National Curriculum Domains and Competencies in Chemistry		
Interpret data and evidence scientifically Analyze and evaluate scientific data, claims and arguments in a variety of representations and draw appropriate conclusions demonstrating the ability to:	**Applying Knowledge**	**Mastery - Communicating**	**Designing an experiment**
• Transform data from one representation to another;		• Utilize various methods to present information. • Read a scientific text	• Devise an experimental procedure.
• Analyze and interpret data and draw appropriate conclusions;	• Classify chemical species based on their properties. • Relate the parameters and / or the variables. • Identify the characteristics of…	• Interpret a schema and / or a graph • Make use of tabulated data	
• Identify the assumptions, evidence and reasoning in science-related texts;	• Explain the consequences of chemistry on health	• Read a scientific text.	• Write a report about an experiment.
• Distinguish between arguments which are based on scientific evidence and theory and those based on other considerations;			
• Evaluate scientific arguments and evidence from different sources (e.g. newspaper, internet, journals).		• Conduct documentary research.	

Appendix F

Table 1: Physical System Content in PISA2015 vs. Content of Physics in the National Curriculum

PISA 2015 Scientific Literacy Assessment	Themes covered in the Lebanese National Curriculum		
Description Physical Systems that require knowledge of:	**Theme**	**Description**	**Grade level**
Structure of matter (e.g., particle model, bonds)	**Matter**	Constituents of matter	G7
Properties of matter (e.g., changes of state, thermal and electrical conductivity)	**Matter**	Solid and liquid states Gaseous phase Change of phase and expansion	G7
Chemical changes of matter (e.g., chemical reactions, energy transfer, acids/bases)	**Electricity**	Circuits – Conductors and insulators	
	Heat	Quantity of heat and heat transfer – already suspended	G9
Motion and forces (e.g., velocity, friction) and action at a distance (e.g., magnetic, gravitational and electrostatic forces)	**Mechanics**	Motion and velocity	G8
		Force: Effects and classification – suspended for the year 16-17 but done in G9	
	Mechanics	Rectilinear motion	G10
		Force and interaction	
		Laws of motion	
Energy and its transformation (e.g., conservation, dissipation, chemical reactions)	**Mechanics**	Work, power and forms of energy– suspended for the year 16-17	G8
Interactions between energy and matter (e.g., light and radio waves, sound and seismic waves)	**Waves**	Characteristics of waves	G8
		Sound waves	
		Electromagnetic waves and colors	
	Waves	Mechanical waves	G10
		Light waves	

Table 2: Physical System Content in PISA2015 vs. Content of Chemistry in the National Curriculum

PISA 2015 Scientific Literacy Assessment	Themes covered in the Lebanese National Curriculum		
Description Physical Systems that require knowledge of:	**Theme**	**Description**	**Grade level**
Structure of matter (e.g., particle model, bonds)	**Pure Sabstances**	Elements: Metals and non-metals - Compounds - Atoms, molecules and ions - Symbols and formulas – Allotropes (suspended in 2016).	G8
	• **The Atom** • **Chemical bonding**	Structure of the atom - Electron Arrangements in Atoms and the periodic table -Chemical Stability. Covalent and Ionic Bonding.	G9
	• **Atoms** • **Molecules** • **Ions** • **Water**	Structure - Electron configuration - Periodic classification of the elements - Mole of atoms - Formation and representation (suspended in 2016). Covalent chemical bond - Shapes of molecules based on the Valence Shell Electron Pair Repulsion theory (VSEPR). Electronegativity and Pauling's Scale (most of them were suspended in 1999 and in 2016) - Mole of molecules. Existence of ions - Monoatomic ions - Polyatomic ions - Mole of ions. Ionic compounds. Structure (suspended since 1999).	G10
Properties of matter (e.g., changes of state, thermal and electrical conductivity)	• **Matter** • **Solutions, Suspensions, colloids**	Classification of matter - Separation techniques. Solutions (the part of suspension and colloids has been suspended since 1999).	G7
	• **Electrical Nature of Matter** • **Pure Substances** • **Chemical reactions**	Electrification (suspended in 1999) - Electric discharge (suspended in 1999) - Conductors and insulators (suspended in 1999) Compounds - Allotropes (suspended in 2016). Rate of chemical reactions.	G8
	• **Electrochemistry**	Electric energy from chemical reactions - applications.	G9
	• **Molecules** • **Ions** • **Water**	Shapes of molecules based on the Valence Shell Electron Pair Repulsion theory (VSEPR) - Electronegativity and Pauling's Scale (most of them were suspended in 1999 and in 2016). Existence of ions - Monoatomic ions - Polyatomic ions - Mole of ions - Ionic compounds. Physical properties (suspended since 1999) - Dissolving property of Water.	G10
Chemical changes of matter (e.g., chemical reactions, energy transfer, acids/bases)	• **Chemical reactions**	Reactants and products - Conservation of matter - Energy and chemical reaction - Combustion as one type of chemical reactions.	G-7
	• **Chemical reactions** • **Acids, bases and salts**	Chemical equations - Types of chemical reactions (suspended in 2016) - Rate of chemical reactions. Acidic and basic solutions - Acidity: concept of pH (suspended in 2016) - Salts (suspended in 2016) - Applications (suspended in 2016).	G8
	• **Chemical bonding** • **Electrochemistry**	Covalent and Ionic Bonding -Electric energy from chemical reactions - applications: Electric energy from chemical reactions - applications (4 of the learning objectives were suspended in 1999 and another 2 learning objectives were suspended in 2016).	G9
	• **Chemical reactions** • **Water** • **Acids and Bases**	Chemical transformation-Representation of a chemical reaction by an equation -Stoichiometric coefficients- Characteristics of chemical reactions - Electrons involved in a reaction - Quantitative aspect. Dissolving property of water- Characteristics of aqueous solutions. Acidity and pH -Definitions: Arrhenius and Bronsted - Acidic solutions - Basic solutions - Salts: Definitions and reactions - Volumetric analysis: Acid- base titration using colored indicators.	G10

PISA 2015 Scientific Literacy Assessment	Themes covered in the Lebanese National Curriculum		
Description Physical Systems that require knowledge of:	**Theme**	**Description**	**Grade level**
Motion and forces and action at a distance			
Energy and its transformation (e.g., conservation, dissipation, chemical reactions)	• **Chemical reactions**	Reactants and products - Conservation of matter - Energy and chemical reaction -Combustion as one type of chemical reactions	G 7
	• **Chemical bonding** • **Electrochemistry**	Covalent and Ionic Bonding. Electric energy from chemical reactions-applications: Electric energy from chemical reactions-applications.	G 9
	• **Thermochemistry** • **Electrochemistry**	Heat of reaction at constant pressure ΔH -Heat of reaction at constant volume ΔU-Heat of formation -Hess's Law Remark: Most learning objectives were suspended in 1999 and the rest were suspended in 2016. Oxidation and Reduction. Redox Couple-The half-Reaction H+/ H2 -Redox Potential -Electrochemical Classification of reduction half- reaction -Balancing redox reactions - Cells and batteries (suspended) - Electrolysis (suspended) - Redox titration.	G 11 Sciences
Interactions between energy and matter			

Table 3: Living System Content in PISA2015 vs. Content of Life Science in the National Curriculum

PISA 2015 Scientific Literacy Assessment	Themes covered in the Lebanese National Curriculum		
Description Living Systems that require knowledge of:	**Theme**	**Description**	**Grade level**
Cells (e.g., structures and function, DNA, plant and animal)	**Cells structure Cells Function DNA**	Compare animal cell to plant cell (basic features) Cell division Notion (very brief) DNA structure and role in gene expression and cell function	Grade 6 Grade 9 Grade 9 Grades 11, 12
The concept of an organism (e.g., unicellular and multicellular)	**Organization of living things**	Levels of organization of living things	Grades 6
Humans (e.g., health, nutrition, subsystems such as digestion, respiration, circulation, excretion, reproduction and their relationship)	**Organization of living things**	Health Nutrition Digestion, respiration, circulation, excretion Reproduction	Grade 5, 9,11 Grade 6, 9 Grades 6, 7,9,12
Populations (e.g., species, evolution, biodiversity, genetic variation)	**Organization of living things**	Population term (implicit and not explicit) Biodiversity (implicit and not explicit) Genetic variation	Grade 7,10,11,12 Grades 11, 12
Ecosystems (e.g., food chains, matter and energy flow)	**Organization of living things**	Ecosystems, …	Grades 5, 7, 11
Biosphere (e.g., ecosystem services, sustainability)	**Organization of living things**	Ecosystems Sustainability (implicit and not explicit)	Grades 5,7,11 Grade 10

Table 4: Earth System content in PISA2015 vs. Content of Earth and Space Science in the National Curriculum

PISA 2015 Scientific Literacy Assessment	Themes covered in the Lebanese National Curriculum		
Description Earth and Space Systems that require knowledge of:	**Theme**	**Description**	**Grade level**
Structures of the Earth systems (e.g., lithosphere, atmosphere, hydrosphere)	**Earth Structure**	Layers of earth	8
Energy in the Earth systems (e.g., sources, global climate)	**None**	None	----
Change in Earth systems (e.g., plate tectonics, geochemical cycles, constructive and destructive forces)	**Earth Structure**	Plate tectonics geochemical cycles, constructive and destructive forces) (none)	8
Earth's history (e.g., fossils, origin and evolution)	**None**	None	----
Earth in space (e.g., gravity, solar systems, galaxies)	**None**	None	
The history and scale of the Universe and its history (e.g., light year, Big Bang theory)	**None**	None	

Appendix G

Procedural knowledge in PISA2015 vs. Knowledge
in Science Subjects in the National Curriculum

PISA 2015 Scientific Literacy Assessment The general features of procedural knowledge that may be tested.	**Features of procedural knowledge in the Lebanese National Curriculum**
General Features	**Description**
The concept of variables including dependent, independent and control variables	**Barely covered explicitly in all sciences**
Concepts of measurement e.g., quantitative [measurements], qualitative [observations], the use of a scale, categorical and continuous variables	**Partially explicitly in all Sciences**
Ways of assessing and minimizing uncertainty such as repeating and averaging measurements	**Not covered In Life sciences and Physics and partially covered in Chemistry**
Mechanisms to ensure the replicability (closeness of agreement between repeated measures of the same quantity) and accuracy of data (the closeness of agreement between a measured quantity and a true value of the measure)	**Not covered**
Common ways of abstracting and representing data using tables, graphs and charts and their appropriate use	**Well covered**
The control of variables strategy and its role in experimental design or the use of randomized controlled trials to avoid confounded findings and identify possible causal mechanisms	**Not covered**
The nature of an appropriate design for a given scientific question e.g., experimental, field based or pattern seeking	**Not covered**

Appendix K

Epistemic knowledge in PISA 2015 vs. Knowledge in Science Subjects in the National Curriculum

General Features		Description
The constructs and defining features of science. That is:	The nature of scientific observations, facts, hypotheses, models and theories;	**Partially covered**
	The purpose and goals of science (to produce explanations of the natural world) as distinguished from technology (to produce an optimal solution to human need), what constitutes a scientific or technological question and appropriate data;	**Not covered**
	The values of science e.g., a commitment to publication, objectivity and the elimination of bias;	**Not covered**
	The nature of reasoning used in science e.g., deductive, inductive, inference to the best explanation (abductive), analogical, and model-based;	**Not covered**
The role of these constructs and features in justifying the knowledge produced by science. That is:	How scientific claims are supported by data and reasoning in science;	**Not covered**
	The function of different forms of empirical enquiry in establishing knowledge, their goal (to test explanatory hypotheses or identify patterns) and their design (observation, controlled experiments, correlational studies);	**Not covered**
	How measurement error affects the degree of confidence in scientific knowledge;	**Not covered**
	The use and role of physical, system and abstract models and their limits;	**Not covered**
	The role of collaboration and critique and how peer review helps to establish confidence in scientific claims;	**Not covered**
	The role of scientific knowledge, along with other forms of knowledge, in identifying and addressing societal and technological issues.	**Not covered**