AMERICAN UNIVERSITY OF BEIRUT

INVESTIGATING THE ALIGNMENT BETWEEN THE FOURTH-GRADE LEBANESE SCIENCE CURRICULUM AND TIMSS-2019 ASSESSMENT FRAMEWORK

by
FATME ADEL AKHDAR

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FATME ADEL AKHDAR

Approved by:

Dr. Karma El-Hassan, Associate Professor
Education — Advisor

Dr. Tamer Amin, Associate Professor
Education — Member of Committee

Dr. Murad Jurdak, Professor
Education — Member of Committee

Date of thesis defense: September 5, 2022

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ABSTRACT
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Title: Investigating the Alignment Between the Fourth-grade Lebanese Science Curriculum and TIMSS-2019 Assessment Framework

This conducted research focused on the alignment between one of the TIMSS large-scale assessment frameworks and the Lebanese curriculum. Particularly, the purpose of this study was to investigate the alignment between the fourth grade Lebanese science curriculum and TIMSS-2019 assessment framework in terms of two dimensions, with content forming the first dimension and cognitive demands forming the second one.

The Surveys of Enacted Curriculum alignment model was adopted in this study to examine the agreement between the two documents under analysis. Data available by means of the two selected documents were analyzed using the three tools: 'Curriculum Matching Sheet' (CMS), 'Assessment Matching Sheet' (AMS) and 'Content-by-Cognitive Demands Matrix' in the three methodological procedures: 'Fourth Grade Lebanese Science Curriculum Matching Procedure', 'TIMSS Assessment Framework Matching Procedure' and 'Curriculum-Assessment Classification Procedure', respectively.

Findings revealed the presence of a huge content gap in the fourth grade Lebanese curriculum with respect to the TIMSS assessment framework requirements. On the other hand, results showed that the latter is not missing a lot from the former's content demands. Further analysis disclosed the existence of similarities and differences in the content and cognitive demands emphasis of the two chosen documents. The calculated Porter alignment index indicated that there exists a somewhat moderate alignment between the fourth grade Lebanese science curriculum and TIMSS assessment framework.

Implications for the concerned educational parties are discussed in the light of these results.

TABLE OF CONTENTS

TABLES

Table

CHAPTER 1

INTRODUCTION

Background and Rationale

TIMSS is an international study that provides information about the mathematics and science achievement of students at the fourth and eighth grades in more than sixty countries worldwide (Mullis, 2017). In 1995, the study administered its first mathematics and science assessments and has proceeded in the form of regular cycles, one every four years-1999, 2003, 2007, 2011, 2015 and 2019. It comes along with TIMSS Advanced that assesses twelfth grade students' achievement in advanced mathematics and physics. The administration of the TIMSS Advanced assessments started in 1995 and reoccurred subsequently in 2008 and 2015 (Mullis, 2017).

TIMSS was established to participate in the international collective action taken towards helping the K-12 educational systems to offer better teaching and learning of the two subject areas: mathematics and science (Robitaille & Beaton, 2002). Indeed, the aim was to yield a comprehensive view of the types of curricula and pedagogical methods that have proven to be effective in attaining top levels of performance, so that teachers, curriculum developers and policymakers all over the world can make an operative use of this rich array of data. Given the outcomes of this cross-national study, they can see themselves through a global lens instead of functioning separately. As stated by Robitaille and Beaton (2002), "TIMSS provided a unique opportunity for them to view themselves in the rich context provided by the participation of many other countries" (p. 12).

The study's mathematics and science instruments have always been developed by not only the TIMSS institutions and agencies but also collaboratively by the countries that took part in the study (Mullis, 2017), allowing these assessments to reflect the commonalities across the participating countries' curricula (Hencke et al., 2009). Despite this, Hencke et al. (2009) acknowledged that the agreement between these large-scale assessments and an official curriculum will vary from one country to another. This matching feature of the TIMSS international assessments to the curricula across the globe has been considerably criticized regardless of the quality given by the tests (Nyström & Lind, 2010; Sjøberg, 2005, as cited in Pedersen, 2013). Accordingly, the relevance of these assessments to each participating country's curriculum should come under research examination. In a nutshell, it is worthy for each participating country to launch a curriculum alignment investigation with the TIMSS assessments.

From all of the TIMSS participating countries, each of Netherland (Vos, 2002; Vos & Bos, 2005), South Africa (Ndlovu & Mji, 2012), Norway (Pedersen, 2013), U.S. (Traynor, 2017), Lebanon (Center for Educational Research and Development [CERD], 2018) and Philippine (Balagtas et al., 2019) tackled this issue. In Lebanon, only one of the curriculum alignment studies found (CERD, 2018) had shed light on this matter in the sense of examining the agreement between the official (G1-12) mathematics as well as science curricula and the eighth grade TIMSS international mathematics and science assessments. Shehayeb's (2017) research is the other Lebanese alignment study that addressed TIMSS but in terms of exploring the alignment between the twelfth grade Lebanese mathematics public exams and TIMSS Advanced framework along with the items. The rest of the identified Lebanese curriculum alignment studies (El Hassan & Baassiri, 2019; Hajo, 2010; Hajo, 2018; Osta, 2007; Sleiman, 2012; Safa, 2013),

excluding El Hassan and Baassiri's, are studies done at the public level investigating the alignment between the official curriculum and the public examinations. As for El Hassan and Baassiri's (2019) study, it is the only one done at the classroom level examining the alignment between the official curriculum and the summative classroom assessments. Thus, it is evident that none of the relevant Lebanese research has dealt with the alignment between any of the fourth grade Lebanese curricula and the fourth grade TIMSS international assessments. Accordingly, it is beneficial to conduct such kind of research in the Lebanese context.

Consequently, the current study aimed at extending previous research (CERD, 2018; Shehayeb, 2017) by conducting an alignment study between the fourth grade Lebanese science curriculum and TIMSS science assessment framework at the fourth grade level.

Statement of the Problem

The purpose of this study was to investigate the alignment between the fourth grade Lebanese science curriculum and TIMSS-2019 assessment framework in terms of two dimensions, with content forming the first dimension and cognitive demands forming the second one.

Research Questions

The following research questions guided the present study:

1) To what extent does the fourth grade Lebanese science curriculum cover the content of the TIMSS-2019 science assessment framework?
2) To what extent does the TIMSS-2019 science assessment framework address the content of the fourth grade Lebanese science curriculum?

3) What are the similarities and discrepancies in the content and cognitive demands emphases that exist between the fourth grade Lebanese science curriculum and TIMSS-2019 science assessment framework?
4) What is the computed index of content and cognitive demands alignment between the fourth grade Lebanese science curriculum and TIMSS-2019 science assessment?

Significance

The findings of the present research can contribute to both educational research and practice.

Contribution to Educational Research

The current study redounds to the field of educational research in three main aspects. First, it is responsive to the research demands in the area of examining the alignment between official worldwide curricula and TIMSS large-scale assessments. Secondly, it illustrates one of the typical research approaches to be followed if one has chosen to study the agreement between a given country's curricula and TIMSS international assessments. Finally, it attempts to address the gap found in the Lebanese literature regarding conducting an alignment study between the Lebanese national curriculum and TIMSS fourth grade assessments.

Contribution to Educational Practice

The outcomes of this research can benefit each of the following Lebanese entities: teachers, curriculum developers and policymakers. For teachers, this exploration allows them to perceive which content aspects of the TIMSS assessment framework are not being covered by the fourth grade Lebanese science curriculum and what similarities and discrepancies in each of the content and cognitive demands

emphasis are present between the two of them. Accordingly, they can try to integrate the TIMSS content topics and sub-topics overlooked by the Lebanese curriculum in their classroom instructional activities, and they might work on maintaining the similarities and tackling the discrepancies found between the TIMSS assessment framework and the Lebanese intended curriculum, with respect to the content and cognitive demands focus, through their pedagogical practices. Thus, they can better prepare their fourth grade Lebanese students for the TIMSS science examination in case of future participation.

With respect to the curriculum developers, this research study exists to provide them with evidence-based guidelines regarding the TIMSS content aspects that might be added to and emphasized by the curriculum document as well as the TIMSS cognitive demands which might be reconsidered for the curriculum objectives. Hence, they can work on empowering the fourth grade Lebanese science curriculum to better meet international standards in preparation for taking the TIMSS assessments.

As for the policymakers, this investigation will assist them in taking the appropriate decision regarding Lebanon's participation in the fourth grade TIMSS science assessment.

Further to all of this, the results of this alignment study are also useful for the TIMSS institutions and agencies responsible for developing the TIMSS science assessments for the fourth-grade level, as it serves as a resource for them to identify the content aspects of the selected Lebanese curriculum that were disregarded by TIMSS and evaluate the possibility of including them when designing the upcoming fourth grade science TIMSS assessment. In view of this, the established TIMSS instruments can better reflect the national fourth grade Lebanese curriculum for the science subject.

CHAPTER 2

LITERATURE REVIEW

Introduction

The ‘Literature Review’ section of the proposed thesis is divided into several main headings so that a thorough review of the topic is provided. These main headings represent the themes found to be relevant to the present research. Hence, a comprehensive review is given to the TIMSS with a focus on the TIMSS-2019 in general and its fourth-grade science assessment framework in specific; the need for alignment studies between national curricula and TIMSS assessments; definition of alignment; alignment models; curriculum alignment studies done with TIMSS; TIMSS in the Lebanese context; the fourth grade Lebanese science curriculum and alignment studies.

TIMSS

In the early 1960s, the International Association for the Evaluation of Educational Achievement, broadly renowned as IEA, was the first to initiate wide-ranging comparative studies of educational achievement (Mullis, 2017). Comprising assessments of international achievement, these large-scale studies aimed at presenting a global comprehensive view of the impacts of various educational policies applied across the different countries worldwide that ultimately can promote enhancements to their educational systems. In 1995, the IEA launched one of its core programs, which is the Trends in International Mathematics and Science Study, more widely known as TIMSS. Since then, this cross-national study continues to conduct, every four years, systematic assessments to measure students’ mathematics and science achievement at the fourth and eighth grades. To fulfil the IEA’s major goal, TIMSS follows a three

folded curriculum model having each of the intended, implemented and attained ones as its main components. The former represents the mathematics and science material that is planned to be taught in the given grade level as identified by the participants' curriculum documents and the educational context that is expected to foster this teaching. The second one denotes the actual instructional outcomes and practices set inside the classrooms as well as the qualifications of those involved in the action of teaching. As for the third, it outlines the mathematics and science concepts that the students have acquired throughout the whole learning process along with their attitudes towards it. Proceeding with this three-facet model, TIMSS requests each of its involved country participants to fill-up a curriculum questionnaire that provides a thorough picture of the three aspects of each country's curriculum. Data collected from these questionnaires along with the results of the administered assessments assist the concerned countries in making the decisions that best enhance the effectiveness of their educational systems (Mullis, 2017).

TIMSS-2019

TIMSS is on its seventh cycle with TIMSS-2019 being latest version in the three decades' old series (Mullis, 2017). TIMSS-2019 assessments were developed following well-established frameworks that provide the basis on what should be tested in each of the mathematics and science curriculum areas at every grade level (Mullis, 2017). For 2019, TIMSS has used the same frameworks previously applied in its sixth cycle but with some changes to certain topic areas to be able to give greater consideration for the participating countries' curricula (Centurino & Jones, 2017; Lindquist et al., 2017). These frameworks have experienced additional updates in accordance with the TIMSS-2019 initial shift into computer-based format to be known as eTIMSS. This upgrade has

been essential as this digital format of test administration offers a great opportunity for assessing students' mathematics and science achievement using wider variety of advanced assessment techniques. The mathematics or science framework for each of the TIMSS-2019 fourth and eighth grades assessments is structured into two dimensions: content dimension representing the subject matter domains to be assessed; the cognitive dimension identifying the thinking processes domains to be assessed (Centurino & Jones, 2017; Lindquist et al., 2017). For the sake of the proposed study, only the fourth grade TIMSS-2019 science assessment framework is further described in the upcoming subsection.

Fourth Grade TIMSS-2019 Science Assessment Framework.

Content Dimension. The science content dimension of the fourth grade TIMSS-2019 assessment framework constitutes of three main subject matter domains: Life Science, Physical Science and Earth Science (Centurino & Jones, 2017). Table: 1 presents the target percentages dedicated for each of the three subject matter domains in the fourth grade TIMSS-2019 science assessment.

Table 1

Target Percentages Devoted for each Subject Matter Area in the Fourth Grade TIMSS-2019 Science Assessment

Subject Matter Domain	Percentage
Life Science	**45%**
Physical Science	**35%**
Earth Science	**20%**

Various topic areas make up each of these subject matter domains, where each topic area for its own part consists of one sub-topic or more (Centurino & Jones, 2017). Additionally, each sub-topic is defined by several objectives that specify clearly the learning outcomes that the fourth-grade students are expected to achieve in every topic

(Centurino & Jones, 2017). The following present the three main subject matter domains briefly, while Appendix A displays a more detailed outline of them along with their topic areas, sub-topics and the objectives associated within each one.

At the fourth-grade level, the content domain of life science includes these topic areas: "Characteristics and Life Processes of Organisms; Life Cycles, Reproduction, and Heredity; Organisms, Environment, and their Interactions; Ecosystems; Human Health" (Centurino & Jones, 2017). Accordingly, fourth grade students should be aware of the main features of different kinds of organisms, their operational mechanisms, and the ways in which they adapt to their environment. Moreover, they should be actively engaged in the process of constructing vigorous base of scientific knowledge about life cycles, heredity and human health as it is going to be the building block for other complex notions related to human body functions in higher grade levels (Centurino & Jones, 2017).

Three topic areas define the study of physical science at the fourth-grade level: "Classification and Properties of Matter and Changes in Matter; Forms of Energy and Energy Transfer; Forces and Motion" (Centurino & Jones, 2017). Therefore, students at this grade level should be familiar with the three physical states of matter and the changes that usually occur within them. Accomplishing this is fundamental as it paves the way for the learning of both chemistry and physics subjects in the upcoming grade levels. Furthermore, fourth grade students must be acquainted with the common forms and sources of energy as well as their practical uses and involved in forming a primary conceptual background about light, sound, electricity and magnetism. Additionally, the concerned students are expected to develop a comprehension of forces in the sense of

relating them to motions they can experience in their everyday life (Centurino & Jones, 2017).

The fourth-grade study of earth science is represented by the subsequent topic areas: "Earth's Physical Characteristics, Resources and History; Earth's Weather and Climates; Earth in the Solar System" (Centurino & Jones, 2017). Fourth grade students should have insights about the structure and physical characteristics of earth's surface as well as the use of its essential resources. Besides that, the topic of earth's history calls for students' descriptions of several earth's processes in terms of observable transformations and their awareness of the time interval over which such transformations have taken place. By monitoring each of the earths and sky's patterns of change, these students should also learn about the planet earth's position in the solar system (Centurino & Jones, 2017).

Cognitive Dimension. The cognitive dimensions of the TIMSS-2019 science assessment frameworks at both the fourth and eighth grades share the same thinking processes domains: Knowing, Applying and Reasoning (Centurino & Jones, 2017). Nevertheless, there exist differences among the target percentages devoted for each domain by each science cognitive dimension to better reflect the increased demands on behalf of students as they proceed across the grades (Centurino & Jones, 2017). Table: 2 presents the target percentages dedicated for each of the three thinking processes domains in the fourth grade TIMSS-2019 science assessment.

Table 2

Target Percentages Devoted for each Thinking Process Domain in the Fourth Grade TIMSS-2019 Science Assessment

Thinking Process Domain	Percentage
Knowing	**40%**
Applying	**40%**
Reasoning	**20%**

In the TIMSS-2019 fourth or eighth grade science assessment, each set of items constructed to address a specific subject matter area in the content dimension is designed to tackle each of the knowing, applying and reasoning domains from the cognitive dimension (Centurino & Jones, 2017). That is to say, the set of questions measuring students' achievement in, for example, the earth science subject matter area assesses their thinking processes in each of the three cognitive domains, the same applies to the other areas. It is worth mentioning that each group of the science items specified for a given cognitive domain reflects a full array of difficulty despite the fact of having some sort of hierarchy within these domains (Centurino & Jones, 2017).

While Appendix B shows an elaborated outline of all the thinking processes that shape the nature of every cognitive domain, it is fundamental to clarify them briefly. The first domain, knowing, requires students to recall or identify scientific facts, relationships, processes, concepts, as well as ways of utilizing tools and conducting experiments that are all crucial for building a strong knowledge base in the science field (Centurino & Jones, 2017). The second one, applying, calls students for applying directly the acquired scientific knowledge in cases that are mostly like those given throughout their learning journey. Unlike its antecedent, the last domain in the hierarchy, reasoning, requests for enlarging the scope of the students' scientific knowledge using often novel complex situations where they are expected to practice scientific reasoning not only while examining any given data but also when deriving conclusions (Centurino & Jones, 2017).

Fourth Grade TIMSS-2019 Science Assessment Items. The fourth grade TIMSS-2019 science assessment contains 175 items of either a selected or constructed response format (Cotter et al., 2020). In the selected response items, students must

choose either a single answer from four possible answer choices or multiple correct responses between a set of responses. In general, 1 score point is assigned for every selected response item answered correctly on TIMSS assessments, except for 2 score points for few questions that require selecting more than one response. On the other hand, in the constructed response questions, each student must produce his/her unique response rather than choose a readily available one. Students who correctly answer this kind of TIMSS item formats receive 1 or 2 score points depending on the level of difficulty imposed (Cotter et al., 2020). Every item in the fourth grade TIMSS-2019 mathematics or science assessment measures students' achievement on two elements from the dimensions of its framework: one subject matter area from the content dimension, and one thinking process domain from the cognitive dimension (Centurino & Jones, 2017). These two aspects of each assessment item collectively determine the type of its format (Cotter et al., 2020). Table: 3 presents the distribution of the fourth grade TIMSS-2019 science assessment items by format within the content and cognitive domains.

Table 3

Distribution of Items Included in the Fourth Grade TIMSS-2019 Science Assessment by Format within the Content and Cognitive Domains

Fourth Grade TIMSS-2019 Science Assessment Items	**Selected Response Items**	**Constructed Response Items**	**Total Items**	**Percentages**
Content Dimension				
Life Science	41	37	78	**46%**
Physical Science	40	22	62	**35%**
Earth Science	28	7	35	**19%**
Total	109	66	175	100%
Percentages	**61%**	**39%**	100%	
Cognitive Dimension				
Knowing	52	21	73	**43%**
Applying	36	29	65	**36%**
Reasoning	21	16	37	**21%**
Total	109	66	175	100%
Percentages	**61%**	**39%**	100%	

It should be noted that not all the items found on the TIMSS-2019 mathematics or science assessments at any grade level are newly constructed ones, should this be the case the TIMSS's goal of measuring trends in worldwide achievement would be an impossible one to attain (Cotter et al., 2020). Accordingly, about 60% of the TIMSS-2019 items, known as trend items, have been moved forward from previous assessment cycles while the rest have been recently developed to keep up to date with the changes evolving across the countries' curricular areas (Cotter et al., 2020).

Test-takers of the TIMSS-2019 fourth grade assessments are given 72 minutes as a total testing time to complete all the mathematics and science items (Martin et al., 2017). After administering the assessments in each of the TIMSS participating countries, answers provided by the fourth grade students to every test question are gathered and reported using scale metrics for both mathematics and science areas. The reported results present evidence of the mathematics and science achievement of the fourth grade students within each of the involved countries. Additionally, they enable TIMSS to measure global trends in educational achievement as they are placed on the scale metrics that were first established for the TIMSS-1995 version and then applied for the cycles that follow (Martin et al., 2017).

The Need for Alignment Studies Between National Curricula and TIMSS Assessments

To ensure their validity and for them to be meaningful, large-scale international assessments like those developed by TIMSS should achieve an acceptable level of agreement with the intended national curricula (Ndlovu & Mji, 2012). While designing TIMSS assessments, test developers tried to include the common emphases of the participating countries' curricula to the maximum extent possible, yet it is still expected

to find some discrepancies between these instruments and a given country's curriculum (Hencke et al., 2009). This particular aspect of this cross-national study concerning the extent of match between its assessments and countrywide curricula has received a great deal of criticism (Nyström & Lind, 2010; Sjøberg, 2005, as cited in Pedersen, 2013). Indeed, the results revealed by Pedersen's (2013) alignment study itself emphasized the soundness of this kind of criticism made against TIMSS examinations as they had shown the existence of certain discrepancies in emphasis across one of the TIMSS large scale assessments and a given country's curricula. Using the Surveys of Enacted Curriculum alignment model, Pedersen (2013) studied the alignment between each of the 1998 and 2008 TIMSS Advanced mathematics tests and the corresponding Norwegian mathematical curriculum for each at the upper secondary school level. Pedersen (2013) discovered the presence of moderate alignment between the selected documents, implying that there exist certain discrepancies in their emphases. Accordingly, she concluded that one should take into account these differences in emphasis when interpreting the results generated by means of the TIMSS assessments.

In conclusion, the correspondence of TIMSS assessments to each participating country's curriculum should be subjected to a research inspection. Simply put, each participating country needs to investigate the degree to which its national curriculum aligns with the TIMSS assessments before coming to conclusions and taking subsequent decisions based on results.

Definition of Alignment

When searching for a clear definition of alignment within the field of education, multiple meanings may be found (Martone & Sireci, 2009). Keeping in mind the ultimate purpose of the thesis at hand, "alignment can be defined as the degree of

agreement between a state's content standards for a specific subject area and the assessment (s) used to measure student achievement of these standards" (Bhola et al., 2003, p. 22). Both assessments and content standards have been emphasized in the definition given by Bhola et al. (2003), yet Roach's et al. (2008) interpretation signifies that the second component can also be denoted as a written curriculum or instructional content as all represent what is meant by "expectations". Hence, the underlying alignment logic relevant to the present study implies that for an agreement between a given national curriculum for a particular subject and the TIMSS assessment, the latter should grant the opportunity for test takers to manifest what they are expected to know and do as stated in the curriculum document (La Marca et al., 2000). Even though the administered assessments can't or shouldn't cover entirely what is set out in the curriculum, examining alignment makes it possible to disclose the extent to which the curriculum specifications have been addressed by the assessments (Martone & Sireci, 2009). It is worth noting that the same logic applies when the TIMSS assessment framework is chosen instead of the actual assessment in the alignment study as it lays down the foundation of the conducted assessment (Mullis, 2017).

Alignment Models

When seeking to study the alignment between assessments and content specifications, various models can be applied (Bhola et al., 2003; La Marca et al., 2000). These methods have been grouped by Bhola et al. (2003) into three different categories based on the level of complexity involved within each. This criterion of classification depends on the number of dimensions examined in the alignment model. A model of low complexity investigates alignment through only one dimension which is the 'content match'. The moderate models work beyond the scope of the former, as

they, in addition to the simple content dimension, include the cognitive complexity one. The latter group, models of high complexity, is extremely demanding as they utilize multiple dimensions in evaluating the degree of alignment (Bhola et al., 2003). Among all the ways that may be followed in conducting alignment research, each of the Surveys of Enacted Curriculum (SEC), Webb and Achieve model is subjected to further elaboration in the upcoming subsections. The reason behind choosing only these three models from all available models relates to the fact that they have been perceived as the best practices to be employed in educational alignment studies (Roach et al., 2008).

Surveys of Enacted Curriculum (SEC) Model

With a moderate complexity level, the SEC model makes it possible to measure all possible alignments across standards, assessments, and instruction (Bhola et al., 2003). The alignment methodology as described by Martone and Sireci (2009) calls first for content experts' coding of each of the standards, assessment items and the instructional focus into a two-dimensional matrix, with content forming the first dimension and cognitive demands representing the second one. As a result of this coding process, a two-dimensional content-by-cognitive demands matrix will be formed for each of the three components, where each cell in the matrix represents the proportion of the standards, assessment items, or instructional content it contains. Matrices' data presented by means of these cell proportions can then be used to compute the Porter's (2002) alignment index which determines the extent of alignment. The alignment index is calculated using the following formula:

$$1 - \frac{\sum |X - Y|}{2},$$

where X denotes the cell proportions in each selected matrix and Y denotes the cell proportions in the other one. The computed alignment index can range from 0 to 1

(Martone & Sireci, 2009). Besides this statistical index, graphs and charts can also be employed to present the information obtained from each of the three matrices (Bhola et al., 2003), so that comparisons across the three components' emphases can be made (Martone & Sireci, 2009).

Webb Alignment Model

Webb designed one of the high complex models for determining the alignment between content standards and assessment systems (Bhola et al., 2003). In this methodology, alignment is understood through five different dimensions: content focus; articulation across grades and ages; equity and fairness; pedagogical implications; and system applicability (Webb, 1999). In fact, the dimension of content focus has been solely implemented in alignment research following this model for the sake of its simplicity compared to the other dimensions (Martone & Sireci, 2009). Within this dimension, the following four subcategories: depth of knowledge consistency; categorical concurrence; range of knowledge consistency; balance of representation need to be examined so that the alignment can be checked (Webb, 1999).

Achieve Model

Located at the end of the continuum of complexity (Bhola et al., 2003), this model shows the qualitative and quantitative features of the standards-assessment alignment (Martone & Sireci, 2009). The six dimensions that represent the alignment criteria required to be met in this method are: accuracy of test blueprint; content centrality; performance centrality; challenge; balance; range (Bhola et al., 2003; Martone & Sireci, 2009). It was noted by Bhola et al. (2003) that there exists consistency between the Achieve's second dimension and that of the Webb's content focus category as well as among the latter's third criteria and the former's first one.

Various approaches to alignment research, ranging across a spectrum from simple to highly complex, can be followed (Bhola et al., 2003). Despite this rich array of available models, there is still no global consensus on the optimal ways to study the alignment between content specifications and assessments (Bhola et al., 2003). Accordingly, this review focused merely on the three models which have appeared in the research literature and practice as the leading paths to pursue for measuring alignment (Roach et al., 2008). Thus, a concise overview was offered to each of the Surveys of Enacted Curriculum (SEC), Webb and Achieve models. The next chapter discloses which one of these three alignment models had been employed in this study and presents the rationale behind choosing it.

Curriculum Alignment Studies Done with TIMSS

Despite the need for alignment studies between national curricula and TIMSS assessments, only a few number of the TIMSS participating countries decided to study this issue. Precisely, the thorough search in the literature disclosed that each of Netherland (Vos, 2002; Vos & Bos, 2005), South Africa (Ndlovu & Mji, 2012), Norway (Pedersen, 2013), U.S. (Traynor, 2017), Lebanon (CERD, 2018) and Philippine (Balagtas et al., 2019) conducted relevant research on this matter. A summary of each of these studies is provided in the next subsections.

Netherland

In searching for the logic behind the intra-curricular discrepancy detected after the administration of the Netherland's eighth grade TIMSS-1995 mathematics written test, Vos (2002) not only examined the alignment between the Dutch mathematics curricular levels, but it also measured the trend in this alignment from 1995 to 1999 to explore its variations post the curriculum reform previously done in 1993. The TIMSS-

1995 results revealed the presence of a confusion between the Dutch students' test performance and the experts' judgements on the relevance of the mathematics written test with respect to Netherland's intended curriculum. In particular, the eighth-grade students scored relatively high on the TIMSS mathematics assessment although the test was judged to be inappropriate by the curriculum experts. Accordingly, the striking 1995 Dutch intra-curricular discrepancy existed between the intended and attained mathematics curricular levels. For every math item included in the 1995 and 1999 iterations of TIMSS, mapping of curriculum experts' judgment, mathematics teachers' evaluation and students' performance was done so that data required at the level of intended, implemented, and attained curriculum can respectively be collected. Data obtained per item from all the Dutch mathematics curricular levels were combined so that the three levels can be correlated. Descriptive statistics of the results gained from both the 1995 and 1999 data analysis revealed that the match of the TIMSS written test to the Dutch intended mathematics curriculum has improved significantly but still considered comparatively low, on the contrary, the students' performance has maintained its steadiness yet experienced slight variations. Indeed, the 1999 statistics also showed that the TIMSS mathematics assessment's appropriateness to the curriculum implemented in Netherland is acceptable but that of the 1995 failed to show any findings at this curricular level due to the inadequacy of data available for it. Trend correlations revealed the presence of weak alignment between the 1995 intended and attained curricular levels, however, couldn't provide any insights at the implemented curriculum level again because of the sacristy of information given. Even though an alignment of a specific degree was found between all the 1999 curricular levels (Vos,

2002), it was, nonetheless, uninterpretable as it needed a sort of comparable element that wasn't at hand at that time (Vos & Bos, 2005).

In trying to provide this feature of comparison required to comprehend the results of the 1999 analysis, Vos and Bos (2005) conducted a supplementary study that compared the Dutch mathematics 1999 curriculum data previously obtained to two benchmarks: a neighbouring country "Belgium" and a different subject area "Science". The two researchers followed the same methodological procedures as was previously applied in the primary study to collect data at each Belgian mathematics and Dutch science curricular level. Similarly, data gathered had also been analysed through both descriptive statistics and correlations. The former revealed that the TIMSS-1999 assessment's match with the Belgian mathematics intended curriculum is higher than that with both the Dutch mathematics and science ones. At the level of the implemented curriculum, the match is approximately the same for the TIMSS-1999 mathematics items in both Belgium and Netherland, while it is lower for the science items when compared to that of the latter. As for the attained curriculum, it was found that the performance of the Dutch students on the TIMSS-1999 mathematics assessment is higher than that of the Belgian but lower than theirs on the science assessment for one of three science subjects. Comparisons of the obtained alignment correlational coefficients showed that the alignment of the Dutch mathematics curricular levels attained the satisfaction level after the reform done six years ago. Considering that a time period of six years would be deemed as a relatively short one, Vos and Bos (2005) concluded that the spreading rate of the newly introduced mathematics curriculum has accelerated since 1993.

South Africa

In their efforts to give insights on one of the possible reasons behind the South African test takers' poor performance on the TIMSS assessments, Ndlovu and Mji (2012) examined the extent to which the eighth grade South Africa's mathematics revised national curriculum statements agree with the TIMSS-2003 assessment frameworks including the objectives, target percentages and test items. The Surveys of Enacted Curriculum model was used in the study to investigate this alignment. Findings revealed the presence of low alignment between the documents being analysed. Accordingly, the researcher called the attention of the concerned South African parties to the existed disparities among the content and cognitive demands emphases between the selected documents (Ndlovu & Mji, 2012).

Norway

To determine the appropriateness of the TIMSS Advanced mathematical examinations administered in each of the 1998 and 2008 cycle for the assessment of the Norwegian students' mathematical achievement at the upper secondary school level, Pedersen (2013) investigated the degree of match between these instruments and each of the corresponding versions of the Norwegian advanced mathematical curriculum by means of the Surveys of Enacted Curriculum alignment methodology. The moderate alignment indices found between the selected curriculum versions and the two iterations of TIMSS advanced inferred the presence of some differences in the mathematical focus between the documents under analysis. It had been concluded that these outcomes don't suggest the inappropriateness of the TIMSS Advanced tools for evaluating the mathematical achievement of the Norwegian upper secondary school students, but rather call for a more careful interpretation of the results obtained from this cross-national assessment (Pedersen, 2013).

U.S.

To investigate the relationship between content-specific test-to-curriculum alignment and test item performance, Traynor (2017) used the content analysis data previously done for the curricular middle school mathematics standards of 10 U.S. states along with the assessment item data readily available for the 2007~NAEP and TIMSS achievement tests as well as those derived from the responses of the states' students on these assessments. The researcher initially worked with the latter to compute for every item present in the NAEP or TIMSS tests its difficulty parameter in the concerned state. The Surveys of Enacted Curriculum methodology was then employed to calculate the alignment indices between every state's mathematics' standards and each of the large-scale mathematics achievement assessments. Given the previously quantified data, the researcher used a sort of complex equation so that discrepancies in item difficulty referable to variations in test-to-standards alignment can be estimated. Results revealed that each of the chosen mathematics achievement tests shows quite a high content alignment with the states' mathematics standards. As for the relationship under examination, findings showed that alignment has a positive effect on the proportion-correct test item difficulty values only when the proportion of a state's standards corresponding to a given item's topic-by-cognitive process cell was high; however, this wasn't the case for all the samples taken (Traynor, 2017).

Lebanon

In seeking to initially provide insights on how well the eighth-grade Lebanese students are performing on the mathematics and science TIMSS assessments with respect to the achievement of their precedents and compared to that of their counterparts in other participating countries, CERD (2018) conducted a national Lebanese study

using the results of the TIMSS-2015 international assessments. The findings on this matter revealed that the Lebanese mathematics and science performances on the eighth grade TIMSS assessments haven't experienced a significant progress since 2003, and both have been lower than that of the other participating countries across all the content and cognitive domains. Intending thereafter to examine the possible parameters that might have an influence on the Lebanese students' mathematics and science TIMSS achievement, the research at hand investigated the match between the official (G1-12) mathematics as well as science curricula and the eighth grade TIMSS international assessments developed for these two subject matter areas. Indeed, the actual alignment procedure followed in this regard wasn't included in the national documented report by CERD (2018) yet the outcomes generated by its means were declared as follows. For the math subject area, it was reported that approximately 33% of the related TIMSS assessment items is covered in the Lebanese curriculum of the grades above the eighth grade level or weren't included in any of the Lebanese curriculum documents. As for the science subject matter, it was found that around 36%, 31% and 23% of the TIMSS assessment items associated respectively to the Earth Science, Physics and Biology content domains are addressed in the corresponding Lebanese curriculum yet above the eighth grade level or not tackled across the (G1-12) Lebanese curricula. Regarding the Chemistry science content domain, curriculum classifications done in relation to the TIMSS assessment framework showed that 22% of the specified TIMSS objectives are partially covered by the respective eighth grade Lebanese curriculum, not covered by any means or dealt with yet at a higher grade level. Based on all the above, CERD (2018) called for undertaking a curriculum reform process that aims to enhance the alignment between the Lebanese curriculum and worldwide curricula along with cross-

national TIMSS assessments so that it can better meet international standards and TIMSS assessments requirements.

Philippine

In their pursuit of evaluating the Filipino's preparedness for the TIMSS mathematics and science assessments thus contributing some of the evidence needed to support the decision-making process regarding Philippine's participation, Balagtas et al. (2019) and her colleagues studied the degree of alignment between the TIMSS-2015 assessment framework and the mathematics and science K to 12 Philippine's curriculum. The methodological procedure of this research started with experts' mapping all the content competencies present in each of the TIMSS-2015 mathematics and science assessment frameworks for grades four and eight versus those found in the Philippine's K to 12 curriculum documents for mathematics and science. For every subject area at the fourth and eighth grades, the overall number of TIMSS-2015 assessment framework competencies was primarily utilized to calculate the percentage of the aligned competencies across the involved documents. Results obtained from this analysis showed that each of the fourth-grade mathematics and science TIMSS-2015 assessment framework is more aligned with the Philippine's curriculum to which it corresponds than that of its counterpart in the eighth grade. Generally, the alignment of the mathematics TIMSS-2015 assessment framework against the K to 12 Philippine's curriculum was found to be more than that of the science framework. The curriculum mapping previously described was followed by specialists' classification of all the mathematical and science competencies included in each of the fourth and eighth grade Philippine's curriculum across the TIMSS cognitive domains. For every cognitive dimension, the percentage of the mathematical and science competencies that addressed

it was calculated to show their distributions over the three cognitive domains. Findings of this classification revealed that there existed at the eighth grade enough mathematics and science curriculum emphasis on the first two cognitive domains of the TIMSS taxonomy while this wasn't the case for the third domain "reasoning" (Balagtas et al., 2019).

In conclusion of what have been reported, curriculum alignment studies done with TIMSS were found across six different worldwide contexts. In each of the South African's (Ndlovu & Mji, 2012), Norwegian's (Pedersen, 2013) and Filipino's (Balagtas et al., 2019) study, investigating the alignment between the national curriculum and TIMSS assessments was the ultimate purpose to achieve. The rest of the documented studies done in Netherland (Vos, 2002; Vos & Bos, 2005), U.S. (Traynor, 2017) and Lebanon (CERD, 2018) examined the intended relationship in a preliminary step to fulfil a supplementary target. Vos (2002) did so in an attempt to understand the reason behind the intra-curricular discrepancy found between the Dutch intended and attained curricular levels after conducting the eighth-grade TIMSS-1995 mathematics written test in Netherland. Vos and Bos (2005) performed the same kind of investigation to present a comparison feature to the results reported by Vos (2002). Likewise, Traynor (2017) addressed this issue trying to study whether a content specific test-to-curriculum alignment is associated to the test item U.S. performance. Finally, CERD (2018) also tackled this matter seeking to investigate the possible parameters that might be affecting the eighth-grade Lebanese students' mathematics and science performance in the TIMSS assessments.

TIMSS in the Lebanese Context

The eighth-grade mathematics and science TIMSS assessments have been administered in Lebanon since 2003 while that of the TIMSS advanced for mathematics and physics since 2008 (Shehayeb, 2017). No participation has been recorded on the behalf of the Lebanese students in any of the fourth grade TIMSS assessments (Shehayeb, 2017).

The Need for an Alignment Study at the Fourth Grade Level

With the growing international focus placed on the achievement results of the TIMSS participating countries (Ndlovu & Mji, 2012), Lebanon's participation in TIMSS at the fourth-grade level becomes a high-stakes local decision that needs among other things a curriculum alignment study to support it. Indeed, it is important for Lebanon to take part in the fourth-grade study as it will reveal how good the Lebanese students are compared to international standards, what curricular adjustments can be made and what instructional practices might be integrated. Based on the above, the researcher acknowledged the importance of conducting a curriculum alignment study at the fourth grade level. While the fourth grade TIMSS-2019 assessments are developed for both the mathematics and science subject areas, the researcher chose to carry out this alignment research using the fourth grade Lebanese science curriculum. The science subject was picked since it is of interest to the researcher and of high relevance to her prior work as a fourth grade science teacher. The selected science curriculum document is further explained in the following section.

Fourth Grade Lebanese Science Curriculum and Alignment Studies

In 1997, the Ministry of Education and Higher Education developed the Lebanese science curriculum for the fourth year of the elementary phase (Center for

Educational Research and Development [CERD], 1997). So far, this previously specified curriculum hasn't been subjected to any modifications as it has been entirely applied up to the present time. In view of this, the fourth grade Lebanese science curriculum was utilized as a primary document to investigate the alignment with the TIMSS-2019 assessment framework. Four basic columns make up the bulk of this curriculum document: content; learning objectives; activities and materials; remarks (CERD, 1997). Five main units outline its 'Content' column: "Plants and Their Habitats; Animals and Their Habitats; Man and His Health; Matter and Energy; Earth and the Universe". Each of these units comprises various sub-units that present the specific content topics that define it. Within the range of one academic school year, this Lebanese curriculum has specified the number of science periods needed to finish each of its units with each of the first, second, third, fourth and fifth unit needing 27, 21, 15, 40 and 17 periods respectively. The competencies and skills required on behalf of the fourth grade Lebanese students as they engage with every content topic are set as 'Learning Objectives' in the second column (CERD, 1997). Note that Appendix C lays out an exhaustive overview of the learning objectives included per each unit and in every sub-unit/topic. To assist the fourth grade Lebanese science teachers in planning their instructional 'Activities and Materials', the third column suggests several ideas to guide their teaching practices (CERD, 1997). As for the last column, 'Remarks', some extra recommendations are provided (CERD, 1997).

In general, the standards set by any of the Lebanese curricula serve as a benchmark for almost all of the published science textbooks used in the Lebanese schools (Marlow-Ferguson, 2002, as cited in El Hassan & Baassiri, 2019). In fact, before the era of 1970s, the Lebanese government had not obliged any school within the

public or private sector to use a particular book for any subject. Thereafter, it has chosen to follow the textbooks developed by CERD and correspondingly stipulated their use by the public schools but given the discretion to the private schools in selecting the ones they prefer for each subject except the civics one as they must stick to those produced by CERD for this area (Marlow-Ferguson, 2002, as cited in El Hassan & Baassiri, 2019).

To provide a thorough overview of the relevant research undertaken in the Lebanese context, the researcher engaged in a literature search of the existing Lebanese curriculum alignment studies. The result of this inspection revealed the presence of six Lebanese studies conducted to measure the alignment of the Lebanese official curriculum to either national exams (Hajo, 2010; Hajo, 2018; Osta, 2007; Sleiman, 2012; Safa, 2013), or classroom summative assessments (El Hassan & Baassiri, 2019) and only one study was carried out to explore the Lebanese national curricular matching with the TIMSS international assessments (CERD, 2018). The latter has been fully described under the previous section titled 'Curriculum Alignment Studies Done with TIMSS', whereas the rest of the studies warranted a further synopsis in what follows.

Giving the focus on the pre-reform period, Osta (2007) examined the extent to which the Lebanese official math exams are aligned with the curriculum at the intermediate school level, in an attempt to design and apply a methodological framework for such kind of alignment studies. The researcher's goal was to study the nature of the pre-reform "assessment culture" that is assumed to be driving the process of developing the post-reform national examinations thus still influencing the currently applied curriculum. The piloted methodological framework considered the qualitative and quantitative analysis of the math tests. In the qualitative part, both the structure and

content coverage of 11 national math tests was specified. The results of this analysis revealed that there exists stability among their format as well as the content topics they cover. As for the quantitative one, the analysis involved not only the test items of the official math exams but also those of the model tests as they represent the old curriculum thus act as a reference against which comparisons with the former will be made. For each group of tests, a double-entry matrix was filled where every test item was classified based on the curriculum topic and sub-topic it tackles as well as the National Assessment of Educational Progress (NAEP) mathematical ability it addresses. Data provided by these matrices were analysed using various statistical techniques. To provide a comprehensive picture of the content strands and cognitive abilities stressed by these tests, the frequencies, and percentages of test items across each content domain, mathematical cognitive level, or both were computed and compared. Additionally, to investigate the degree of alignment between the national tests and the pre-reform curriculum, correlation coefficients between the pre-reform tests and the model ones were calculated. The quantitative findings proved the lack of cohesion among the two types of tests as discrepancies appeared among them (Osta, 2007).

Using the methodological framework previously established by Osta (2007), Sleiman (2012) studied the alignment between the Lebanese national exams and the post-reform math curriculum but this time at the secondary school level with a specific emphasis on the "Literature and Humanities" (LH) track. As previously mentioned, the quantitative analysis in this kind of investigations calls first for classifying the test items of both the national exams and model tests across the content and cognitive demands dimensions then utilizing simple statistical methods to study the data obtained (Sleiman, 2012). It should be noted that the NAEP mathematical abilities adopted in Osta's (2007)

study, had been replaced by the TIMSS cognitive domains in this research (Sleiman, 2012). When comparing the distribution of test items for both types of tests over the detailed objectives and cognitive domains, a low positive correlation was found. However, there existed a high positive correlation between the official math exams and the model tests when replacing the detailed objectives by the math areas in the formula of computation. The qualitative analysis of each of the reformed curriculum, official exams and model tests detected the presence of problems in content and cognitive demands coverage. Results revealed that some areas within the content dimension of the new curriculum were not dealt with by the two types of tests. Moreover, it was shown that the first two cognitive domains of the TIMSS hierarchy dominated of these tests while the last one 'reasoning' had been neglected by them (Sleiman, 2012).

To complement the work of the studies previously conducted by Osta (2007) and Sleiman (2012), Safa (2013) proceeded with the same kind of research to investigate the alignment between the post-reform math curriculum and the Lebanese official math exams but for the "Life Science" (LS) section of the secondary school education. In his study, Safa (2013) followed Osta's (2007) methodological approach except for adopting TIMSS cognitive domains when mapping the test items as had already done by Sleiman (2012). The findings of both the qualitative and quantitative analysis of Safa's (2013) alignment study were parallel to those revealed by his fellows' (Osta, 2007; Sleiman, 2012) previous work.

Likewise, Hajo (2010) targeted the Lebanese LS track but in the sense of investigating the degree to which its national chemistry exams measure the content and cognitive demands of the grade 12 chemistry curriculum. The results of this alignment examination can support the use of scores obtained on the Lebanese official chemistry

exams for examinee certification as they provide the ‘content’ and ‘substantive’ validity evidence needed in this regard. To present these two lines of validity evidence, the Webb alignment model was utilized in this study. Following this model, the researcher called nine experts in the chemistry subject to participate in a three-day alignment analysis institute. The experts in the chemistry field were asked to review the curriculum document along with three of the national chemistry exams administered in 2004, 2005 and 2006 to judge their alignment. Additionally, in an attempt to gain insights into their opinions on the quality of the LS chemistry curriculum and the alignment between it and the official exams, the reviewers were requested to complete three survey questionnaires during the three-day organized assembly. Quantitative data collected from the expert reviews were analysed through comparing the content and cognitive demands emphases of the curriculum to that of each official exam included in the specified 3-year period and by applying the four alignment criteria identified by Webb along with their cut-off numbers. Analysis of the qualitative data obtained from the self-completion questionnaires filled by the reviewers involved: reading of the collected answers, coming up with related themes, classifying them into categories, arranging data in tables and finally calculating the rate at which the specified themes appeared in the reviewers’ responses. The findings of this doctoral dissertation revealed that the alignment model by Webb is inappropriate for studies done in the Lebanese context, the Lebanese national examinations for the chemistry subject failed to adequately measure the content of the corresponding curriculum and the latter had been unsuccessful in identifying clearly the cognitive skills supposed to be emphasized by the official tests (Hajo, 2010).

Working with the same mentality, Hajo (2018) conducted a parallel study to her previous research but at the intermediate Lebanese school level. In like manner, this study examined the alignment between the ninth-grade Lebanese official chemistry exams and the ninth-grade chemistry curriculum in terms of the content and cognitive demands dimensions in order to validate the use of the scores attained on these tests for the ninth-grade test takers' certification. As qualified chemistry experts, the researcher and her colleague worked collaboratively to analyse and compare the content and cognitive demands of the documents being selected. Three basic steps summarized the methodological procedures involved in this study. On the first step, the two reviewers used the Webb's Depth of Knowledge (DOK) taxonomy to simultaneously assign each coded objective included in the ninth-grade chemistry curriculum document to the DOK level it tackles. In the second step, the same action was applied to every coded item presented in each of the sixteen chosen ninth-grade chemistry national tests. As for the third one, the two chemistry experts continued working coactively in trying to match each of the coded test items to a learning objective of the elected curriculum. By means of descriptive statistics, quantitative data analysis was carried out in this research so that each of the content and cognitive demands emphasis can be compared across the documents at hand. Findings revealed the presence of insufficient content alignment between the Lebanese chemistry national exams and the official curriculum of the ninth-grade level. With respect to the cognitive demands dimension, it was found that the DOK levels addressed by the ninth-grade chemistry test items were higher than those tackled by the ninth-grade chemistry curriculum objectives (Hajo, 2018).

It is evident that all the previously described Lebanese curriculum alignment studies were done at the intermediate (Hajo, 2018; Osta, 2007) or secondary school

level (Hajo, 2010; Sleiman, 2012; Safa, 2013) using official examinations. El Hassan and Baassiri's (2019) study was the only curriculum alignment research that tackled the Lebanese elementary level making use of summative classroom assessments instead of national ones. Using the most comprehensive curriculum unit, El Hassan and Baassiri (2019) explored the extent to which the fourth grade summative classroom assessments are aligned with the fourth grade Lebanese science curriculum in terms of the content and cognitive levels. Classroom assessments provided by a sample of public and private Lebanese schools along with the fourth grade Lebanese science curriculum were subjected to both qualitative and quantitative analysis in three phases. The first phase involved coding of each learning objective found within the selected curricular unit into its content topic and assigning the Bloom's cognitive level it tends to address. The second one was concerned with the collected assessments as it entailed coding them then matching each item included into a curricular content topic, learning objective, and allocating the cognitive level it tackles. In the last phase, for every assessment given, the codes of the test items that proved to have content match were listed according to their corresponding learning objectives so that the total number of item points dedicated for every learning objective along with their relative percentages across each content topic were calculated. The same was applied over the six cognitive levels of Bloom's taxonomy. The researcher utilized both descriptive statistics and frequency tables to present the overall results offered by all the 42 summative classroom assessments. The results revealed that there exist moderate content alignment and low cognitive level one between the curricular unit chosen and the classroom assessments aggregated. Deeper examination showed that public exams had higher content alignment than the private ones. In terms of items distribution over the curricular content topics, findings showed

that the assessment items highly measure some topics at the expense of others. However, it was found that public schools displayed a wider distribution of items across all the topics than the private ones. As for the items distribution over the six cognitive levels, outcomes revealed that only the first two cognitive levels of Bloom's taxonomy were targeted by the assessment items while the rest had been almost neglected. Schools within the private sector appeared to have a wider distribution of items in this regard. Differences did exist between the science curriculum and summative assessments when comparing their cognitive level distributions (El Hassan & Baassiri, 2019).

In accordance with what have been reviewed, it is evident that Lebanese research examining the alignment between official curricula and TIMSS international assessments has been initiated only once by CERD (2018). Indeed, Shehayeb's (2017) research is the other Lebanese alignment study that addressed TIMSS but in the sense of investigating the alignment between the twelfth grade Lebanese mathematics public exams for the GS track and the TIMSS Advanced framework along with the items. The methodology began with experts' classification of the math items included in the twelfth grade Lebanese national exam according to the content and cognitive domains of the TIMSS Advanced framework. Ratios of the Lebanese math items tackling each content and cognitive domain were calculated and used along with that of the TIMSS Advanced framework to calculate the Porter (2002) alignment index. The procedures continued to work with the Lebanese math tasks and the TIMSS Advanced items in the sense of sorting them based on both their type and domain. Similarly, cross tabulations of ratios for each of the two documents were obtained and utilized to compute the index. When comparing the resulting alignment indices given by Porter (2002), findings revealed that the twelfth grade Lebanese mathematics public exams share with the

TIMSS Advanced framework a higher alignment index than with the actual assessment items. Shehayeb (2017) suggested that the lack of consistency between the item formats and domains may be the reason behind this weakening in the alignment.

All of the Lebanese alignment research previously reviewed provides a rationale for conducting this study as none of them tackled the area of alignment in terms of investigating the degree to which it exists between the official Lebanese curriculum and the TIMSS cross-national assessments at the fourth grade level. Therefore, this part of the 'Literature Review' section has highlighted the importance of examining the alignment between the fourth grade Lebanese science curriculum and TIMSS-2019 assessment framework.

Summary

The aim of this research was to examine the degree to which the TIMSS-2019 assessment framework is aligned to the fourth grade Lebanese science curriculum in terms of content and cognitive demands. In line with this study's purpose, the content of the 'Literature Review' chapter were determined. To sum up, this chapter focused on the following three major parts.

The first part tackled the Trends in International Mathematics and Science Study 'TIMSS'. It started by introducing this cross-national study set by IEA and continued by zooming-in to its most recent cycle 'TIMSS-2019'. Then, it moved on to describing in depth the first element involved in this study, the fourth-grade TIMSS-2019 science assessment framework with a particular focus on its content and cognitive demands dimensions. Finally, it ended up by elaborating on the actual administered TIMSS-2019 assessment items for the science subject at the fourth-grade level.

The second part addressed the relationship under examination, which is ‘alignment’. It began with explaining the need for studies investigating this relationship between the developed assessments of TIMSS and the existing national curricula. It moved forward by defining the relevant meaning of alignment and presenting the three best models to be utilized when studying it. Finally, it outlined the research work done on the topic of TIMSS-to-curriculum alignment.

As a whole, the last part dealt with the ‘Lebanese context’, initially in the sense of shedding light on its involvement in TIMSS and subsequently in terms of rationalizing for a curriculum alignment study with the TIMSS assessments at the fourth-grade level. It proceeded to providing a detailed emphasis on the second element concerned with in this research, the fourth grade Lebanese science curriculum. Finally, it summed up the curriculum alignment studies previously conducted in the Lebanese context.

The next chapter will describe the alignment method followed to answer the research questions raised in this study.

CHAPTER 3

METHODOLOGY

Introduction

The current chapter's main focus is to describe the methodological pathway followed by this research to investigate the agreement between the fourth-grade Lebanese science curriculum and TIMSS assessment framework. It starts by describing the research design of the study and continues with giving information about the two analyzed documents, used instruments and applied procedures. Finally, it ends up by providing insights into the data analysis implemented in the study.

Research Design

The purpose of this study was to investigate the alignment between the fourth grade Lebanese science curriculum and TIMSS-2019 assessment framework. Document analysis of each of the fourth grade Lebanese science curriculum and TIMSS-2019 assessment framework was applied in order to answer the questions concerning the current state of their alignment in terms of the two dimensions: content and cognitive demands. This aspect of the conducted research called for a descriptive non-experimental research design (Gall et al., 2014).

It is worth mentioning that the study aimed to explore the degree of alignment between these two components as it is without any manipulation. Assigning randomly subjects to conditions in an attempt to manipulate a certain independent variable or controlling for all variables except the latter had simply not been part of this research. According to Gall et al. (2014), research which aims to study an existing relationship between two variables with no manipulation falls into the correlational category of the

non-experimental research. Therefore, the carried-out research was a relationship study following another type of non-experimental research design, which is the correlational design.

Analyzed Documents

The analyzed documents in this research consisted of both the fourth grade Lebanese science curriculum and the TIMSS-2019 science assessment framework set out for this grade level. Data available by means of these two documents were qualitatively and quantitatively analyzed to tackle the research questions raised in this study.

Instruments

For qualitative analysis of the data given by the two documents under examination, three instruments were employed. The researcher designed all these tools to perform this kind of data analysis.

Curriculum Matching Sheet (CMS)

The first instrument, the ‘Curriculum Matching Sheet’ (CMS), was utilized in the first stage of the methodology to match every learning objective found under a given content topic in each fourth grade Lebanese science curriculum unit to a content domain, topic, and sub-topic of the TIMSS-2019 science assessment framework. A sample of a CMS is provided in Table: 4. The CMS composed of two main columns, and each one in turn consisted of separate columns. The former column ‘Fourth Grade Lebanese Curriculum’ was split into two different columns titled ‘Content Topic’ and ‘Learning Objective’ correspondingly. The ‘Content Topic’ column presented the fourth grade Lebanese science curriculum content topics along with the code given to each one as indicated by means of the curriculum document. Each of the given codes was

represented by two digits separated by a dot, where the first one denoted the number of the curriculum unit to which a certain content topic belongs and the second one signified the order of that topic in the series of each curriculum unit. Accordingly, the code 3.4, for example, was given to the fourth content topic (Malnutrition and some of its consequences) of the third curriculum unit "Man and His Health". The second column ‘Learning Objective’ displayed the learning objectives assigned under every content topic included in each of the five curriculum units as well as the code set for each one of them based on its arrangement in the sequence of each content topic. Thus, continuing with the same example previously stated, the codes 3.4.a, 3.4.b, 3.4.c and 3.4.d were given respectively for the four learning objectives found within the curriculum content topic 3.4. The next major column ‘TIMSS-2019 Assessment Framework’ was divided into three different columns captioned ‘TIMSS Content Domain Covered’, ‘TIMSS Content Topic Covered’ and ‘TIMSS Content Sup-Topic Covered’ respectively. The first column ‘TIMSS Content Domain Covered’ revealed the TIMSS content domain(s) into which each learning objective corresponds to as judged by the researcher. The Roman numerals “I”, “II” and “III” were used respectively as codes for the TIMSS content domains "Life Science", "Physical Science" and "Earth Science" in this regard. The second column ‘TIMSS Content Topic Covered’ indicated, within the already specified TIMSS content domain, the content topic(s) that every learning objective is deemed, by the researcher, to be covering. The identified content topics were coded depending on the appearance of each in every fourth grade TIMSS-2019 science content domain. So, the code I.5, for example, was given for the fifth content topic (Human Health) of the TIMSS content domain "Life Science". The third column ‘TIMSS Content Sub-Topic Covered’ pointed out, within

the previously noted TIMSS content topic(s), the exact content sub-topic(s) into which every learning objective is matched to as viewed by the researcher. The same number given to each content sub-topic within every topic of the TIMSS-2019 assessment framework document was used for codification in this matter. Therefore, the second sub-topic of the fifth topic in the "Life Science" TIMSS content domain was given the code I.5.2. Based on all the above, for example, the curriculum learning objective 3.4.d was judged to be covering the TIMSS content sub-topic I.5.2 found in the second place under the fifth content topic of the first TIMSS content domain. A minor column 'Notes' was inserted to the CMS to add few remarks related to certain parts of some learning objectives. In the cases where a given curriculum learning objective wasn't matched to any of the TIMSS content domains, topics and sub-topics, like objective 3.4.a for example, the word "None" was written in the three corresponding cells. It is worth noting that the CMS was filled out across every unit found in the Lebanese curriculum. The five completed CMSs are all displayed in Appendix D.

Table 4

Sample of a 'Curriculum Matching Sheet' (CMS)

Fourth Grade Lebanese Curriculum			**TIMSS-2019 Assessment Framework**			
Content Topic		**Learning Objective**	**TIMSS Content Domain Covered**	**TIMSS Content Topic Covered**	**TIMSS Content Sub-Topic Covered**	**Notes**
3.4 (Malnutrition and some of its consequences)	3.4.a	Defines malnutrition as the trouble or affliction caused in our body because of the amount or kind of food eaten.	**None**	**None**	**None**	
	3.4.b	States the outstanding symptoms of undernourishment.	**None**	**None**	**None**	
	3.4.c	States the harmful effects of overeating.	**None**	**None**	**None**	
	3.4.d	Infers the importance of conforming to times of meals and eating proper amount and kind of food.	**I**	**I.5**	**I.5.2**	

Assessment Matching Sheet (AMS)

The second tool, the 'Assessment Matching Sheet' (AMS), was used in the second stage of the study so that every learning objective, covered by a certain content sub-topic of any topic contained within the fourth grade TIMSS-2019 science assessment framework's content domains, is matched to the fourth grade Lebanese science curriculum's content unit(s) and topic(s). A sample of an AMS is given in Table: 5. The instrument consisted of two major columns where each was divided into two adjacent columns. The first prime column 'TIMSS-2019 Assessment Framework' was split into two separate columns captioned 'TIMSS Content Topics & Sub-Topics' and 'TIMSS Learning Objective' correspondingly. The first column 'TIMSS Content Topics & Sub-Topics' displayed the codes previously given for the content topics of the fourth grade TIMSS-2019 science content domains together with the codes formerly set for the content sub-topics included within each. The 'TIMSS Learning Objective' column presented the TIMSS learning objectives clustered under a given content sub-topic of a certain topic allocated for any of the TIMSS-2019 science content domains along with the code generated for each one by means of the TIMSS-2019 assessment framework document. The capital letter code (A, B, C...) decided for each TIMSS learning objective by the TIMSS-2019 assessment framework document was added to the original code given for the content sub-topic to which it belongs to create a unique code for each. For example, the codes II.1.2.A, II.1.2.B and II.1.2.C were specified respectively for the three learning objectives grouped under the TIMSS content sub-topic II.1.2.

The second prime column 'Fourth Grade Lebanese Curriculum' was divided into two distinct columns titled 'Curriculum Content Unit Covered' and 'Curriculum

Content Topic Covered' respectively. The first column 'Curriculum Content Unit Covered' showed the code(s) of the curriculum content unit(s) that the researcher identified as being addressed by each TIMSS learning objective. The numbers "1", "2", "3", "4" and "5" were utilized respectively for the five curriculum units "Plants and Their Habitats"; "Animals and Their Habitats"; "Man and His Health"; "Matter and Energy"; "Earth and the Universe" in this regard. The second column 'Curriculum Content Topic Covered' revealed, within the previously specified curriculum content unit(s), the content topic(s) that the researcher considered to be tackled by every TIMSS learning objective. For example, the TIMSS learning objective II.1.2.A was deemed to be covering the curriculum content topics 4.1, 4.2, 4.3 and 4.5 from the content unit 4 of the Lebanese curriculum. A secondary column 'Notes' was added to the AMS to point out some comments about specific parts of several TIMSS learning objectives. For the TIMSS learning objectives that couldn't be matched to any of the curriculum content units/topics, like objective II.1.1.A for example, the word "None" was provided in the two corresponding cells. It is worth mentioning that an AMS was completed for each of the three TIMSS content domains. The three filled out AMSs are all presented in Appendix E.

Table 5

Sample of an 'Assessment Matching Sheet' (AMS)

TIMSS-2019 Assessment Framework				Fourth Grade Lebanese Curriculum		
TIMSS Content Topics & Sub-Topics			**TIMSS Learning Objective**	**Curriculum Content Unit Covered**	**Curriculum Content Topic Covered**	**Notes**
II.1	**II.1.1**	**II.1.1.A**	Identify and describe three states of matter (i.e., a solid has a definite shape and volume, a liquid has a definite volume but not a definite shape, and a gas has neither a definite shape nor a definite volume).	**None**	**None**	
	II.1.2	**II.1.2.A**	Compare and sort objects and materials on the basis of physical properties (e.g., weight/mass, volume, state of matter, **ability to conduct heat or electricity, ability to float or sink in water,** ability to be attracted by a magnet)**.** [Note: Students in the fourth grade are not expected to differentiate between mass and weight.]	**4**	**4.1-4.2-4.3-4.5**	**Bold part is not covered**

Content-by-Cognitive Demands Matrix

The content classifications completed in the CMSs (Appendix D) have shown all the curriculum learning objectives whose content is tackled by the TIMSS assessment framework. Similarly, the content classifications done in the AMSs (Appendix E) have revealed all the TIMSS learning objectives whose content is covered by the Lebanese curriculum. To investigate the existing similarities and discrepancies in content and cognitive demands emphases between the selected documents, the researcher continued working in the third phase of the study with the group of curriculum objectives that have been verified to be covered by the TIMSS content dimension and the group of TIMSS objectives which have proven to be addressed by the content dimension of the Lebanese curriculum.

For the third stage of the study, the 'Content-by-Cognitive Demands Matrix' (Appendix F) was utilized to represent these two groups of curricula and TIMSS

learning objectives in two dimensions: the content dimension and the cognitive demands dimension. Therefore, this instrumental matrix was arranged according to two dimensions. The content dimension was derived based on the results of the CMSs, as they have revealed, for every content domain in TIMSS, the TIMSS content topics and sub-topics that are tackled in the Lebanese curriculum. It is worth noting that the TIMSS content dimension has been chosen as a reference for the content dimension of the matrix instead of the Lebanese curriculum's one since it offers a more comprehensive scope of content. As for the cognitive demands dimension, it was adopted from the TIMSS taxonomy that consists of three cognitive domains: Knowing, Applying and Reasoning.

Curriculum Matrix (CM). Through this two-dimensional matrix, each curriculum objective whose content proved to correspond to the TIMSS content dimension was categorized depending on the TIMSS content domain, topic and sub-topic to which it matches and the TIMSS thinking process domain it addresses. Accordingly, the 'Content-by-Cognitive Demands Matrix' was filled across every TIMSS content domain to represent the included curriculum objectives. The codes formerly specified to all the involved curriculum objectives were used to represent each in the matrix. The resultant matrix is included in Appendix G captioned 'Curriculum Matrix' (CM). A sample from the CM is given in Table: 6.

Table 6

Sample of the 'Curriculum Matrix' (CM)

TIMSS Content Topics & Sub-Topics / TIMSS Cognitive Domains		Knowing	Applying	Reasoning
I.1	**I.1.2**	1.4.a (Define- give examples) 1.5.a 2.1.a (Name/recognize) 2.3.a (Define- recognize) 2.3.b 2.4.a (Define- give examples)	1.1.b *1.1.c (Relate)*	1.7.a 2.5.a
II.1	**II.1.2**	4.1.a 4.1.c 4.3.a 4.3.b 4.3.c 4.4.a (Define- give examples) 4.4.d (Define)* 4.4.f	4.1.d 4.2.b 4.2.c 4.4.d (Distinguish)*	
	II.1.3	4.5.a (Recognize- identify)		4.5.b
	II.1.4	4.4.d (Define)*	4.4.d (Distinguish)*	4.4.e

Assessment Matrix (AM). This tool has allowed the categorization of each TIMSS learning objective, verified to be correspondent to the Lebanese curriculum content dimension, under the TIMSS content domain, topic and sub-topic it already covers and the TIMSS cognitive domain it addresses. Likewise, the 'Content-by-Cognitive Demands Matrix' was completed across every TIMSS content domain to represent the involved TIMSS objectives this time. The codes previously given to all the included TIMSS objectives were used to represent each in the matrix. The resultant matrix is included in Appendix H titled 'Assessment Matrix' (AM). A sample from the AM is provided in Table: 7.

Table 7

Sample of the 'Assessment Matrix' (AM)

TIMSS Content Topics & Sub-Topics / TIMSS Cognitive Domains		Knowing	Applying	Reasoning
III.1	**III.1.1**	III.1.1.A (Describe-recognize)		
	III.1.2	III.1.2.A	III.1.2.B	
	III.1.3	III.1.3.A III.1.3.B (Recognize)	III.1.3.B (make simple deductions)	

Cognitive Domains Classifications. It is worth mentioning that the researcher has assigned a TIMSS cognitive domain for every curriculum objective and TIMSS one based on the action verb included in each. For the objectives covering one TIMSS content sub-topic and having one verb thus covering one TIMSS cognitive domain, their originated codes were used to represent each across the two dimensions of its corresponding matrix. For example, the TIMSS learning objective of code III.1.2.A, originally including "Identify" as a verb, was represented in the content dimension of the AM (Appendix H) within the topic III.1 under its corresponding sub-topic III.1.2 and in the cognitive dimension within the domain "Knowing" as it entails by the verb it includes. Regarding the III.1.2.B TIMSS learning objective, which initially contained the verb "Explain", its code was displayed in the same content dimension of the same matrix but under the cognitive domain "Applying" as it is required by its action verb.

With respect to the objectives comprising one verb so tackling one TIMSS cognitive domain yet addressing two TIMSS content sub-topics, each was delineated in its matching matrix two times using its verb that was added next to its code, where both were written in an italic font. For example, the curriculum learning objective 1.1.c encompassing the verb "Relate", got its italicized code with the verb "Relate" next to it

under the “Applying” cognitive domain of the CM (Appendix G) two times, one time within the TIMSS content sub-topic I.1.2 and the other time within the I.4.1 one.

Concerning the objectives possessing more than one verb, many formats were made:

1. To represent those covering one TIMSS content sub-topic and their verbs were deemed to tackle the same cognitive domain, in the equivalent matrix, their verbs were added next to their created codes yet separated by a hyphen (-). For example, the code of the TIMSS learning objective III.1.1.A, originally having the verbs “Describe” and “recognize”, was presented in the AM (Appendix H) across the TIMSS content sub-topic III.1.1 and the “Knowing” cognitive domain with these two verbs next to it but separated by a hyphen.
2. To portray those tackling different TIMSS content sub-topics yet still their verbs were classified as addressing the same cognitive domain, in the corresponding matrix, their codes were supplemented with their verbs that were split up using a slash (/) this time. For example, the code of the curriculum learning objective 2.1.a was inserted twice under the cognitive domain “Knowing” in the CM (Appendix G) across the content sub-topics I.1.2 and I.4.1 respectively, with its verbs “Name” and “recognize” beside it yet separated by a dash.
3. To present the objectives addressing different cognitive domains yet a single TIMSS content sub-topic, their codes were written and underlined in the equivalent matrix across the sub-topic that each one is covering and the cognitive domains that each has been judged to tackle, yet each time alongside the respective verb it has for each cognitive level. For example, the code for the TIMSS learning objective III.1.3.B, that primarily included the two verbs

"Recognize" and "make deductions", was written and underlined in the AM (Appendix H) across the content sub-topic III.1.3 and the TIMSS "Knowing" as well as "Applying" cognitive domains alongside the verbs "Recognize" and "make deductions" respectively.

4. To illustrate those covering different cognitive domains as well as distinct content sub-topics, their codes were included across the relevant cells in the corresponding matrix separately alongside the respective verb that each has for every cognitive domain yet with an asterisk (*) this time. For example, the code of the curriculum learning objective 4.4.d, covering the content sub-topics II.1.2 and II.1.4 also having the two verbs "Define" and "Distinguish", has been written in the CM (Appendix G) with the star-shaped symbol (*), in the two corresponding cells across each of the "Knowing" as well as the "Applying" cognitive domains, next to each of the "Define" and "Distinguish" verbs respectively.

Procedures

By means of the Surveys of Enacted Curriculum alignment model, the three tools described previously were used in the three methodological procedures: 'Fourth Grade Lebanese Science Curriculum Matching Procedure', 'TIMSS Assessment Framework Matching Procedure' and 'Curriculum-Assessment Classification Procedure', respectively.

Chosen Alignment Model

To investigate the alignment between the fourth grade Lebanese science curriculum and TIMSS-2019 assessment framework, the Surveys of Enacted Curriculum (SEC) model was adopted in this study. Given the three best alignment

models discussed earlier (Roach et al., 2008), this particular method was chosen above all not only because of its moderate complexity level (Bhola et al., 2003), but also since it was the dominant approach followed by most of the alignment studies of this kind (Ndlovu & Mji, 2012; Pedersen, 2013; Traynor, 2017) as well as by one of the studies that the current research intends to extend (Shehayeb, 2017). Based on this alignment model, a three-stage process was employed for this research methodology.

Fourth Grade Lebanese Science Curriculum Matching Procedure

In the first stage, the five units found in the fourth grade Lebanese science curriculum were reviewed with respect to the content dimension of the TIMSS-2019 assessment framework. Each content topic given under any of the curriculum units was noted down next to its code in the 'Curriculum Matching Sheet' (CMS). Afterwards, each learning objective covered within every curriculum content topic was displayed and given a code in the CMS. Following these steps, each curriculum learning objective was matched, on the CMS, to a coded content domain, topic, and sub-topic of the TIMSS-2019 science assessment framework. A CMS was completed for every unit included in the fourth grade Lebanese science curriculum. This task was accomplished by the researcher as she is knowledgeable of the science subject matter at the elementary level. She is a graduate student who has earned a Bachelor of Arts degree in elementary education with an emphasis in Math and Science and an elementary school teacher who had taught the science subject at the Lebanese fourth grade level. For subsequent quantitative data analysis, the researcher counted for each curriculum unit the total number of its objectives and added up the total number of those that are shown to be covered by the TIMSS-2019 assessment framework. Likewise, the same overall numbers were calculated and noted down for the whole curriculum document.

The results of this curriculum matching procedure were validated by having two other reviewers judging them separately. Both reviewers were qualified for completing this task as one of them is a holder of a master's degree in science education and the other one is an assistant professor at the Lebanese university with an extensive background in K-12 inquiry-based research in curriculum and assessment alignment. Each reviewer was given a copy of the document containing the specifications of the three content domains included in the fourth grade TIMSS-2019 science assessment framework along with a copy of another document encompassing all the filled-out CMSs for the five curriculum units. Thus, the two science experts were asked to judge, independently, the appropriateness of the researcher's content categorizations for the coded curriculum objectives using the specifications set by the fourth grade TIMSS-2019 science assessment framework for each of the Life Science, Physical Science and Earth Science content domains. Only one of the reviewers had few comments regarding the soundness of the TIMSS-2019 content domain, topic and sub-topic into which some of the curriculum objectives were matched to. A meeting between the researcher and this qualified reviewer was held, allowing a lively discussion of the selected content classifications so that a full agreement of the content elicited by each curriculum objective was determined. In this way, the inter-rater reliability of the results was better assured.

TIMSS Assessment Framework Matching Procedure

As for the second stage, the three content domains set in the TIMSS-2019 assessment framework were examined against the content dimension of the fourth grade Lebanese science curriculum. All the coded content topics covered within every TIMSS content domain were presented in the 'Assessment Matching Sheet' (AMS) along with

coded sub-topics clustered under each one. Then, each learning objective grouped under a given TIMSS content sub-topic was coded and represented in the AMS. Afterwards, each assessment learning objective was matched to to the fourth grade Lebanese science curriculum's content unit(s) and topic(s). For every fourth grade TIMSS-2019 science content domain, an AMS was filled by the researcher. Following that, the total number of the objectives stated in each of these subject matter domains was derived along with that of those that are proven to be covered by the Lebanese curriculum in order to generate quantitative data for further analysis. The researcher also calculated similar overall numbers for the objectives of the entire TIMSS-2019 assessment framework document.

The outcomes originated by this assessment matching step were subjected to validation through an individual evaluation by each of the two expert reviewers who had previously participated in the first phase of the study. A copy of the Word file including the specifications of the five fourth grade Lebanese curriculum science units was forwarded to each science expert together with that of the one comprising all the completed AMSs for the three TIMSS-2019 science content domains. The adequacy of the content categorizations provided by the researcher to the coded TIMSS-2019 assessment framework objectives was judged by each science expert, individually, using the shared specifications of the fourth grade Lebanese science curriculum units: "Plants and Their Habitats; Animals and Their Habitats; Man and His Health; Matter and Energy; Earth and the Universe". The researcher received from the same qualified reviewer just two comments with respect to the cogency of the Lebanese curriculum content unit(s) and topic(s) selected for two of the TIMSS-2019 learning objectives. Accordingly, to ensure the reliability of the results, another meeting between the

reviewer and this science expert was carried out to review the specified content classifications in an attempt to reach a full consensus concerning the content tackled by each TIMSS objective.

Curriculum-Assessment Classification Procedure

The results of the first and second stages previously described revealed two groups of learning objectives. The first group encompassed all the fourth grade Lebanese science curriculum objectives whose content has been validated to be matching to that of the TIMSS assessment framework. Likewise, the second group included all the fourth grade TIMSS-2019 science assessment framework objectives whose content has been endorsed to be correspondent to that of the Lebanese curriculum. These two groups of learning objectives were selected for subsequent review in the third stage of the study to reveal the similarities and discrepancies which exist between the two documents under investigation in terms of their content as well as cognitive demands focus.

In the third stage of the study, the two groups of learning objectives eligible for subsequent review were represented in two dimensions: the content dimension and the cognitive demands dimension. Using the 'Content-by-Cognitive Demands Matrix', the researcher represented all these coded objectives on the basis of the TIMSS-2019 content topic as well as sub-topic covered by each and the TIMSS cognitive domain tackled by each. It must be noted that each curriculum or TIMSS learning objective was assigned to a TIMSS thinking process domain using the TIMSS taxonomy based on the action verb it comprises. Neither the curriculum nor the TIMSS learning objectives have been classified previously on the TIMSS taxonomy by any means. Thus, the researcher filled out a 'Content-by-Cognitive Demands Matrix' in this stage twice, one

time to represent the identified Lebanese curriculum learning objectives and the other time to classify those of the TIMSS assessment framework.

The researcher's work for this curriculum-assessment classification phase was validated by the same two reviewers' individual evaluation. Each reviewer received a copy of the TIMSS taxonomy specifying each of the three TIMSS cognitive domains: Knowing, Applying and Reasoning; along with a copy of the document encompassing the resultant Curriculum Matrix (CM) and the resultant Assessment Matrix (AM). The reviewers checked, separately, the suitability of the cognitive domain(s) assigned by the researcher to each objective included in one of the two identified learning objectives groups using the TIMSS taxonomy. The two science experts provided few comments concerning the accuracy of the TIMSS thinking process domain assigned for some of the TIMSS and curriculum learning objectives, where both agreed that some of the objectives which were categorized under the 'Reasoning' level should be at the application one as the task required by their verbs is very simple and not enough to be considered at the third cognitive level 'Reasoning'. Thus, to verify the reliability of the results, the researcher conducted an individual meeting with each reviewer, discussed the conflicting cognitive demands classifications and reached consensus on the thinking process domain(s) addressed by each.

Data Analysis

The first question raised in the study addressed the extent to which the fourth grade Lebanese science curriculum covers the content of the TIMSS assessment framework. To answer this question, two steps were undertaken. First, each curriculum learning objective was matched to a TIMSS content domain, topic, and sub-topic during the first stage of the study. For each TIMSS content domain, the content topics that

proved to be covered and those that found to be neglected by the Lebanese curriculum were noted down along with the content sub-topics that were included as well as excluded within each. Second, each TIMSS learning objective was matched to a Lebanese curriculum content unit and topic during the second stage of the study. The percentage of the TIMSS learning objectives whose content was matched to the Lebanese curriculum content dimension was calculated across every TIMSS content domain and for the whole TIMSS assessment framework document. The percentage of the TIMSS learning objectives whose content verified to be ignored by the content dimension of the Lebanese curriculum was also computed for each TIMSS content domain and the TIMSS assessment framework. The outcomes resulting from the steps described above indicated the extent to which the content of the TIMSS assessment framework is covered by that of the Lebanese curriculum.

The second question targeted the extent to which the TIMSS assessment framework set for the science subject at the fourth grade level addresses the content of the Lebanese curriculum. Another line of results was derived by means of the two previously carried out procedures to answer this question. In reference to the second phase of the study, the researcher extracted, for every curriculum unit, the content topics which were tackled and those which were overlooked by the TIMSS assessment framework. As regards to the first phase of the study, the researcher calculated the percentage of curriculum learning objectives whose content found to be correspondent to that of the TIMSS assessment framework per curriculum unit and for the entire curriculum document. Then again, the researcher computed, for every curriculum unit and the curriculum document, the percentage of the learning objectives that proved to be disregarded by the content dimension of the TIMSS assessment framework. The

results obtained based on the first two stages of the study denoted the extent to which the content of the Lebanese curriculum is covered by that of the TIMSS assessment framework.

The third question focused on the similarities and discrepancies in the content and cognitive demands emphases which exist between the fourth grade Lebanese science curriculum and the TIMSS assessment framework. To reveal the existing similarities and discrepancies in each of the content and cognitive demands emphasis between the two selected documents, the researcher represented the group of the matched curriculum objectives in the 'Content-by-Cognitive Demands Matrix' and the group of the covered TIMSS objectives using the same matrix during the third stage of the study. Accordingly, the third phase of the study yielded two 'Content-by-Cognitive Demands' matrices, where the first one included the coded objectives of the fourth grade Lebanese science curriculum and the second one contained those of the TIMSS assessment framework document. As required by the chosen alignment model, the researcher first counted the number of objectives presented within every cell of each matrix thus derived matrices of frequencies for each of the two involved documents. Using the frequencies found in each of the newly originated matrices along with the total number of objectives existed respectively in each, the researcher then calculated the ratio of the coded objectives in every cell of each matrix. The ratios given for each TIMSS content domain, topic as well as sub-topic and across every TIMSS thinking process domain were afterwards added up for each of the curriculum and assessment matrix allowing for a direct comparison between their content and cognitive demands emphases. Through these descriptive statistics, the researcher was able to answer the third question raised in the study.

The above procedures resulted in two ratio matrices, each having the cell proportions for the objectives of the fourth grade Lebanese science curriculum and the TIMSS assessment framework correspondingly. These were then used to deal with the last research question brought up in the study. For the purpose of quantifying the extent to which the distribution of the objectives' proportions found in the curriculum matrix is aligned to the one presented in the TIMSS assessment matrix, the researcher computed the Porter (2002) index of alignment developed in particular for achieving this goal. The following formula, previously introduced in the 'Literature Review' section, was used to calculate this single alignment index:

$$1 - \frac{\sum | X - Y |}{2},$$

where X denoted the cell proportions in the curriculum matrix and Y denoted the cell proportions in the assessment one. As stated earlier, the computed alignment index can range from 0 to 1, where the value of 1 implies that there exist same distributions across the two documents thus indicates the presence of perfect alignment (Porter, 2002).

Summary

As has been pointed out in this chapter, the present study falls into the non-experimental research design as it follows two of its types: the descriptive and the correlational ones. The path taken to analyze the fourth grade Lebanese science curriculum and the TIMSS assessment framework documents has also been discussed in this chapter. It started with developing the three tools: 'Curriculum Matching Sheet' (CMS), 'Assessment Matching Sheet' (AMS) and 'Content-by-Cognitive Demands Matrix' then continued with using them in the three methodological steps: 'Fourth Grade Lebanese Science Curriculum Matching Procedure', 'TIMSS Assessment Framework Matching Procedure' and 'Curriculum-Assessment Classification

Procedure', respectively. Finally, it ended up by coming up with descriptive data and statistics, deriving frequency and ratio matrices as well as computing the Porter (2002) index for alignment.

CHAPTER 4

RESULTS

This study aimed to investigate the alignment between the fourth grade Lebanese science curriculum and TIMSS-2019 assessment framework with respect to the content as well as the cognitive demands dimensions. In trying to fulfil this aim, the researcher designed and used three instruments: 'Curriculum Matching Sheet' (CMS), 'Assessment Matching Sheet' (AMS) and 'Content-by-Cognitive Demands Matrix' in the three methodological steps: 'Fourth Grade Lebanese Science Curriculum Matching Procedure', 'TIMSS Assessment Framework Matching Procedure' and 'Curriculum-Assessment Classification Procedure', respectively. The results obtained by means of each step are reported in this chapter.

Fourth Grade Lebanese Science Curriculum Matching Procedure

As previously stated, the CMS was filled in across every unit present in the fourth grade Lebanese science curriculum to match every curriculum learning objective to a TIMSS content domain, topic, and sub-topic.

Descriptive Data

The outcomes disclosed by the five completed CMSs showed, across every TIMSS science domain, the TIMSS content topics that are considered and those that are missed by the Lebanese science curriculum at the fourth-grade level together with the content sub-topics that are considered as well those that are left out. Table: 8 below represents the results across the three TIMSS content domains: Life Science, Physical Science and Earth Science.

Table 8

TIMSS Content Topics Included and Excluded in the Lebanese Curriculum with the Excluded Sub-Topics

Content Domain	Content Topics Excluded	Content Topics Included	Content Sub-Topics Excluded
Life Science	I.2 'Life Cycles, Reproduction, and Heredity'	I.1 'Characteristics and Life Processes of Organisms'	I.1.1 'Differences between living and non-living things and what living things require to live'
		I.3 'Organisms, Environment, and Their Interactions'	- I.3.1 'Physical features or behaviors of living things that help them survive in their environment' - I.3.2 'Responses of living things to environmental conditions'
		I.4 **'**Ecosystems'	I.4.3 'Competition in ecosystems'
		I.5 **'**Human Health'	I.5.1 'Transmission, prevention, and symptoms of communicable diseases'
Physical Science	II.3 'Forces and Motion'	II.1 'Classification and Properties of Matter and Changes in Matter'	- II.1.1 'States of matter and characteristic differences of each state' - II.1.5 'Chemical changes observed in everyday life'
		II.2 'Forms of Energy and Energy Transfer'	- II.2.1 'Common sources and uses of energy' - II.2.3 'Heat transfer' - II.2.4 'Electricity and simple electrical systems'
Earth Science	- III.2 'Earth's Weather and Climates' - III.3 'Earth in the Solar System'	III.1 'Earth's Physical Characteristics, Resources, and History'	None
Total	**4**	**7**	**10**

As shown in Table: 8 above, the fourth grade Lebanese science curriculum has entirely disregarded the second content topic 'I.2' of the TIMSS 'Life Science' domain titled 'Life Cycles, Reproduction, and Heredity'. The remaining content topics have partially been considered though as the Lebanese curriculum has excluded at least one

sub-topic from each. Relying on Table: 8, it is evident that the fourth grade Lebanese science curriculum has failed to address the TIMSS Life Science concepts related to the "differences between living and non-living things and what living things require to live" 'I.1.1', "physical features or behaviors of living things that help them survive in their environment" 'I.3.1', "responses of living things to environmental conditions" 'I.3.2', "competition in ecosystems" 'I.4.3' along with "transmission, prevention, and symptoms of communicable diseases" 'I.5.1'.

As for TIMSS 'Physical Science' domain, Table: 8 revealed that out of three content topics only one, 'II.3' captioned as 'Forces and Motion' is overlooked by the fourth grade Lebanese science curriculum. Indeed, the Lebanese curriculum has partially tackled the first two Physical Science content topics 'II.1' and 'II.2' as it has ignored two and three sub-topics across each, respectively. As it turned out to be by means of Table: 8, the two content sub-topics 'II.1.1' and 'II.1.5' have been excluded from the first TIMSS Physical Science content topic 'II.1' in addition to 'II.2.1', 'II.2.3' and 'II.2.4' ones in the second content topic 'II.2'. Accordingly, the TIMSS Physical Science notions corresponding to the "states of matter and characteristic differences of each state" 'II.1.1', "chemical changes observed in everyday life" 'II.1.5', "common sources and uses of energy" 'II.2.1', "heat transfer" 'II.2.3' as well as "electricity and simple electrical systems" 'II.2.4' have been unacknowledged by the selected Lebanese curriculum.

With respect to the third TIMSS content domain 'Earth Science', the fourth grade Lebanese science curriculum has neglected all its content topics except the first one 'III.1', as indicated by Table: 8. Hence, neither the second TIMSS Earth Science content topic 'III.2' 'Earth's Weather and Climates' nor the third one 'III.3' 'Earth in

the Solar System' has been addressed by the science curriculum at the fourth grade Lebanese level. On the other hand, as disclosed by Table: 8, none of the content sub-topics associated with the first TIMSS Earth Science content topic has been omitted by this Lebanese curriculum.

Descriptive Statistics

This matching procedure done for the fourth grade Lebanese science curriculum showed not only qualitative kind of data but also quantitative one as it revealed for every curriculum unit along with the whole Lebanese curriculum document the percentage of objectives whose content is covered by the TIMSS assessment framework and that of those whose content is disregarded by it. To obtain this type of numerical data, the researcher calculated the overall number of objectives specified per curriculum unit and for the entire curriculum document in addition to that of those which proved to be addressed by the fourth grade TIMSS science assessment framework across each. All these total numbers and percentages for each of the five curriculum units as well as that for the curriculum document are presented in Table: 9 below.

Table 9

Percentages of Curriculum Objectives Covered and Disregarded by the TIMSS Assessment Framework

Curriculum Unit	Total Number of Objectives	Total Number of Objectives whose content is covered by TIMSS	Percentage of Objectives whose content is covered by TIMSS	Percentage of Objectives whose content is disregarded by TIMSS
Plants and Their Habitats	17	15	(15/17)×100= **88%**	100-88= **12%**
Animals and Their Habitats	10	8	(8/10)×100= **80%**	100-80= **20%**
Man and His Health	24	17	(17/24)×100= **71%**	100-71= **29%**
Matter and Energy	34	27	(27/34)×100= **79%**	100-79= **21%**
Earth and the Universe	13	12	(12/13)×100= **92%**	100-92= **8%**
Curriculum Document	98	79	(79/98)×100= **81%**	100-81= **19%**

As displayed by Table: 9, the fifth curriculum unit ‘Earth and the Universe’ got the highest percentage of covered objectives across the five curriculum units, where 92% of its total number of objectives is covered by TIMSS with only 8% as disregarded ones. In the second place comes the first curriculum unit ‘Plants and Their Habitats’ as TIMSS considers 88% of its total group of objectives and neglects approximately 12% of them. As for the second ‘Animals and Their Habitats’ and fourth ‘Matter and Energy’ curriculum units, TIMSS almost covers 80% of the objectives found within each and excludes around 20% of them. Regarding the third curriculum unit ‘Man and His Health’, it got the lowest percentage of addressed objectives, where 71% of its overall number of objectives is tackled by TIMSS with about 29% as overlooked ones. Thus, the percentage of covered objectives among the five curriculum units ranged between 71 and 91% with an average of 81% and 19% as neglected (Table: 9).

TIMSS Assessment Framework Matching Procedure

As already mentioned in the preceding chapter, the AMS was completed for each of the three content domains included in the fourth grade TIMSS science assessment framework in an attempt to match every TIMSS learning objective to the fourth grade Lebanese science curriculum’s content unit(s) and topic(s).

Descriptive Data

The results generated by means of the three completed AMSs revealed, for every fourth grade Lebanese science curriculum unit, the content topics that are considered and those that are neglected by the TIMSS assessment framework. Table: 10 below summarizes these results for the five curriculum units.

Table 10

Lebanese Curriculum Content Topics Included and Excluded in the TIMSS Assessment Framework for The Five Curriculum Units

UNIT	Content Topics Included	Content Topics Excluded
Plants and Their Habitats	- 1.1 'Plants common in Lebanon' - 1.2 'Freshwater habitats' - 1.3 'Plants which grow in freshwater habitats or on their banks' - 1.4 'Flowering plants' - 1.5 'Conifers' - 1.7 'Principles of plant classification' - 1.8 'Role of plants in the conservation of topsoil' - 1.9 'Pollution of freshwater'	1.6 'Nonflowering plants: mushrooms'
Animals and Their Habitats	- 2.1 'Wild animals in Lebanon' - 2.2 'Animals of freshwater habitats' - 2.3 'The vertebrates' - 2.4 'The invertebrates' - 2.5 'Principles of animal classification'	2.6 'The social insects: bees and ants'
Man and His Health	All	None
Matter and Energy	- 4.1 'Definition of matter' - 4.2 'Properties of matter' - 4.3 'Measurement of mass' - 4.4 'Mixtures and water solutions' - 4.5 'Magnets' - 4.7 'Sound and some of its properties' - 4.8 'Propagation of sound' - 4.9 'How do we hear?' - 4.10 'Effect of noise on our health'	4.6 'The electric charge'
Earth and the Universe	- 5.1 'Soil and some of its kinds' - 5.2 'Clay and related crafts' - 5.3 'Soil Erosion' - 5.4 'Sandstone and limestone' - 5.5 'Fossils in sandstone and limestone' - 5.6 'Weathering of rocks and soil formation'	5.7 'Formation of subterranean water reservoirs and their relation to rocks'
Total	**32**	**4**

As indicated by Table: 10, the TIMSS assessment framework has missed only one content topic from each of the first, second, fourth and fifth curriculum units but covered fully the third one without omitting any of its content topics. Each of the '1.6' 'Nonflowering plants: mushrooms', '2.6' 'The social insects: bees and ants', '4.6' 'The electric charge' and '5.7' 'Formation of subterranean water reservoirs and their relation

to rocks' curriculum content topics is excluded across the first, second, fourth and fifth curriculum units, respectively.

Descriptive Statistics

On the other hand, the TIMSS assessment framework matching procedure generated a quantitative line of results that disclosed across every TIMSS science content domain as well as the whole TIMSS assessment framework document the percentage of objectives whose content is covered by the Lebanese curriculum and that of those whose content is ignored by the selected curriculum. For the sake of deriving this line of outcomes, the researcher counted the total number of objectives included in each TIMSS content domain and in the entire TIMSS assessment framework document together with that of those which verified to be tackled by the fourth grade Lebanese science curriculum across each. Table: 11 below displays all these overall numbers and percentages for each of the Life Science, Physical Science and Earth Science domains along with that for the TIMSS assessment framework.

Table 11

Percentages of TIMSS Objectives Covered and Ignored by the Lebanese Curriculum

TIMSS Content Domain	**Total Number of Objectives**	**Total Number of Objectives whose content is covered by the Lebanese Curriculum**	**Percentage of Objectives whose content is covered by the Lebanese Curriculum**	**Percentage of Objectives whose content is ignored by the Lebanese Curriculum**
Life Science	26	8	(8/26)×100= **31%**	100-31= **69%**
Physical Science	19	8	(8/19)×100= **42%**	100-42= **58%**
Earth Science	12	5	(5/12)×100= **42%**	100-42= **58%**
TIMSS Assessment Framework	57	21	(21/57)×100=**37%**	100-37= **63%**

As shown by Table: 11, only 42% of the group of objectives related to each of the Physical Science and Earth Science content domains is covered by the Lebanese science curriculum at the fourth-grade level while 58% across each was ignored by it. As for the Life Science content domain, Table: 11 reveals that the selected Lebanese curriculum covers only 31% of its total number of objectives and ignores 69% of it. With respect to the whole TIMSS assessment framework document, 37% of its total number of objectives is addressed by the curriculum document with 63% of them is overlooked by it.

Curriculum-Assessment Classification Procedure

As noted earlier, by means of the first and second procedures of the study, 81% of the total number of the Lebanese curriculum learning objectives is covered by the TIMSS assessment framework while only 37% of the TIMSS framework is found to be tackled by the Lebanese curriculum document. As already stated, the researcher continued working with these two groups of learning objectives in the third procedure of the study, where a 'Content-by-Cognitive Demands Matrix' was filled out across each group to classify every covered curriculum as well as TIMSS assessment learning objective into the TIMSS content domain, topic, and sub-topic to which it matches and the TIMSS cognitive domain it tackles.

The results initially revealed by the two completed matrices indicated that, based on the TIMSS taxonomy, at least one cognitive domain was assigned to each objective included within the covered TIMSS assessment learning objectives group. Unlike the covered Lebanese curriculum learning objectives group, as the curriculum classification procedure showed that the following seven curriculum learning objectives "1.8.b, 3.1.d, 3.3.f, 4.2.a, 4.4.b, 4.4.c and 4.8.b" haven't been included in the 'Curriculum Matrix'

(CM) as each of them doesn't have an action verb that reveals the TIMSS cognitive level addressed. Additionally, each of the following four curriculum learning objectives "1.9.c, 3.2.d, 4.1.c and 4.5.b" hasn't been fully classified in the CM as each of them has one of its encompassed action verbs that doesn't fall under any of the TIMSS cognitive domains. Based on all the above, in total, 72 curriculum learning objectives were classified in the 'Curriculum Matrix' (CM) while 21 TIMSS assessment learning objectives were included in the 'Assessment Matrix' (AM).

Frequency Matrices

The researcher used the two resultants 'Content-by-Cognitive Demands' matrices for further data analysis in an attempt to identify any existing similarities and differences between the two documents under examination. Accordingly, the researcher started by counting the number of objectives found in every cell included within each matrix in trying to come up with a 'Sub-Topics-by-Cognitive Demands' frequency matrix for each of the Lebanese curriculum (Appendix I) and the TIMSS assessment framework (Appendix J). Subsequently, the researcher added up the numbers of objectives present across every TIMSS content topic of each matrix and derived two 'Topics-by-Cognitive Demands' frequency matrices found in Appendices K and L for the curriculum document and the TIMSS assessment framework, respectively. As a following step, the researcher calculated the same total numbers of objectives yet per TIMSS content domain thus created a 'Content Domains-by-Cognitive Demands' frequency matrix for the selected curriculum (Appendix M) and another one for the TIMSS assessment framework (Appendix N).

Ratio Matrices

The researcher afterwards generated a corresponding ratio matrix for each of the newly originated frequency matrices using the frequencies obtained within the cells and the overall number of objectives found in each matrix. By means of these generated ratio matrices, the researcher then computed the cumulative ratio attained by each matrix for every TIMSS content domain, topic, and sub-topic together with that of each TIMSS cognitive demands domain so that it would be possible to make direct comparisons between the content and cognitive demands emphases of the two selected documents. For ease of comparison, the researcher then combined the ratios obtained by each matrix for the TIMSS content topics, sub-topics and domains in Tables: 12, 13 and 14, respectively, and added a column of absolute difference for the found ratios across each. The three tables are presented below along with the descriptive comparisons made for each.

Table 12

Lebanese Curriculum VS. TIMSS (Topics Ratio Differences)

Curriculum VS. TIMSS / **TIMSS Content Topics**	**Lebanese Curriculum**	**TIMSS**	**|Difference|**
I.1 'Characteristics and Life Processes of Organisms'	0.2	0.18	0.02
I.3 'Organisms, Environment, and Their Interactions'	0.06	0.04	0.02
I.4 'Ecosystems'	0.1	0.09	0.01
I.5 'Human Health'	**0.11**	**0.04**	**0.07**
II.1 'Classification and Properties of Matter and Changes in Matter'	**0.18**	**0.32**	**0.14**
II.2 'Forms of Energy and Energy Transfer'	0.07	0.04	0.03
III.1 'Earth's Physical Characteristics, Resources, and History'	0.2	0.23	0.03

When looking at the content topics ratios concentration of the Lebanese curriculum versus the TIMSS assessment framework (Table: 12), it is apparent that both devoted somehow similar consideration for all the TIMSS content topics except for two of them. The differences in emphasis (|Difference|>0.05) existed among the two content topics 'I.5' 'Human Health' and 'II.1' 'Classification and Properties of Matter and Changes in Matter'.

Table 13

Lebanese Curriculum VS. TIMSS (Sub-Topics Ratio Differences)

TIMSS Content Topics & Sub-Topics / **Curriculum VS. TIMSS**		**Lebanese Curriculum**	**TIMSS**	**|Difference|**
I.1 'Characteristics and Life Processes of Organisms'	**I.1.2** 'Physical and behavioral characteristics of major groups of living things'	0.13	0.15	0.02
	I.1.3 'Functions of major structures in living things'	0.08	0.05	0.03
I.3 'Organisms, Environment, and Their Interactions'	**I.3.3** 'The impact of humans on the environment'	0.07	0.05	0.02
I.4 'Ecosystems'	**I.4.1** 'Common ecosystems'	0.066	0.05	0.016
	I.4.2 'Relationships in simple food chains'	0.03	0.04	0.01
I.5 'Human Health'	**I.5.2** 'Ways of maintaining good health'	**0.11**	**0.05**	**0.06**
II.1 'Classification and Properties of Matter and Changes in Matter'	**II.1.2** 'Physical properties as a basis for classifying matter'	0.15	0.15	0
	II.1.3 'Magnetic attraction and repulsion'	**0.02**	**0.10**	**0.08**
	II.1.4 'Physical changes observed in everyday life'	**0.016**	**0.10**	**0.084**
II.2 'Forms of Energy and Energy Transfer'	**II.2.2** 'Light and sound in everyday life'	0.08	0.05	0.03
III.1 'Earth's Physical Characteristics, Resources, and History'	**III.1.1** 'Physical characteristics of the Earth system'	0.02	0.05	0.03
	III.1.2 'Earth's resources'	0.14	0.10	0.04
	III.1.3 'Earth's history'	**0.04**	**0.09**	**0.05**

In view of the ratios obtained for the sub-topics by each of the curriculum and the TIMSS assessment framework (Table: 13), it is inferred that out of thirteen TIMSS content sub-topics, nine earned approximately equal proportions from the two selected documents. The remaining four sub-topics 'I.5.2' 'Ways of maintaining good health', 'II.1.3' 'Magnetic attraction and repulsion', 'II.1.4' 'Physical changes observed in everyday life' and 'III.1.3' 'Earth's history' experienced slight variations of focus (|Difference|≥0.05) as the first one got the curriculum's prominence, and the rest got the assessment's attention.

Table 14

Lebanese Curriculum VS. TIMSS (Content and Cognitive Demands Ratios Comparisons)

Curriculum VS. TIMSS / TIMSS Content and Cognitive Domains	Lebanese Curriculum	TIMSS
Life Science	0.5	0.37
Physical Science	0.26	0.37
Earth Science	0.2	0.23
Knowing	0.59	0.55
Applying	0.18	0.42
Reasoning	0.19	0

When comparing the Lebanese curriculum's content domains emphasis to that of the TIMSS assessment framework, it is evident that both got almost the same focus for the third content domain 'Earth Science' yet the former gave more attention than the latter to the first one 'Life Science' at the expense of the second content domain 'Physical Science'. As for the cognitive demands' emphasis comparison, it is clear that the first thinking process level 'Knowing' received the same significance by the two matrices; however, it is unexpected to find that the TIMSS matrix had neglected the third cognitive demands domain 'Reasoning' while provided the full remaining focus to

the second one ‘Applying’, unlike the curriculum one which had addressed both equally.

Porter Alignment Index

In seeking to quantify the degree to which the ratios’ distribution of the curriculum objectives is aligned to that of the TIMSS assessment framework ones, the researcher calculated the relevant Porter (2002) index of alignment as a final step in the study. By means of the curriculum ‘Content Domains-by-Cognitive Demands’ ratio matrix and that of the TIMSS assessment framework, as well as the mathematical formula given by Porter (2002) for this index, the researcher computed this single index as follows:

$$1 - \frac{\sum |X - Y|}{2}$$

$$1 - \frac{(0.16+0.13+0.1+0.09+0.1+0.08+0.03+0.0075+0.013)}{2}$$

$$1 - \frac{(0.7105)}{2}$$

$$1 - 0.35525 = \mathbf{0.64475}$$

Hence, the alignment between the fourth grade Lebanese science curriculum and the TIMSS assessment framework seems to be moderate, indicating that there exist some differences in emphasis across the two documents.

CHAPTER 5

DISCUSSION

In this alignment study, the researcher investigated the degree of alignment between the fourth grade Lebanese science curriculum and TIMSS-2019 assessment framework using the two dimensions: content and cognitive demands. By means of the Surveys of Enacted Curriculum (SEC) model, the researcher followed a three-step methodology utilizing the three developed instruments: 'Curriculum Matching Sheet' (CMS), 'Assessment Matching Sheet' (AMS) and 'Content-by-Cognitive Demands Matrix'. In the first step, the curriculum learning objectives were matched against the TIMSS assessment framework content dimension. As a second step, the TIMSS framework's learning objectives were matched with reference to the content dimension of the Lebanese curriculum. As a final step, every curriculum and assessment learning objective covered was classified into the TIMSS content domain, topic, and sub-topic to which it matches and the cognitive domain it addresses using the TIMSS taxonomy. Descriptive data and statistics, frequency and ratio matrices along with Porter (2002) alignment index were thereafter derived to answer the following research questions:

1) To what extent does the fourth grade Lebanese science curriculum cover the content of the TIMSS-2019 science assessment framework?
2) To what extent does the TIMSS-2019 science assessment framework address the content of the fourth grade Lebanese science curriculum?
3) What are the similarities and discrepancies in the content and cognitive demands emphases that exist between the fourth grade Lebanese science curriculum and TIMSS-2019 science assessment framework?

4) What is the computed index of content and cognitive demands alignment between the fourth grade Lebanese science curriculum and TIMSS-2019 science assessment?

Research Question 1

The first research question raised in the study attempted to examine the degree to which the selected Lebanese curriculum is tackling the content of the correspondent TIMSS assessment framework. It is worth mentioning that raising such a question doesn't imply that the fourth grade Lebanese science curriculum should be aligned with the TIMSS assessment framework. Such an assumption is not adopted in this research study. However, the researcher found it important to view not only the degree to which the Lebanese curriculum's content is covered by the TIMSS assessment framework but also the extent to which the latter's content is covered by the former as it would redound to the Lebanese field of educational practice some implications that can be useful in case of future participation in TIMSS.

After filling out a CMS for every unit found in the fourth grade Lebanese science curriculum, it was so easy to detect the TIMSS content topics and sub-topics covered and missed by the Lebanese curriculum document. Out of the eleven stated content topics in the TIMSS assessment framework, seven are introduced in the intended Lebanese science curriculum of grade four and four are disregarded by it. Based on the TIMSS assessment framework, the content topics on 'Life Cycles, Reproduction, and Heredity', 'Forces and Motion', 'Earth's Weather and Climates', and 'Earth in the Solar System' are the ones not explicitly stated in the Lebanese curriculum. As for the covered content topics, not all of them are developed fully in grade four of the Lebanese science curriculum as out of their twenty-three sub-topics,

ten are not reflected in the intended curriculum. With reference to the TIMSS assessment framework, the sub-topics on “differences between living and non-living things and what living things require to live”, “physical features or behaviors of living things that help them survive in their environment”, “responses of living things to environmental conditions”, “competition in ecosystems”, “transmission, prevention, and symptoms of communicable diseases”, “states of matter and characteristic differences of each state”, “chemical changes observed in everyday life”, “common sources and uses of energy”, “heat transfer”, and “electricity and simple electrical systems” are those which have been missed in the Lebanese curriculum.

When trying to match every learning objective covered in the selected TIMSS assessment framework to the Lebanese curriculum’s content dimension, a quantitative result relevant to the current research question has been found. It was revealed that out of the 57 stated TIMSS learning objectives, 21 (37%) have been mapped to the target Lebanese curriculum while 36 (63%) haven’t been matched to it. The fourth grade Filipino’s science curriculum covered a slightly higher percentage (56%) of the TIMSS assessment framework objectives (Balagtas et al., 2019), compared to what the fourth grade Lebanese science curriculum has covered. In spite of that, Balagtas et al. (2019) and her colleagues inferred that such a percentage indicates the presence of content gaps in the Filipino’s science curriculum in the light of the TIMSS assessment framework demands at the fourth grade level.

When looking at the same kind of results found at the eighth grade level, it was apparent that the eighth grade Filipino’s science curriculum got a lower percentage (18%) of the tackled TIMSS assessment framework objectives (Balagtas et al., 2019), relatively to each of the Filipino’s and Lebanese science curriculum at the fourth grade

level. Hence, it was concluded that the alignment between the TIMSS assessment framework and the Filipino's science curriculum is better at the fourth grade than that at the eighth grade. By implication, Balagtas et al. (2019) and her colleagues recommended the participation of Philippine in the fourth grade TIMSS science assessment instead of that at the eighth grade level as they have assumed that it will be considered a somewhat difficult test to be taken by the Filipino's eight graders due to the content gap into which their curriculum is facing with respect to the TIMSS requirements.

In view of the alignment results revealed by CERD (2018) for the science curriculum and the TIMSS assessment at the eighth grade level, it is difficult to assume that there exists a great agreement across the documents under analysis as findings revealed the presence of content gaps in the selected Lebanese curriculum in relation to the four science TIMSS content domains: Chemistry, Physics, Biology and Earth Science. However, the percentages found for the missed TIMSS assessment items across each of the Earth Science (36%), Physics (31%) and Biology (23%) content domains as well as that of the objectives for the Chemistry content area (22%) might imply that the TIMSS science assessment is more aligned with the eighth grade Lebanese science curriculum than that with the fourth grade one (about 63% missed).

The previously declared findings have implications for each of the Lebanese teachers, curriculum developers and policy makers. First, for teachers, the findings revealed earlier give them the chance to design and implement intervention programs that could emphasize the TIMSS content competencies that are missed by the Lebanese curriculum document so that their fourth graders can be familiarized with these content aspects required for the TIMSS fourth grade science assessments. As for curriculum

developers, the results already mentioned provide them with the opportunity to narrow the content gap that is present between the fourth grade Lebanese science curriculum and the TIMSS assessment framework. Indeed, these findings inform the curriculum reform process that they might be engaged in as they report the TIMSS content competencies that can be captured by the followed Lebanese science curriculum at the fourth grade level. Working on these adjustments could enrich the intended Lebanese science curriculum with respect to the international requirements set by TIMSS. Finally, for the policy makers, the outcomes stated above allow them to take the actions which might help in preparing the fourth grade Lebanese students for taking the TIMSS test, in case they have taken the decision to participate in the upcoming TIMSS-2023 fourth grade science assessments.

In view of the foregoing, it is clear that the fourth grade Lebanese science curriculum isn't considerably covering the content of the TIMSS assessment framework. Working towards modifying this intended curriculum in the light of the TIMSS assessment framework content demands could hold benefits in terms of making it possible for this curriculum to better meet international standards.

Research Question 2

By means of the second research question raised in the study, the researcher sought to investigate the degree to which the chosen TIMSS assessment framework is addressing the content of the equivalent intended Lebanese curriculum. Following the completion of the AMS for every science content domain included in the TIMSS assessment framework, it was so simple to spot the Lebanese curriculum content topics that are being addressed as well as disregarded by the TIMSS assessment framework. Out of the thirty-six content topics distributed over the five science curriculum units,

only four haven't been tackled by the selected TIMSS assessment framework as the rest has been fully developed in the framework document. In accordance to the intended fourth grade Lebanese science curriculum, the fourth grade TIMSS science assessment framework has overlooked the following curriculum content topics: 'Nonflowering plants: mushrooms', 'The social insects: bees and ants', 'The electric charge' and 'Formation of subterranean water reservoirs and their relation to rocks'.

An unexpected finding, applicable to the above research question, has been generated when seeking to map the curriculum learning objectives against the TIMSS assessment framework's content dimension. It was striking to notice that out of the 98 learning objectives specified in the fourth grade Lebanese science curriculum, 79 (81%) have been matched to the TIMSS assessment framework and merely 19 (19%) have been omitted by it.

Based on the above, it is clear that the TIMSS assessment framework has remarkably reflected the content given in the fourth grade Lebanese science curriculum document as only few curriculum content topics and objectives have been neglected by it. Yet, these left out content competencies may draw the attention of the TIMSS institutions and agencies in charge of designing the framework into which the fourth grade TIMSS science assessments are based on, as they could study the possibility of covering them when developing the fourth grade science framework dedicated for the upcoming TIMSS-2023 assessment. Taking these unacknowledged curriculum content competencies into account should enhance the alignment between the TIMSS assessment framework and the intended fourth grade Lebanese science curriculum thus raise the prospects of performing well on the TIMSS assessment.

It is evident by now that the chosen TIMSS assessment framework is not missing a lot with respect to the content dimension of the fourth grade Lebanese science curriculum. However, working towards incorporating the uncovered content competencies when developing the upcoming fourth grade TIMSS science assessment framework is important in order for this large-scale assessment to better reflect national curricula.

Research Question 3

The third research question of the study aimed to reveal the similarities and differences in the content and cognitive demands focus that exist between the two documents under analysis. After classifying the curriculum's matched learning objectives and that of the TIMSS assessment framework on the 'Content-by-Cognitive Demands Matrix', deriving the 'Sub-Topics-by-Cognitive Demands', 'Topics-by-Cognitive Demands' and 'Content Domains-by-Cognitive Demands' frequency matrices along with the equivalent ratio matrix for each, and computing the overall ratios found by means of each matrix for every TIMSS content domain, topic, and sub-topic together with that of each TIMSS cognitive demands domain, it was possible to compare the correspondent ratios given by each matrix thus shed the light on the similarities and discrepancies in the content and cognitive demands emphases that are present between the selected documents.

When looking at the ratio differences obtained at the level of the seven topics included in the content dimension of each matrix, one can infer that both matrices got a similar coverage of content across five topics yet a different one across only two of them: 'I.5' 'Human Health' and 'II.1' 'Classification and Properties of Matter and Changes in Matter'. While observing the details of the ratio differences attained at the

level of the thirteen covered sub-topics, it was clear that only four sub-topics, ‘I.5.2’, ‘II.1.3’, ‘II.1.4’ and ‘III.1.3’, have experienced discrepancies in the content coverage at their levels. Unsurprisingly, one of these sub-topics ‘I.5.2’ ‘Ways of maintaining good health’ falls under the topic ‘I.5’ that is already encountering differences of content coverage at its level. Similarly, two of them ‘II.1.3’ ‘Magnetic attraction and repulsion’ and ‘II.1.4’ Physical changes observed in everyday life’ belong to the topic ‘II.1’ that has content discrepancies at its level. Unexpectedly, one of the sub-topics ‘III.1.3’ ‘Earth’s history’ has faced also at its level some variations in the content focus although it falls under a topic ‘III.1’ that is experiencing similarity of content coverage.

When examining the ratio comparisons generated at the level of the three content domains, it is evident that there exist similarities in the content emphasis of the two matrices only at the level of the ‘Earth Science’ content domain, yet disparities of content concentration present across the two content domains: ‘Life Science’ and ‘Physical Science’. Likewise, inspecting the ratio comparisons made at the level of the three thinking processes domains showed that only one thinking process domain ‘Knowing’ encountered at its level resemblance of the cognitive demands emphasis, while the remaining two domains ‘Applying’ and ‘Reasoning’ experienced deviations in the cognitive demands emphasis at their levels. Discrepancies in content and cognitive domains emphasis have also been revealed in the alignment study done in South Africa (Ndlovu & Mji, 2012) with the eighth grade TIMSS mathematics assessment as well as in the ones conducted in each of Lebanon (Shehayeb, 2017) and Norway (Pedersen, 2013) yet with the TIMSS Advanced mathematics assessment at the twelfth grade level. In the light of such differences, it was concluded that one should keep in mind such

discrepancies when interpreting the validity of the TIMSS assessments results (Ndlovu & Mji, 2012; Pedersen, 2013).

A closer look at the ratio obtained by the TIMSS assessment framework matrix for the cognitive demands domain ‘Reasoning’ revealed an unexpected finding as the matrix’s focus on the third thinking process domain seems to be absent. The underlying logical reason behind such a result in the present study may relate to the fact that the third methodological procedure covered only the TIMSS assessment framework learning objectives which are aligned with the chosen Lebanese curriculum (37%). Accordingly, the resultant ratio for the focus of the TIMSS assessment framework’s matrix on the TIMSS thinking process domain ‘Reasoning’ has been applied to this sample only.

As it is evident by now, there exist similarities and differences in emphasis between the fourth grade Lebanese science curriculum and TIMSS assessment framework at the level of content domains, topics and sub-topics as well as cognitive demands. In the light of such an outcome, Lebanese teachers and curriculum developers should consider some implications. While seeking to prepare the Lebanese students for performing well on the fourth grade TIMSS science assessment, teachers need to maintain the similarities and deal with the differences present in the content and cognitive demands emphases between the two documents under analysis. As for the curriculum developers, in an attempt to empower the fourth grade Lebanese science curriculum against the TIMSS content and cognitive demands requirements, they must consider the content and cognitive demands emphases that need to be preserved in the intended Lebanese curriculum and reconsider those that must be emphasized by it.

In brief, it is apparent that similarities and differences in content and cognitive demands emphasis have been detected in this study between the fourth grade Lebanese science curriculum and TIMSS assessment framework. That being so, one should be attentive to these existing discrepancies when interpreting the results of the fourth grade TIMSS science assessments in case of future participation.

Research Question 4

Through the last research question raised in the study, the researcher tried to compute the Porter (2002) index of content and cognitive demands alignment existing between the documents under examination as it is required by means of the chosen alignment model. Accordingly, the researcher calculated the Porter (2002) alignment index to quantify the degree of agreement between the ratios' distribution of the curriculum objectives and the TIMSS assessment framework's ones. The resultant alignment index of value approximately 0.65 implies moderate alignment thus the presence of some differences in emphasis between the fourth grade Lebanese science curriculum and TIMSS assessment framework. A value greater than 0.5 for the Porter (2002) index of alignment has also been found by each of Ndlovu and Mji (2012); Pedersen (2013); and Shehayeb (2017) in their alignment studies. Although Porter (2002) hasn't set a minimum value to be considered for the range of an acceptable alignment, Ndlovu and Mji (2012) along with Shehayeb (2017) identified their resultant values as being indicators of misalignment between the documents under analysis thus called for an immediate attention from the concerned teachers, curriculum developers, policy makers as well as assessment designers to take the needed measures in order to get better achievement results in the upcoming TIMSS assessments. However, Pedersen (2013) declared that such values don't necessarily mean the inappropriateness of the

TIMSS assessments for evaluating the performance of the participating students, therefore, suggested that further research is vital in this regard so that rigorous conclusions could be made with respect to the alignment between such large-scale instruments and the curricula of its participating countries. Based on the above, one may conclude that the value found in the present study for the Porter (2002) alignment index is by some means indecisive with respect to the current state of alignment between the selected documents. Accordingly, it couldn't be firmly judged that there exists an acceptable level of agreement between the fourth grade TIMSS-2019 science assessment framework and the Lebanese science curriculum for the fourth grade level. The only way of making sense of such an index value is comparing it to other alignment indices of the same nature (Shehayeb, 2017), which hasn't been available in this study.

It is quite clear that the Porter (2002) index of alignment obtained in this study is not really informative. Thus, it is essential in this regard to supplement such a study with further research of the same kind which offers a comparative alignment index that would make the current attained value for alignment somehow a meaningful one.

Concluding Summary

Lebanese participation in the fourth grade TIMSS science assessment is essential so that it would be possible for them to view how their students are performing with respect to international standards. Taking into consideration the implications given in the present study and putting them into action can enhance the alignment between the two selected documents thus encourage Lebanon to go for the fourth grade TIMSS science assessment.

Limitations and Recommendations

As previously stated, the current research lacked of the comparative element needed to make somehow firm judgments regarding the agreement between the selected documents given by Porter (2002) index of alignment. Given this limitation of the study, it is recommended to conduct additional research in this regard which could involve investigating the alignment, using the Surveys of Enacted Curriculum (SEC) alignment model, between TIMSS or TIMSS Advanced assessments and other Lebanese curricula such as the mathematics ones at the fourth, eighth and twelfth grade levels, the science one at the eighth grade level or the physics one at the twelfth grade level. Ultimately, this way it would be possible to evaluate firmly the degree of alignment between the chosen documents by comparing the current value of their alignment index to other alignment indices of the same kind.

The study conducted has another limitation. Due to the constraints imposed by time on this thesis work, this research has chosen only the fourth grade Lebanese science curriculum to investigate the alignment with the fourth grade TIMSS science assessment framework thus the findings may not be generalizable to other grade levels. The alignment between the Lebanese science curriculum in prior grades could have also been examined in this regard as the fourth grade TIMSS science assessment framework is not only dedicated for grade four but also covering up to its level. Accordingly, it is recommended that further research can be targeting this matter as it would provide a more comprehensive view of what TIMSS is covering from the Lebanese curricula.

APPENDIX A

Specifications of the Content Domains Included in the Fourth Grade TIMSS-2019 Science Assessment Framework

Life Science

Characteristics and Life Processes of Organisms:

1. Differences between living and non-living things and what living things require to live:
   A. Recognize and describe differences between living and non-living things (i.e., all living things can reproduce, grow and develop, respond to stimuli, and die; and non-living things cannot).
   B. Identify what living things require in order to live (i.e., air, food, water, and an environment in which to live).

2. Physical and behavioral characteristics of major groups of living things:
   A. Compare and contrast physical and behavioral characteristics that distinguish major groups of living things (i.e., insects, birds, mammals, fish, reptiles, and flowering plants).
   B. Identify or provide examples of members of major groups of living things (i.e., insects, birds, mammals, fish, reptiles, and flowering plants).
   C. Distinguish groups of animals with backbones from groups of animals without backbones.

3. Functions of major structures in living things:
   A. Relate major structures in animals to their functions (e.g., teeth break down food, bones support the body, lungs take in air, the heart circulates blood, the stomach digests food, muscles move the body).
   B. Relate major structures in plants to their functions (i.e., roots absorb water and nutrients and anchor the plant, leaves make food, the stem transports water and food, petals attract pollinators, flowers produce seeds, and seeds produce new plants).

Life Cycles, Reproduction, and Heredity:

1. Stages of life cycles and differences among the life cycles of common plants and animals:
   A. Identify stages of the life cycles of plants (i.e., germination, growth and development, reproduction, and seed dispersal).
   B. Recognize, compare, and contrast the life cycles of familiar plants and animals (e.g., trees, beans, humans, frogs, butterflies).

2. Inheritance and reproduction strategies:
   A. Recognize that plants and animals reproduce with their own kind to produce offspring with features that closely resemble those of the parents.
   B. Distinguish between features of plants and animals that are inherited from their parents (e.g., number of petals, color of petals, eye color, hair color), and those that are not (e.g., some broken branches in a tree, length of human hair).

C. Identify and describe different strategies that increase the number of offspring that survive (e.g., a plant producing many seeds, mammals caring for their young).

Organisms, Environment, and Their Interactions:

1. Physical features or behaviors of living things that help them survive in their environment:

A. Associate physical features of plants and animals with the environments in which they live and describe how these features help them to survive (e.g., a thick stem, a waxy coating, and a deep root help a plant survive in an environment with little water; the coloring of an animal helps camouflage it from predators).

B. Associate behaviors of animals with the environments in which they live and describe how these behaviors help them to survive (e.g., migration or hibernation helps an animal to stay alive when food is scarce).

2. Responses of living things to environmental conditions:

A. Recognize and describe how plants respond to environmental conditions (e.g., amount of available water, amount of sunlight).

B. Recognize and describe how different animals respond to changes in environmental conditions (e.g., light, temperature, danger); recognize and describe how the human body responds to high and low temperatures, exercise, and danger.

3. The impact of humans on the environment:

A. Recognize that human behavior has negative and positive effects on the environment (e.g., negative effects of air and water pollution, the benefits of reducing air and water pollution); provide general descriptions and examples of the effects of pollution on humans, plants, and animals, and their environments.

Ecosystems:

1. Common ecosystems:

A. Relate common plants and animals (e.g., evergreen trees, frogs, lions) to common ecosystems (e.g., forests, ponds, grasslands).

2. Relationships in simple food chains:

A. Recognize that all plants and animals need food to provide energy for activity and need raw materials for growth and repair; explain that plants need sunlight to make their food, while animals eat plants or other animals to get their food.

B. Complete a model of a simple food chain using common plants and animals from familiar ecosystems, such as a forest or a desert.

C. Describe the roles of living things at each link in a simple food chain (e.g., plants produce their own food; some animals eat plants, while other animals eat the animals that eat plants).

D. Identify and describe common predators and their prey.

3. Competition in ecosystems:

A. Recognize and explain that some living things in an ecosystem compete with others for food or space.

Human Health:

1. Transmission, prevention, and symptoms of communicable diseases:
   A. Relate the transmission of common communicable diseases to human contact (e.g., touching, sneezing, coughing).
   B. Identify or describe some methods of preventing disease transmission (e.g., vaccination, washing hands, avoiding people who are sick); recognize common signs of illness (e.g., high body temperature, coughing, stomachache).

2. Ways of maintaining good health:
   A. Describe everyday behaviors that promote good health (e.g., a balanced diet, exercising regularly, brushing teeth, getting enough sleep, wearing sunscreen); identify common food sources included in a balanced diet (e.g., fruits, vegetables, grains).

Physical Science

Classification and Properties of Matter and Changes in Matter:

1. States of matter and characteristic differences of each state:
   A. Identify and describe three states of matter (i.e., a solid has a definite shape and volume, a liquid has a definite volume but not a definite shape, and a gas has neither a definite shape nor a definite volume).

2. Physical properties as a basis for classifying matter:
   A. Compare and sort objects and materials on the basis of physical properties (e.g., weight/mass, volume, state of matter, ability to conduct heat or electricity, ability to float or sink in water, ability to be attracted by a magnet). [Note: Students in the fourth grade are not expected to differentiate between mass and weight.]
   B. Identify properties of metals (i.e., conducting electricity and conducting heat) and relate these properties to uses of metals (e.g., a copper electrical wire, an iron cooking pot).
   C. Describe examples of mixtures and how they can be physically separated (e.g., sifting, filtration, evaporation, magnetic attraction).

3. Magnetic attraction and repulsion:
   A. Recognize that magnets have two poles and that like poles repel and opposite poles attract.
   B. Recognize that magnets can be used to attract some metal objects.

4. Physical changes observed in everyday life:
   A. Identify observable changes in materials that do not result in new materials with different properties (e.g., dissolving, crushing an aluminum can).
   B. Recognize that matter can be changed from one state to another by heating or cooling; describe changes in the state of water (i.e., melting, freezing, boiling, evaporation, and condensation).
   C. Identify ways of increasing how quickly a solid material dissolves in a given amount of water (i.e., increasing the temperature, stirring, and breaking the solid into smaller pieces); distinguish between strong and weak concentrations of simple solutions.

5. Chemical changes observed in everyday life:
    A. Identify observable changes in materials that make new materials with different properties (e.g., decaying, such as food spoiling; burning; rusting).

Forms of Energy and Energy Transfer:

1. Common sources and uses of energy:
    A. Identify sources of energy (e.g., the Sun, flowing water, wind, coal, oil, gas), and recognize that energy is needed to move objects and for heating and lighting.

2. Light and sound in everyday life:
    A. Relate familiar physical phenomena (i.e., shadows, reflections, and rainbows) to the behavior of light.
    B. Relate familiar physical phenomena (i.e., vibrating objects and echoes) to the production and behavior of sound.

3. Heat transfer:
    A. Recognize that warmer objects have a higher temperature than cooler objects; describe what will happen when a hot object and a cold object are brought into contact (i.e., the temperature of the hot object decreases and the temperature of the cold object increases).

4. Electricity and simple electrical systems:
    A. Recognize that electrical energy in a circuit can be transformed into other forms of energy (e.g., heat, light, sound).
    B. Explain that simple electrical systems (e.g., a flashlight) require a complete (unbroken) electrical pathway.

Forces and Motion:

1. Familiar forces and the motion of objects:
    A. Identify gravity as the force that draws objects to Earth.
    B. Recognize that forces (i.e., pushing and pulling) may cause an object to change its motion; compare the effects of these forces of different strengths in the same or opposite directions acting on an object; and recognize that friction force works against the direction of motion (e.g., friction working against a push or a pull makes it more difficult to move an object along a surface).

2. Simple machines:
    A. Recognize that simple machines, (e.g., levers, pulleys, gears, ramps) help make motion easier (e.g., make lifting things easier, reduce the amount of force required, change the distance, change the direction of the force).

Earth Science

Earth's Physical Characteristics, Resources, and History:

1. Physical characteristics of the Earth system:
    A. Recognize that Earth's surface is made up of land and water in unequal proportions (more water than land) and is surrounded by air; describe where fresh and salt water are found, and recognize that water in rivers or streams flows from mountains to oceans or lakes.

2. Earth's resources:
   A. Identify some of Earth's resources that are used in everyday life (e.g., water, wind, soil, forests, oil, natural gas, minerals).
   B. Explain the importance of using Earth's renewable and non-renewable resources responsibly (e.g., fossil fuels, forests, water).

3. Earth's history:
   A. Recognize that wind and water change Earth's landscape and that some features of Earth's landscape (e.g., mountains, river valleys) result from changes that happen very slowly over a long time.
   B. Recognize that some remains (fossils) of animals and plants that lived on Earth a long time ago are found in rocks and make simple deductions about changes in Earth's surface from the location of these remains.

Earth's Weather and Climates:

1. Weather and climates on Earth:
   A. Apply knowledge of changes of state of water to common weather events (e.g., cloud formation, dew formation, the evaporation of puddles, snow, rain).
   B. Describe how weather (i.e., daily variations in temperature, humidity, precipitation in the form of rain or snow, clouds, and wind) can vary with geographic location.
   C. Describe how average temperature and precipitation can change with the seasons and location.

Earth in the Solar System:

1. Objects in the Solar System and their movements:
   A. Identify the Sun as a source of heat and light for the Solar System; describe the Solar System as the Sun and the planets that revolve around it.
   B. Recognize that the Earth has a moon that revolves around it, and from Earth the Moon looks different at different times of the month.

2. Earth's motion and related patterns observed on Earth:
   A. Explain how day and night are related to Earth's daily rotation about its axis, and provide evidence of this rotation from the changing appearance of shadows during the day.
   B. Describe how seasons in Earth's northern and southern hemispheres are related to Earth's annual movement around the Sun.

APPENDIX B

Specifications of the Cognitive Domains Included in the Fourth Grade TIMSS-2019 Science Assessment Framework

	Knowing
Recall/Recognize	Identify or state facts, relationships, and concepts; identify the characteristics or properties of specific organisms, materials, and processes; identify the appropriate uses for scientific equipment and procedures; and recognize and use scientific vocabulary, symbols, abbreviations, units, and scales.
Describe	Describe or identify descriptions of properties, structures, and functions of organisms and materials, and relationships among organisms, materials, and processes and phenomena.
Provide Examples	Provide or identify examples of organisms, materials, and processes that possess certain specified characteristics; and clarify statements of facts or concepts with appropriate examples.
	Applying
Compare/Contrast/Classify	Identify or describe similarities and differences between groups of organisms, materials, or processes; and distinguish, classify, or sort individual objects, materials, organisms, and processes based on characteristics and properties.
Relate	Relate knowledge of an underlying science concept to an observed or inferred property, behavior, or use of objects, organisms, or materials.
Use Models	Use a diagram or other model to demonstrate knowledge of science concepts, to illustrate a process cycle relationship, or system, or to find solutions to science problems.
Interpret Information	Use knowledge of science concepts to interpret relevant textual, tabular, pictorial, and graphical information.
Explain	Provide or identify an explanation for an observation or a natural phenomenon using a science concept or principle.
	Reasoning
Analyze	Identify the elements of a scientific problem and use relevant information, concepts, relationships, and data patterns to answer questions and solve problems.
Synthesis	Answer questions that require consideration of a number of different factors or related concepts.
Formulate Questions/ Hypothesize/Predict	Formulate questions that can be answered by investigation and predict results of an investigation given information about the design; formulate testable

	assumptions based on conceptual understanding and knowledge from experience, observation, and/or analysis of scientific information; and use evidence and conceptual understanding to make predictions about the effects of changes in biological or physical conditions.
Design Investigations	Plan investigations or procedures appropriate for answering scientific questions or testing hypotheses; and describe or recognize the characteristics of well-designed investigations in terms of variables to be measured and controlled and cause-and-effect relationships.
Evaluate	Evaluate alternative explanations; weigh advantages and disadvantages to make decisions about alternative processes and materials; and evaluate results of investigations with respect to sufficiency of data to support conclusions.
Draw Conclusions	Make valid inferences on the basis of observations, evidence, and/or understanding of science concepts; and draw appropriate conclusions that address questions or hypotheses, and demonstrate understanding of cause and effect.
Generalize	Make general conclusions that go beyond the experimental or given conditions; apply conclusions to new situations.
Justify	Use evidence and science understanding to support the reasonableness of explanations, solutions to problems, and conclusions from investigations.

APPENDIX C

Specifications of the Units Included in the Fourth Grade Lebanese Science Curriculum

1- Plants and Their Habitats

1.1 Plants common in Lebanon

- Recognizes and names some wild plants common in Lebanon: trees (pine, oak, cedar, planetree), bushes and herbs (spartium broom, inula, oleander, thyme, mallow,…).
- Distinguishes between wild and cultivated plants.
- Relates between these plants and the suitable areas in which they grow.

1.2 Freshwater habitats

- States and describes the kinds of freshwater habitats in Lebanon: rivers, lakes, swamps, ponds, streams.
- Infers the properties of freshwater habitats: unsalty water, quantity and depth variable, temperature variable, liable to pollution.

1.3 Plants which grow in freshwater habitats or on their banks

- Recognizes some freshwater plants: algae, herbs,…
- Recognizes and names some plants which grow on banks of freshwater habitats: reeds, planetree, mallow, oleander,…

1.4 Flowering plants

- Defines flowering plants and gives examples from trees, shrubs, herbs.

1.5 Conifers

- States general features of conifers: cones, seeds, leaves, evergreen,…
- States characteristics of mushrooms.

1.6 Nonflowering plants: mushrooms

- Recognizes edible mushroom and infers the danger of poisonous mushrooms.

1.7 Principles of plant classification

- Summarizes the principles of plant classification that were studies.

1.8 Role of plants in the conservation of topsoil

- Explains role of plants in the prevention of soil erosion: decreasing flow speed of running rain water, roots hold the soil.
- Is aware of his responsibilities in soil conversation: does not cut trees and shrubs, does not cause fires in the woods.

1.9 Pollution of freshwater habitats and consequences

- Names materials which pollute the freshwater and states their sources.
- Infers the consequences of polluted freshwater on living organisms.
- States and practices of the proper behaviors which protect freshwater habitats from pollution.

2- Animals and Their Habitats

2.1 Wild animals in Lebanon

- Names and recognizes some common wild animals in Lebanon; mammals, birds, reptiles, insects,…
- Explains the consequences of hunting wild animals and eroding their habitats.

2.2 Animals of freshwater habitats

- Recognizes and names some animals which live in freshwater habitats or on their banks.
- States the interrelation among, plants and animals in freshwater habitats.
- Indicates the role of fisheries in the development of food resources…

2.3 The vertebrates

- Defines vertebrates and recognizes their major groups: mammals, birds, reptiles, amphibians, fish.
- States the important distinguishing characteristics of each vertebrate group.

2.4 The invertebrates

- Defines the following invertebrates: insects, molluscs, worms, and gives examples of each group.

2.5 Principles of animal classification

- Summarizes the principles of classification of the animals which were studied.

2.6 The social insects: bees and ants

- Gives a simple description of the social life of bees and of ants.

3- Man and His Health

3.1 Support and movement systems

- Defines the human skeleton and explains its functions in the body: support, protection of some organs, enhancement of body movement,…
- Names the parts of the skeleton: skull, vertebral column, ribs, hipbones, bones of arms and legs.
- Recognizes the forms of bones: flat, long, and short bones.
- Observes that the bones are connected together by special tissue at their joints.
- State the types of joints and brings out the relation between the type of joint and the kind of movement.
- Infers that our bones develop and grow, and the parts join again if a bone is broken.
- States the functions of the muscles in our body: support the bones, produce movement, protect the bones,…
- Infers the system of elongation and contraction in the muscles of the arms and legs.
- Infers that skeleton and muscles determine the shape of our body.
- Infers that our muscles, as our bones, develop and grow.

3.2 Care and protection of skeleton and the muscles

- States the kinds of food which help in the growth of bones and muscles.
- Describe the role of play, exercise, and rest in the development of bones and muscles: healthy growth, acquisition of force, normal maintenance.
- States some problems which might occur with respect to the skeleton and is aware of the need to refer to a physician.
- States and applies some principles for the care of the skeleton: proper way of sitting, avoiding of raising or carrying of heavy objects, avoiding harmful play.

3.3 The food pyramid, balanced diet

- Identifies the importance of the food for our body: growth, repair, energy, and keeping healthy.
- Describes the food pyramid and expresses it in a drawing.
- Gives examples on various food groups and states the benefit of each group.
- Defines the content of a balanced diet, states its importance, and suggests balanced meals.
- Concludes that milk and its derivatives from a stable component of our daily food.
- Takes an attitude with regard to eating counter prepared foods and soft drinks.

3.4 Malnutrition and some of its consequences

- Defines malnutrition as the trouble or affliction caused in our body because of the amount or kind of food eaten.
- States the outstanding symptoms of undernourishment.
- States the harmful effects of overeating.
- Infers the importance of conforming to times of meals and eating proper amount and kind of food.

4- Matter and Energy

4.1 Definition of matter

- Recognizes some common examples of matter: iron, water, clay, glass, etc.…
- Defines matter as a body which has a definite chemical composition.
- Observes some objects and recognizes the kinds of matter in them.
- Distinguishes between matter and objects.

4.2 Properties of matter

- Observes that objects occupy space.
- Infers that two objects cannot occupy the same space under the same conditions.
- Infers by observation that matter has mass.

4.3 Measurement of mass

- Measure the mass of an object by using the balance.
- Recognizes the standard units of mass.
- Recognizes some modern types of balances.

4.4 Mixtures and water solutions

- Defines a mixture and gives examples.
- Explores the kinds of mixtures: homogenous, heterogeneous.
- Explores some substances which dissolve in water.
- Defines a solution as composed of a solvent and a solute. Distinguishes a true solution in a practical way.
- Concludes that the substance of a solute remains unchanged in a solution.
- Give examples of non-aqueous solution.

4.5 Magnets

- Recognizes the common shapes of magnets and identifies materials which are attracted by magnets.
- Explores the parts of a magnet and infers the law of magnetic attraction and repulsion.
- Recognizes the magnetic compass and uses it properly. Identifies the magnet in some toys and gadgets.

4.6 The electric charge

- States some aspects of electric charges around us, and produces electric charges by friction of suitable materials.
- Explores the attraction and repulsion of electric charges and infers that like charges repel each other and unlike charges attract each other.

4.7 Sound and some of its properties

- Infers that sound is produced when bodies vibrate.
- Infers that the frequency of sound determines the sharpness of sound.
- Concludes that the kind of vibrating body determines the quality of sound produced.
- Recognizes the kinds of musical instruments and identifies the sound producing element in each kind.

4.8 Propagation of sound

- Infers that sound travels only in matter.
- Observes that the speed of sound is greatest in solids, decreases in liquids, and has least speed in air.
- Concludes that sound travels in all directions.
- Recognizes some modern sound instruments.

4.9 How do we hear?

- Identifies the parts of human ear, and recognizes the function of each part.
- Describes the passage of sound within the ear and the production of sound sensation.

4.10 Effect of noise on our health

- Recognizes disturbing noises.
- States some of the effects of noise pollution, and identifies personal responsibility, if any.
- Gives examples of modern devices for reducing noise.

5- Earth and the Universe

5.1 Soil and some of its kinds

- Defines “soil”.
- States the common kinds of soil: soil rich in sand, soil rich in clay, soil rich in calcium carbonate. Recognized each kind of soil.

5.2 Clay and related crafts

- Distinguishes clay and recognizes its basic properties: odor, color, plasticity, permeability to water.
- Gives examples of industries which use clay and describes the various stages in making pottery.

5.3 Soil Erosion

- Explains soil erosion by running water and winds.
- Infers that ground plants prevent soil erosion.
- Enumerates some ways of conserving the soil.
- States his role in soil conservation.

5.4 Sandstone and limestone

- Recognizes sandstone and limestone.
- Gives examples on the use of sandstone and limestone.

5.5 Fossils in sandstone and limestone

- Recognizes fossils and states their scientific importance.

5.6 Weathering of rocks and soil formation

- States factors which cause weathering of rocks and explains formation of soil.

5.7 Formation of subterranean water reservoirs and their relation to rocks

- Relates formation of subterranean reservoirs to the permeability of some sedimentary rocks to rain and snow water.

APPENDIX D

Curriculum Matching Sheets (CMSs)

Table D1

UNIT: Plants and Their Habitats (1)

Fourth Grade Lebanese Curriculum			TIMSS-2019 Assessment Framework			
Content Topic		**Learning Objective**	**TIMSS Content Domain Covered**	**TIMSS Content Topic Covered**	**TIMSS Content Sub-Topic Covered**	**Notes**
1.1 (Plants common in Lebanon)	1.1.a	Recognizes and names some wild plants common in Lebanon: trees (pine, oak, cedar, planetree), bushes and herbs (spartium broom, inula, oleander, thyme, mallow,…).	**I**	**I.4**	**I.4.1**	
	1.1.b	Distinguishes between wild and cultivated plants.	**I**	**I.1**	**I.1.2**	
	1.1.c	Relates between these plants and the suitable areas in which they grow.	**I**	**I.1/I.4**	**I.1.2/I.4.1**	
1.2 (Freshwater habitats)	1.2.a	States and describes the kinds of freshwater habitats in Lebanon: rivers, lakes, swamps, ponds, streams.	**III**	**III.1**	**III.1.1**	
	1.2.b	Infers the properties of freshwater habitats: unsalty water, quantity and depth variable, **temperature variable, liable to pollution.**	**III**	**III.1**	**III.1.1**	**Bold part is not covered**
1.3 (Plants which grow in freshwater habitats or on their banks)	1.3.a	Recognizes some freshwater plants: algae, herbs,…	**I**	**I.4**	**I.4.1**	
	1.3.b	Recognizes and names some plants which grow on banks of freshwater habitats: reeds, planetree, mallow, oleander,…	**I**	**I.4**	**I.4.1**	
1.4 (Flowering plants)	1.4.a	Defines flowering plants and gives examples from trees, shrubs, herbs.	**I**	**I.1**	**I.1.2**	
1.5 (Conifers)	1.5.a	States general features of conifers: cones,	**I**	**I.1**	**I.1.2**	

		seeds, leaves, evergreen,…				
	1.5.b	States characteristics of mushrooms.	**None**	**None**	**None**	**Misconception**
1.6 (Nonflowering plants: mushrooms)	1.6.a	Recognizes edible mushroom and infers the danger of poisonous mushrooms.	**None**	**None**	**None**	**Misconception**
1.7 (Principles of plant classification)	1.7.a	Summarizes the principles of plant classification that were studied.	**I**	**I.1**	**I.1.2**	
1.8 (Role of plants in the conservation of topsoil)	1.8.a	Explains role of plants in the prevention of soil erosion: decreasing flow speed of running rain water, roots hold the soil.	**III**	**III.1**	**III.1.2**	
	1.8.b	Is aware of his responsibilities in soil conversation: does not cut trees and shrubs, does not cause fires in the woods.	**III**	**III.1**	**III.1.2**	
1.9 (Pollution of freshwater habitats and consequences)	1.9.a	Names materials which pollute the freshwater and states their sources.	**I**	**I.3**	**I.3.3**	
	1.9.b	Infers the consequences of polluted freshwater on living organisms.	**I**	**I.3**	**I.3.3**	
	1.9.c	States and practices of the proper behaviors which protect freshwater habitats from pollution.	**I** **III**	**I.3** **III.1**	**I.3.3** **III.1.2**	

Table D2

UNIT: Animals and Their Habitats (2)

Fourth Grade Lebanese Curriculum			TIMSS-2019 Assessment Framework			
Content Topic		**Learning Objective**	**TIMSS Content Domain Covered**	**TIMSS Content Topic Covered**	**TIMSS Content Sub-Topic Covered**	**Notes**
2.1 (Wild animals in Lebanon)	2.1.a	Names and recognizes some common wild animals in Lebanon; mammals, birds, reptiles, insects,…	**I**	**I.1/I.4**	**I.1.2/I.4.1**	
	2.1.b	Explains the consequences of hunting wild animals and eroding their habitats.	**I**	**I.3**	**I.3.3**	
2.2 (Animals of freshwater habitats)	2.2.a	Recognizes and names some animals which live in freshwater habitats or on their banks.	**I**	**I.4**	**I.4.1**	
	2.2.b	States the interrelation among, plants and animals in freshwater habitats.	**I**	**I.4**	**I.4.2**	
	2.2.c	Indicates the role of fisheries in the development of food resources…	**None**	**None**	**None**	
2.3 (The vertebrates)	2.3.a	Defines vertebrates and recognizes their major groups: mammals, birds, reptiles, amphibians, fish.	**I**	**I.1**	**I.1.2**	
	2.3.b	States the important distinguishing characteristics of each vertebrate group.	**I**	**I.1**	**I.1.2**	
2.4 (The invertebrates)	2.4.a	Defines the following invertebrates: insects, molluscs, worms, and gives examples of each group.	**I**	**I.1**	**I.1.2**	
2.5 (Principles of animal classification)	2.5.a	Summarizes the principles of classification of the animals which were studied.	**I**	**I.1**	**I.1.2**	
2.6 (The social insects: bees and ants)	2.6.a	Gives a simple description of the social life of bees and of ants.	**None**	**None**	**None**	

Table D3

UNIT: Man and His Health (3)

Fourth Grade Lebanese Curriculum			TIMSS-2019 Assessment Framework			
Content Topic		**Learning Objective**	**TIMSS Content Domain Covered**	**TIMSS Content Topic Covered**	**TIMSS Content Sub-Topic Covered**	**Notes**
3.1 (Support and movement systems)	3.1.a	Defines the human skeleton and explains its functions in the body: support, protection of some organs, enhancement of body movement,…	**I**	**I.1**	**I.1.3**	
	3.1.b	Names the parts of the skeleton: skull, vertebral column, ribs, hipbones, bones of arms and legs.	**None**	**None**	**None**	
	3.1.c	Recognizes the forms of bones: flat, long, and short bones.	**None**	**None**	**None**	
	3.1.d	Observes that the bones are connected together by special tissue at their joints.	**I**	**I.1**	**I.1.3**	
	3.1.e	State the types of joints and brings out the relation between the type of joint and the kind of movement.	**I**	**I.1**	**I.1.3**	
	3.1.f	Infers that our bones develop and grow, **and the parts join again if a bone is broken.**	**I**	**I.4/I.5**	**I.4.2/1.5.2**	**Bold part is not covered**
	3.1.g	States the functions of the muscles in our body: support the bones, produce movement, protect the bones,…	**I**	**I.1**	**I.1.3**	
	3.1.h	Infers the system of elongation and contraction in the muscles of the arms and legs.	**I**	**I.1**	**I.1.3**	
	3.1.i	Infers that skeleton and muscles determine the shape of our body.	**I**	**I.1**	**I.1.3**	
	3.1.j	Infers that our muscles, as our bones, develop and grow.	**I**	**I.4/I.5**	**I.4.2/I.5.2**	
3.2	3.2.a	States the kinds of food which help in the	**I**	**I.5**	**I.5.2**	

(Care and protection of skeleton and the muscles)		growth of bones and muscles.				
	3.2.b	Describe the role of play, exercise, and rest in the development of bones and muscles: healthy growth, acquisition of force, normal maintenance.	**I**	**I.5**	**I.5.2**	
	3.2.c	States some problems which might occur with respect to the skeleton and is aware of the need to refer to a physician.	**None**	**None**	**None**	
	3.2.d	States and applies some principles for the care of the skeleton: proper way of sitting, avoiding of raising or carrying of heavy objects, avoiding harmful play.	**I**	**I.5**	**I.5.2**	
3.3 (The food pyramid, balanced diet)	3.3.a	Identifies the importance of the food for our body: growth, repair, energy, **and keeping healthy**.	**I**	**I.4/I.5**	**I.4.2/1.5.2**	**Bold part is covered in I.5.2**
	3.3.b	Describes the food pyramid and expresses it in a drawing.	**None**	**None**	**None**	
	3.3.c	Gives examples on various food groups and states the benefit of each group.	**I**	**I.5**	**I.5.2**	
	3.3.d	Defines the content of a balanced diet, states its importance, and suggests balanced meals.	**I**	**I.5**	**I.5.2**	
	3.3.e	Concludes that milk and its derivatives form a stable component of our daily food.	**I**	**I.5**	**I.5.2**	
	3.3.f	Takes an attitude with regard to eating counter prepared foods and soft drinks.	**I**	**I.5**	**I.5.2**	
3.4 (Malnutrition and some of its consequences)	3.4.a	Defines malnutrition as the trouble or affliction caused in our body because of the amount or kind of food eaten.	**None**	**None**	**None**	

3.4.b	States the outstanding symptoms of undernourishment.	**None**	**None**	**None**
3.4.c	States the harmful effects of overeating.	**None**	**None**	**None**
3.4.d	Infers the importance of conforming to times of meals and eating proper amount and kind of food.	**I**	**I.5**	**I.5.2**

Table D4

UNIT: Matter and Energy (4)

Fourth Grade Lebanese Curriculum			TIMSS-2019 Assessment Framework			
Content Topic		**Learning Objective**	**TIMSS Content Domain Covered**	**TIMSS Content Topic Covered**	**TIMSS Content Sub-Topic Covered**	**Notes**
4.1 (Definition of matter)	4.1.a	Recognizes some common examples of matter: iron, water, clay, glass, etc.…	**II**	**II.1**	**II.1.2**	
	4.1.b	Defines matter as a body which has a definite chemical composition.	**None**	**None**	**None**	
	4.1.c	Observes some objects and recognizes the kinds of matter in them.	**II**	**II.1**	**II.1.2**	
	4.1.d	Distinguishes between matter and objects.	**II**	**II.1**	**II.1.2**	
4.2 (Properties of matter)	4.2.a	Observes that objects occupy space.	**II**	**II.1**	**II.1.2**	
	4.2.b	Infers that two objects cannot occupy the same space under the same conditions.	**II**	**II.1**	**II.1.2**	
	4.2.c	Infers by observation that matter has mass.	**II**	**II.1**	**II.1.2**	
4.3 (Measurement of mass)	4.3.a	Measure the mass of an object by using the balance.	**II**	**II.1**	**II.1.2**	
	4.3.b	Recognizes the standard units of mass.	**II**	**II.1**	**II.1.2**	
	4.3.c	Recognizes some modern types of balances.	**II**	**II.1**	**II.1.2**	
4.4 (Mixtures and water solutions)	4.4.a	Defines a mixture and gives examples.	**II**	**II.1**	**II.1.2**	
	4.4.b	Explores the kinds of mixtures: homogenous, heterogeneous.	**II**	**II.1**	**II.1.2**	
	4.4.c	Explores some substances which dissolve in water.	**II**	**II.1**	**II.1.4**	

	4.4.d	Defines a solution as composed of a solvent and a solute. Distinguishes a true solution in a practical way.	**II / II**	**II.1/ II.1**	**II.1.2/II.1.4**
	4.4.e	Concludes that the substance of a solute remains unchanged in a solution.	**II**	**II.1**	**II.1.4**
	4.4.f	Give examples of non-aqueous solution.	**II**	**II.1**	**II.1.2**
4.5 (Magnets)	4.5.a	Recognizes the common shapes of magnets and identifies materials which are attracted by magnets.	**II**	**II.1**	**II.1.3**
	4.5.b	Explores the parts of a magnet and infers the law of magnetic attraction and repulsion.	**II**	**II.1**	**II.1.3**
	4.5.c	Recognizes the magnetic compass and uses it properly. Identifies the magnet in some toys and gadgets.	**None/ None**	**None/ None**	**None/None**
4.6 (The electric charge)	4.6.a	States some aspects of electric charges around us, and produces electric charges by friction of suitable materials.	**None**	**None**	**None**
	4.6.b	Explores the attraction and repulsion of electric charges and infers that like charges repel each other and unlike charges attract each other.	**None**	**None**	**None**
4.7 (Sound and some of its properties)	4.7.a	Infers that sound is produced when bodies vibrate.	**II**	**II.2**	**II.2.2**
	4.7.b	Infers that the frequency of sound determines the sharpness of sound.	**None**	**None**	**None**
	4.7.c	Concludes that the kind of vibrating body determines the quality of sound produced.	**II**	**II.2**	**II.2.2**

	4.7.d	**Recognizes the kinds of musical instruments and** identifies the sound producing element in each kind.	**II**	**II.2**	**II.2.2**	**Bold part is not covered**
4.8 (Propagation of sound)	4.8.a	Infers that sound travels only in matter.	**II**	**II.2**	**II.2.2**	
	4.8.b	Observes that the speed of sound is greatest in solids, decreases in liquids, and has least speed in air.	**II**	**II.2**	**II.2.2**	
	4.8.c	Concludes that sound travels in all directions.	**II**	**II.2**	**II.2.2**	
	4.8.d	Recognizes some modern sound instruments.	**None**	**None**	**None**	
4.9 (How do we hear?)	4.9.a	Identifies the parts of human ear, and recognizes the function of each part.	**I**	**I.1**	**I.1.3**	
	4.9.b	Describes the passage of sound within the ear and the production of sound sensation.	**II**	**II.2**	**II.2.2**	
4.10 (Effect of noise on our health)	4.10.a	Recognizes disturbing noises.	**I**	**I.3**	**I.3.3**	
	4.10.b	States some of the effects of noise pollution, and identifies personal responsibility, if any.	**I**	**I.3**	**I.3.3**	
	4.10.c	Gives examples of modern devices for reducing noise.	**None**	**None**	**None**	

Table D5

UNIT: Earth and the Universe (5)

Fourth Grade Lebanese Curriculum			TIMSS-2019 Assessment Framework			
Content Topic		**Learning Objective**	**TIMSS Content Domain Covered**	**TIMSS Content Topic Covered**	**TIMSS Content Sub-Topic Covered**	**Notes**
5.1 (Soil and some of its kinds)	5.1.a	Defines "soil".	**III**	**III.1**	**III.1.2**	
	5.1.b	States the common kinds of soil: soil rich in sand, soil rich in clay, soil rich in calcium carbonate. Recognized each kind of soil.	**III**	**III.1**	**III.1.2**	
5.2 (Clay and related crafts)	5.2.a	Distinguishes clay **and recognizes its basic properties: odor, color, plasticity, permeability to water.**	**III**	**III.1**	**III.1.2**	**Bold part is not covered**
	5.2.b	Gives examples of industries which use clay **and describes the various stages in making pottery.**	**III**	**III.1**	**III.1.2**	**Bold part is not covered**
5.3 (Soil Erosion)	5.3.a	Explains soil erosion by running water and winds.	**III**	**III.1**	**III.1.3**	
	5.3.b	Infers that ground plants prevent soil erosion.	**III**	**III.1**	**III.1.2**	
	5.3.c	Enumerates some ways of conserving the soil.	**III**	**III.1**	**III.1.2**	
	5.3.d	States his role in soil conservation.	**III**	**III.1**	**III.1.2**	
5.4 (Sandstone and limestone)	5.4.a	Recognizes sandstone and limestone.	**III**	**III.1**	**III.1.2**	
	5.4.b	Gives examples on the use of sandstone and limestone.	**III**	**III.1**	**III.1.2**	
5.5 (Fossils in sandstone and limestone)	5.5.a	Recognizes fossils and states their scientific importance.	**III**	**III.1**	**III.1.3**	
5.6 (Weathering of rocks and soil formation)	5.6.a	States factors which cause weathering of rocks and explains formation of soil.	**III**	**III.1**	**III.1.3**	
5.7 (Formation of subterranean	5.7.a	Relates formation of subterranean reservoirs to the	**None**	**None**	**None**	

water reservoirs and their relation to rocks)	permeability of some sedimentary rocks to rain and snow water.

APPENDIX E

Assessment Matching Sheets (AMSs)

Table E1

Content Domain: Life Science (I)

TIMSS-2019 Assessment Framework				Fourth Grade Lebanese Curriculum		
TIMSS Content Topics & Sub-Topics			**TIMSS Learning Objective**	**Curriculum Content Unit Covered**	**Curriculum Content Topic Covered**	**Notes**
I.1	**I.1.1**	**I.1.1.A**	Recognize and describe differences between living and non-living things (i.e., all living things can reproduce, grow and develop, respond to stimuli, and die; and non-living things cannot).	**None**	**None**	
		I.1.1.B	Identify what living things require in order to live (i.e., air, food, water, and an environment in which to live).	**None**	**None**	
	I.1.2	**I.1.2.A**	Compare and contrast physical and behavioral characteristics that distinguish major groups of living things (i.e., insects, birds, mammals, fish, reptiles, and flowering plants).	**1** **2**	**1.1-1.4-1.5-1.6-1.7** **2.3-2.4-2.5**	
		I.1.2.B	Identify or provide examples of members of major groups of living things (i.e., insects, birds, mammals, fish, reptiles, and flowering plants).	**1** **2**	**1.4** **2.1-2.4**	
		I.1.2.C	Distinguish groups of animals with backbones from groups of animals without backbones.	**2**	**2.3-2.4-2.5**	
	I.1.3	**I.1.3.A**	Relate major structures in animals to their functions (e.g., **teeth break down food**, bones	**3** **4**	**3.1** **4.9**	**Bold part is not covered**

			support the body, **lungs take in air, the heart circulates blood**, **the stomach digests food,** muscles move the body).		
		I.1.3.B	Relate major structures in plants to their functions (i.e., roots absorb water and nutrients and anchor the plant, leaves make food, the stem transports water and food, petals attract pollinators, flowers produce seeds, and seeds produce new plants).	**None**	**None**
I.2	**I.2.1**	**I.2.1.A**	Identify stages of the life cycles of plants (i.e., germination, growth and development, reproduction, and seed dispersal).	**None**	**None**
		I.2.1.B	Recognize, compare, and contrast the life cycles of familiar plants and animals (e.g., trees, beans, humans, frogs, butterflies).	**None**	**None**
	I.2.2	**I.2.2.A**	Recognize that plants and animals reproduce with their own kind to produce offspring with features that closely resemble those of the parents.	**None**	**None**
		I.2.2.B	Distinguish between features of plants and animals that are inherited from their parents (e.g., number of petals, color of petals, eye color, hair color), and those that are not (e.g., some broken branches in a tree, length of human hair).	**None**	**None**
		I.2.2.C	Identify and describe different strategies that increase the	**None**	**None**

			number of offspring that survive (e.g., a plant producing many seeds, mammals caring for their young).			
I.3	**I.3.1**	**I.3.1.A**	Associate physical features of plants and animals with the environments in which they live and describe how these features help them to survive (e.g., a thick stem, a waxy coating, and a deep root help a plant survive in an environment with little water; the coloring of an animal helps camouflage it from predators).	**None**	**None**	
		I.3.1.B	Associate behaviors of animals with the environments in which they live and describe how these behaviors help them to survive (e.g., migration or hibernation helps an animal to stay alive when food is scarce).	**None**	**None**	
	I.3.2	**I.3.2.A**	Recognize and describe how plants respond to environmental conditions (e.g., amount of available water, amount of sunlight).	**None**	**None**	
		I.3.2.B	Recognize and describe how different animals respond to changes in environmental conditions (e.g., light, temperature, danger); recognize and describe how the human body responds to high and low temperatures, exercise, and danger.	**None**	**None**	
	I.3.3	**I.3.3.A**	Recognize that human behavior has negative and positive	**1** **2** **4**	**1.9** **2.1** **4.10**	**Bold part is not covered**

			effects on the environment (e.g., negative effects of **air** and water pollution, the benefits of reducing **air** and water pollution); provide general descriptions and examples of the effects of pollution on humans, plants, and animals, and their environments.		
I.4	**I.4.1**	**I.4.1.A**	Relate common plants and animals (e.g., evergreen trees, frogs, lions) to common ecosystems (e.g., forests, ponds, grasslands).	**1** **2**	**1.1-1.3** **2.1-2.2**
	I.4.2	**I.4.2.A**	Recognize that all plants and animals need food to provide energy for activity and need raw materials for growth and repair; explain that plants need sunlight to make their food, while animals eat plants or other animals to get their food.	**1** **2** **3**	**1.1** **2.2** **3.2-3.3**
		I.4.2.B	Complete a model of a simple food chain using common plants and animals from familiar ecosystems, such as a forest or a desert.	**None**	**None**
		I.4.2.C	Describe the roles of living things at each link in a simple food chain (e.g., plants produce their own food; some animals eat plants, while other animals eat the animals that eat plants).	**None**	**None**
		I.4.2.D	Identify and describe common predators and their prey.	**None**	**None**
	I.4.3	**I.4.3.A**	Recognize and explain that some living things in an ecosystem compete	**None**	**None**

			with others for food or space.			
I.5	**I.5.1**	**I.5.1.A**	Relate the transmission of common communicable diseases to human contact (e.g., touching, sneezing, coughing).	**None**	**None**	
		I.5.1.B	Identify or describe some methods of preventing disease transmission (e.g., vaccination, washing hands, avoiding people who are sick); recognize common signs of illness (e.g., high body temperature, coughing, stomachache).	**None**	**None**	
	I.5.2	**I.5.2.A**	Describe everyday behaviors that promote good health (e.g., a balanced diet, exercising regularly, **brushing teeth, getting enough sleep, wearing sunscreen**); identify common food sources included in a balanced diet (e.g., fruits, vegetables, grains).	**3**	**3.1-3.2-3.3-3.4**	**Bold part is not covered**

Table E2

Content Domain: Physical Science (II)

TIMSS-2019 Assessment Framework				Fourth Grade Lebanese Curriculum		
TIMSS Content Topics & Sub-Topics			**TIMSS Learning Objective**	**Curriculum Content Unit Covered**	**Curriculum Content Topic Covered**	**Notes**
II.1	**II.1.1**	**II.1.1.A**	Identify and describe three states of matter (i.e., a solid has a definite shape and volume, a liquid has a definite volume but not a definite shape, and a gas has neither a definite shape nor a definite volume).	**None**	**None**	
	II.1.2	**II.1.2.A**	Compare and sort objects and materials on the basis of physical properties (e.g., weight/mass, volume, state of matter, **ability to conduct heat or electricity, ability to float or sink in water,** ability to be attracted by a magnet)**.** [Note: Students in the fourth grade are not expected to differentiate between mass and weight.]	**4**	**4.1-4.2-4.3-4.5**	**Bold part is not covered**
		II.1.2.B	Identify properties of metals **(i.e., conducting electricity and conducting heat) and relate these properties to uses of metals (e.g., a copper electrical wire, an iron cooking pot).**	**4**	**4.5**	**Bold part is not covered**
		II.1.2.C	Describe examples of mixtures **and how they can be physically separated (e.g., sifting, filtration, evaporation,**	**4**	**4.4**	**Bold part is not covered**

			magnetic attraction).			
	II.1.3	**II.1.3.A**	Recognize that magnets have two poles and that like poles repel and opposite poles attract.	**4**	**4.5**	
		II.1.3.B	Recognize that magnets can be used to attract some metal objects.	**4**	**4.5**	
	II.1.4	**II.1.4.A**	Identify observable changes in materials that do not result in new materials with different properties (e.g., dissolving, **crushing an aluminium can**).	**4**	**4.4**	**Bold part is not covered**
		II.1.4.B	Recognize that matter can be changed from one state to another by heating or cooling; describe changes in the state of water (i.e., melting, freezing, boiling, evaporation, and condensation).	**None**	**None**	
		II.1.4.C	**Identify ways of increasing how quickly a solid material dissolves in a given amount of water (i.e., increasing the temperature, stirring, and breaking the solid into smaller pieces);** distinguish between strong and weak concentrations of simple solutions.	**4**	**4.4**	**Bold part is not covered**
	II.1.5	**II.1.5.A**	Identify observable changes in materials that make new materials with different properties (e.g., decaying, such as food spoiling; burning; rusting).	**None**	**None**	
II.2	**II.2.1**	**II.2.1.A**	Identify sources of energy (e.g., the Sun, flowing water, wind, coal, oil, gas),	**None**	**None**	

			and recognize that energy is needed to move objects and for heating and lighting.		
	II.2.2	**II.2.2.A**	Relate familiar physical phenomena (i.e., shadows, reflections, and rainbows) to the behavior of light.	**None**	**None**
		II.2.2.B	Relate familiar physical phenomena (i.e., vibrating objects and echoes) to the production and behavior of sound.	**4**	**4.7-4.8-4.9**
	II.2.3	**II.2.3.A**	Recognize that warmer objects have a higher temperature than cooler objects; describe what will happen when a hot object and a cold object are brought into contact (i.e., the temperature of the hot object decreases and the temperature of the cold object increases).	**None**	**None**
	II.2.4	**II.2.4.A**	Recognize that electrical energy in a circuit can be transformed into other forms of energy (e.g., heat, light, sound).	**None**	**None**
		II.2.4.B	Explain that simple electrical systems (e.g., a flashlight) require a complete (unbroken) electrical pathway.	**None**	**None**
II.3	**II.3.1**	**II.3.1.A**	Identify gravity as the force that draws objects to Earth.	**None**	**None**
		II.3.1.B	Recognize that forces (i.e., pushing and pulling) may cause an object to change its motion; compare the effects of these forces of different strengths in the same or opposite directions acting on	**None**	**None**

		an object; and recognize that friction force works against the direction of motion (e.g., friction working against a push or a pull makes it more difficult to move an object along a surface).		
II.3.2	**II.3.2.A**	Recognize that simple machines, (e.g., levers, pulleys, gears, ramps) help make motion easier (e.g., make lifting things easier, reduce the amount of force required, change the distance, change the direction of the force).	**None**	**None**

Table E3

Content Domain: Earth Science (III)

TIMSS-2019 Assessment Framework				Fourth Grade Lebanese Curriculum		
TIMSS Content Topics & Sub-Topics			**TIMSS Learning Objective**	**Curriculum Content Unit Covered**	**Curriculum Content Topic Covered**	**Notes**
III.1	**III.1.1**	**III.1.1.A**	**Recognize that Earth's surface is made up of land and water in unequal proportions (more water than land) and is surrounded by air;** describe where fresh and **salt** water are found, and recognize that water in rivers or streams flows from mountains to oceans or lakes.	**1**	**1.2**	**Bold part is not covered**
	III.1.2	**III.1.2.A**	Identify some of Earth's resources that are used in everyday life (e.g., **water, wind**, soil, **forests, oil, natural gas, minerals**).	**5**	**5.1-5.2-5.4**	**Bold part is not covered**
		III.1.2.B	Explain the importance of using Earth's renewable and **non-renewable** resources responsibly (e.g., **fossil fuels**, forests, water).	**1** **5**	**1.8-1.9** **5.3**	**Bold part is not covered**
	III.1.3	**III.1.3.A**	Recognize that wind and water change Earth's landscape and that some features of Earth's landscape (e.g., mountains, river valleys) result from changes that happen very slowly over a long time.	**5**	**5.3-5.6**	
		III.1.3.B	Recognize that some remains (fossils) of animals and plants that	**5**	**5.5**	

			lived on Earth a long time ago are found in rocks and make simple deductions about changes in Earth's surface from the location of these remains.		
III.2	**III.2.1**	**III.2.1.A**	Apply knowledge of changes of state of water to common weather events (e.g., cloud formation, dew formation, the evaporation of puddles, snow, rain).	**None**	**None**
		III.2.1.B	Describe how weather (i.e., daily variations in temperature, humidity, precipitation in the form of rain or snow, clouds, and wind) can vary with geographic location.	**None**	**None**
		III.2.1.C	Describe how average temperature and precipitation can change with the seasons and location.	**None**	**None**
III.3	**III.3.1**	**III.3.1.A**	Identify the Sun as a source of heat and light for the Solar System; describe the Solar System as the Sun and the planets that revolve around it.	**None**	**None**
		III.3.1.B	Recognize that the Earth has a moon that revolves around it, and from Earth the Moon looks different at different times of the month.	**None**	**None**
	III.3.2	**III.3.2.A**	Explain how day and night are related to Earth's daily rotation about its axis, and	**None**	**None**

	provide evidence of this rotation from the changing appearance of shadows during the day.		
III.3.2.B	Describe how seasons in Earth's northern and southern hemispheres are related to Earth's annual movement around the Sun.	**None**	**None**

APPENDIX F

Content-by-Cognitive Demands Matrix

TIMSS Cognitive Domains / TIMSS Content Topics & Sub-Topics		Knowing	Applying	Reasoning
I.1	**I.1.2**			
	I.1.3			
I.3	**I.3.3**			
I.4	**I.4.1**			
	I.4.2			
I.5	**I.5.2**			
II.1	**II.1.2**			
	II.1.3			
	II.1.4			
II.2	**II.2.2**			
III.1	**III.1.1**			
	III.1.2			
	III.1.3			

APPENDIX G

Curriculum Matrix (CM)

TIMSS Cognitive Domains / TIMSS Content Topics & Sub-Topics		Knowing	Applying	Reasoning
I.1	**I.1.2**	1.4.a (Define- give examples) 1.5.a 2.1.a (Name/recognize) 2.3.a (Define- recognize) 2.3.b 2.4.a (Define- give examples)	1.1.b *1.1.c (Relate)*	1.7.a 2.5.a
	I.1.3	3.1.a (Define) 3.1.e (State) 3.1.g 4.9.a (Identify- recognize)	3.1.a (explain) 3.1.e (bring out the relation)	3.1.h 3.1.i
I.3	**I.3.3**	1.9.a (Name- state) *1.9.c (State)* 4.10.a 4.10.b (State- identify)	2.1.b	1.9.b
I.4	**I.4.1**	1.1.a (Recognize- name) 1.3.a 1.3.b (Recognize- name) 2.1.a (Name/recognize) 2.2.a (Recognize- name)	*1.1.c (Relate)*	
	I.4.2	2.2.b *3.3.a (Identify)*	*3.1.f (Infer)* *3.1.j (Infer)*	
I.5	**I.5.2**	3.2.a 3.2.b 3.2.d *3.3.a (Identify)* 3.3.c (Give examples- state) 3.3.d (Define- state)	*3.1.f (Infer)* *3.1.j (Infer)*	3.3.d (suggest) 3.3.e 3.4.d
II.1	**II.1.2**	4.1.a 4.1.c 4.3.a 4.3.b 4.3.c 4.4.a (Define- give examples) 4.4.d (Define)* 4.4.f	4.1.d 4.2.b 4.2.c 4.4.d (Distinguish)*	
	II.1.3	4.5.a (Recognize- identify)		4.5.b
	II.1.4	4.4.d (Define)*	4.4.d (Distinguish)*	4.4.e

II.2	**II.2.2**	4.7.d 4.9.b		4.7.a 4.7.c 4.8.a 4.8.c
III.1	**III.1.1**	1.2.a (State- describe)		1.2.b
	III.1.2	*1.9.c (State)* 5.1.a 5.1.b (State - Recognize) 5.2.b 5.3.c 5.3.d 5.4.a 5.4.b	1.8.a 5.2.a 5.3.b	
	III.1.3	5.5.a (Recognize - state) 5.6.a (State)	5.3.a 5.6.a (explain)	

APPENDIX H

Assessment Matrix (AM)

TIMSS Cognitive Domains / TIMSS Content Topics & Sub-Topics		Knowing	Applying	Reasoning
I.1	**I.1.2**	I.1.2.B	I.1.2.A I.1.2.C	
	I.1.3		I.1.3.A	
I.3	**I.3.3**	I.3.3.A (Recognize-provide general descriptions and examples)		
I.4	**I.4.1**		I.4.1.A	
	I.4.2	I.4.2.A (Recognize)	I.4.2.A (explain)	
I.5	**I.5.2**	I.5.2.A (Describe-identify)		
II.1	**II.1.2**	II.1.2.B II.1.2.C	II.1.2.A	
	II.1.3	II.1.3.A II.1.3.B		
	II.1.4	II.1.4.A	II.1.4.C	
II.2	**II.2.2**		II.2.2.B	
III.1	**III.1.1**	III.1.1.A (Describe-recognize)		
	III.1.2	III.1.2.A	III.1.2.B	
	III.1.3	III.1.3.A III.1.3.B (Recognize)	III.1.3.B (make simple deductions)	

APPENDIX I

Curriculum Frequency Matrix (Sub-Topics-by-Cognitive Demands)

TIMSS Cognitive Domains / TIMSS Content Topics & Sub-Topics		Knowing	Applying	Reasoning
I.1	**I.1.2**	5.5	1.5	2
	I.1.3	3	1	2
I.3	**I.3.3**	3.5	1	1
I.4	**I.4.1**	4.5	0.5	
	I.4.2	1.5	1	
I.5	**I.5.2**	5.17	1	2.33
II.1	**II.1.2**	7.25	3.25	
	II.1.3	1		1
	II.1.4	0.25	0.25	1
II.2	**II.2.2**	2		4
III.1	**III.1.1**	1		1
	III.1.2	7.5	3	
	III.1.3	1.5	1.5	

APPENDIX J

Assessment Frequency Matrix (Sub-Topics-by-Cognitive Demands)

TIMSS Cognitive Domains / TIMSS Content Topics & Sub-Topics		Knowing	Applying	Reasoning
I.1	**I.1.2**	1	2	
	I.1.3		1	
I.3	**I.3.3**	1		
I.4	**I.4.1**		1	
	I.4.2	0.5	0.5	
I.5	**I.5.2**	1		
II.1	**II.1.2**	2	1	
	II.1.3	2		
	II.1.4	1	1	
II.2	**II.2.2**		1	
III.1	**III.1.1**	1		
	III.1.2	1	1	
	III.1.3	1.5	0.5	

APPENDIX K

Curriculum Frequency Matrix (Topics-by-Cognitive Demands)

TIMSS Cognitive Domains / TIMSS Content Topics	Knowing	Applying	Reasoning
I.1	8.5	2.5	4
I.3	3.5	1	1
I.4	6	1.5	
I.5	5.17	1	2.33
II.1	8.5	3.5	2
II.2	2		4
III.1	10	4.5	1

APPENDIX L

Assessment Frequency Matrix (Topics-by-Cognitive Demands)

TIMSS Cognitive Domains / TIMSS Content Topics	Knowing	Applying	Reasoning
I.1	1	3	
I.3	1		
I.4	0.5	1.5	
I.5	1		
II.1	5	2	
II.2		1	
III.1	3.5	1.5	

APPENDIX M

Curriculum Frequency Matrix (Content Domains-by-Cognitive Demands)

TIMSS Cognitive Domains / TIMSS Content Domains	Knowing	Applying	Reasoning
I	23.17	6	7.33
II	10.5	3.5	6
III	10	4.5	1

APPENDIX N

Assessment Frequency Matrix (Content Domains-by-Cognitive Demands)

TIMSS Cognitive Domains / TIMSS Content Domains	Knowing	Applying	Reasoning
I	3.5	4.5	
II	5	3	
III	3.5	1.5	

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