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**The Effects of the Language of Instruction in the
Science and Math Achievement of Lebanese Students**

By

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The Effect of the Language of Instruction on the Math and Science Achievement of
Lebanese Students

Nadine Adnan Dandashly

Abstract

The effect of language of instruction on the science and mathematics achievement of students is a debatable subject and the question of several research studies. Several studies revealed the relationship that exists between language and the learning of math/science. They also showed that learning math and science in the first language allows students to obtain better results than students learning in the second language. Some studies indicated that students achieved better in questions requiring higher cognitive levels of thinking when they study in their first language. This study focused on examining the effect of the language of instruction on the science and math achievement of Lebanese students. In particular, it aimed at examining whether students who learn math/science in their first language (Arabic) achieve better results on different levels cognitive questions than students learning in the second language (English). This quantitative study conducted on two groups of Lebanese students, where one group teaches math and science in the first language (Arabic) and the second teaches these subjects in the second language (English). Science and math achievement tests were administered to 368 grade 5 students and 157 grade 11 students to test their achievement in math and science. The analysis of their achievement test results and their scores on the different cognitive levels of thinking was done using the analysis of variance statistical method which revealed that students studying in the first language achieved higher than students studying in the second language. Moreover, when exposed to questions of higher cognitive levels these students achieved better. Learning math and science in the first language might be a need for Lebanon to increase students' achievement and allow a fluent use of the second language in math and science at universities.

Keywords: First Language, Second Language, Cognitive Levels of Thinking,
Students' Achievement, Bilingualism, Language Proficiency

Contents

CHAPTER ONE: INTRODUCTION	1
1.1 Overview	1
1.2 Statement of Purpose.....	3
1.3 Research Questions	4
1.4 Operational Definitions	4
1.5 Significance of the Study.....	5
1.6 Summary	6
CHAPTER TWO: LITERATURE REVIEW	7
2.1 Introduction	7
2.2 The First theme: The Interdependence of language and science and math instruction	9
2.3 The Second Theme: The Benefits and Challenges of Learning in the First Language (L1) and the Drawbacks of Learning in the Second Language (L2)	11
2.4 The Third theme: Factors Affecting the Success of Immersion Programs in Raising Students' Academic Achievement.....	15
2.5 Summary	21
CHAPTER THREE: METHODOLOGY	23
3.1 Overview	23
3.2 Subjects	24
3.2.1 Selected Schools	24
3.2.2 Participants	26
3.3 Procedure.....	30
3.4 Instruments	30
3.4.1 Preparing the list of objectives.....	31
3.4.2 Designing six achievement tests.....	32
3.4.3 Piloting achievement tests	35
3.4.4 Validity and Reliability.....	35
3.5 Data Analysis Method/ Framework and Procedure.....	37
3.5.1 Analysis of the exercises of the books used	37
3.5.2 Grading the achievement tests for each school.....	37

3.5.3 Calculating the Scores of Each Group of Schools	38
3.5.4 Comparing the calculated mean values of each group of schools	38
3.6 Summary	39
 CHAPTER FOUR: DATA ANALYSIS	41
4.1 Introduction	41
4.2 The Levels of Questions in Lebanese Text Books	42
4.2.1 Science book of grade 5.....	43
4.2.2 Math book of grade 5.....	44
4.2.3 Science book of grade 5.....	44
4.2.4 Math book of grade 11.....	46
4.3 Science and Math Achievement for Grade 5 of L1 and L2 Students	47
4.3.1 Comparing the results of the total scores of grade 5 science and math achievement tests in students learning in Arabic (L1) and students learning in English (L2)	49
4.3.2 Comparing the Results of the three Cognitive Levels of Math and Science Grade 5 Achievement Tests.....	50
4.4 Results of Science and Math Achievement Tests for Grade 11	54
4.4.1 Comparing the results of the total scores of grade 11 science and math achievement tests in students learning in Arabic (L1) and students learning in English (L2)	56
4.4.2 Comparing the Results of the three Cognitive Levels of Math and Science Grade 11 Achievement Tests.....	57
4.5 Conclusion.....	61
 CHAPTER FIVE: CONCLUSIONS	63
5.1 Introduction	63
5.2 Discussion of Results Based on Research Questions	64
5.2.1 Research question one	64
5.2.2 Research question two	66
5.3 Recommendations	69
5.4 Difficulties and Limitations to the Study	71
5.4.1 Difficulties of the study	71
5.4.2 Limitations of the study	72
5.5 Recommendations for Future Research.....	73

REFERENCES.....	75
APPENDICES	81
Appendix A: Principal's Interview	81
Appendix B: Students' Questionnaire.....	82
Appendix C: استبيان الطلاب	84
Appendix D: Grade Five Science Achievement Test-English Version (T1)	85
Appendix E: Grade Five Science Achievement Test-Arabic Version (T1').....	91
Appendix F: Grade Five Math Achievement Test-English Version (T2)	98
Appendix G: Grade Five Math Achievement Test-Arabic Version (T2')	101
Appendix H: Grade Eleven Science Achievement Test (T3).....	104
Appendix I: Grade Eleven Math Achievement Test (T4)	110
Appendix J: Exercises of the Science lesson of Grade 5 Plants.....	112
Appendix K: Science Teacher's Classification to the Exercises of Grade 5 Science Lesson (Appendix E).....	114
Appendix L: Exercises of Grade 5 Math Lesson: Subtraction of Fractions.....	115
Appendix M: Math Teacher's Classification of the Exercises of Grade 5 Math Lesson (Appendix G)	118
Appendix N: Exercises of Grade 11 Biology Lesson: The Diversity of Organisms and the Uniqueness of the Individual	119
Appendix O: Biology Teacher's Classification of the Exercises Grade 11 Biology Lesson (of Appendix I).....	121
Appendix P: Exercises of Grade 11 Physics Lesson (Musical Sounds-Waves) ..	122
Appendix Q: Physics Teacher's Classification of the Physics Exercises of Appendix K	124
Appendix R: Exercises of Grade 11 Chemistry Lesson: Redox Reactions	125
Appendix S: Chemistry Teacher's Classification of the Chemistry Exercises of Appendix M.....	127
Appendix T: Exercises of Grade 11 Math Lesson: Calculation on Polynomials .	128
Appendix U: Math Teacher's Classification of Exercises of the Math Lesson (Appendix O).....	131

List of Tables

Table 1	28
Table 2	29
Table 3	35
Table 4	43
Table 5	44
Table 6	45
Table 7	46
Table 8	48
Table 9	49
Table 10	50
Table 11	51
Table 12	52
Table 13	53
Table 14	54
Table 15	55
Table 16	56
Table 17	57
Table 18	58
Table 19	59
Table 20	60
Table 21	61

CHAPTER ONE

INTRODUCTION

1.1 Overview

For many years, research studies have documented the bearing that the language of instruction has on the learning of mathematics and science. Many educational systems are concerned with the effects of the language of instruction on the academic achievement of students in math and science. A relation between language of instruction and students' achievement in science and math was recognized by a number of academicians (Stubbs, 1976; Secada, 1991; Huang & Normandia, 2008). They showed that students need proficiency in the language of instruction to be able to have an active role in the science and math learning process. Their mastery of the language of instruction facilitates the reaction and interaction process with their teachers and peers (Lambert, 1990), and provides them with an emotionally safe environment to communicate their math and science thoughts and experiences. It also allows them to focus on thinking and discussing the rules of math and science themselves, rather than to focus on the language used to express their thoughts (Setati & Adler, 2000). Moreover, the students' active role in the science and math classrooms brings on their motivation to learn and practice solving math and science problems. These outcomes of the mastery of language help in increasing the students' academic achievement in these two subjects. For this reason, when low proficiency of language exists, students face many challenges in achieving well in math and science (Tan, 2011; Xie & Mouw, 1999; Capps & Pickreign, 1993, McKeon, 1994; Zakaria & Abd Aziz, 2011).

In addition to the language proficiency, the choice of the language of instruction showed an effect on the students' performance in math and science (Strevens, 1991; Za'rour & Nashif, 1977; Gorgorio & Planas, 2001). Several studies addressed the role of receiving instruction in the students' first language in engaging them in the learning process and allowing them to better perform in math and science over students studying in the second language (Bunyi, 1999; Collison, 1975; Ehindero, 1980; Seliji, 2003; Gfeller & Robinson, 1998). Other studies showed positive results as a result of using the second language for instruction in a medium where the proficiency of languages, the first and the second language existed (Bankston & Zhou, 1995; Cummins and Gulutsan, 1974; Hakuta & Diaz, 1985, Lambert, 1990; Swain and Lampkin, 1982; Mouw & Xie, 1999). This is in addition to the advantages of studying in the second language, which include the availability of plenty of teachers' and students' resources. Thus, choosing the language of instruction of math and science has been an issue of debate in many educational systems.

The first language (L1) is defined by Calvet (2006) as the language first learned by an individual, his/her primary and home language. In Lebanon, the first language learned is Arabic. However, Lebanese students use the Lebanese dialect to communicate with their family and peers, and not the modern standard Arabic (Amin, 2009). In this study, the first language is considered to be modern standard Arabic, as the complexity of the different uses of the dialect and the modern standard Arabic is not addressed in this study.

In Lebanon the second language might be English or French. Most Lebanese students learn math and science using the second language and few schools are teaching math and science in the first language at the elementary level. It can be

assumed, therefore, that Lebanese students' performance in math and science is affected by their proficiency or mastery of the language of instruction of math and science as will be explored below.

1.2 Statement of Purpose

Many international research studies were conducted to track the academic progress of students learning math and science in L1 compared to those studying these subjects in L2. However, one may ask whether the findings of international studies necessarily apply to the Lebanese context. Lebanon has two groups of schools regarding the language of instruction of math and science. One group of schools teaches math and science in the first language (Arabic) at the elementary level, and then allows a transition to studying in the second language (English or French) at the intermediate and secondary levels. The other group of schools teaches math and science in the second language (English or French) at all levels. Students of this group of schools start learning math and science before achieving mastery of their first language as applied by international educational programs using L2 as the language of instruction. Therefore, such research into the effects of the language of instruction is required within Lebanon to clarify what best suits the Lebanese environment and determine whether or not Lebanese schools should teach math and science in Arabic.

This study is designed to examine whether the language of instruction (L1 or L2) of math and science at the elementary level has an effect on the science and math achievement of Lebanese students, with specific focus on higher cognitive levels of thinking. The extent to which students' achievement in science and math is

influenced by the language of instruction at the elementary level (whether it is L1 (Arabic) or L2 (namely English in this study)) is investigated.

1.3 Research Questions

This study aims to measure the effects of receiving math and science instruction in the first language on the students' academic achievement. It further aims at measuring the influence of the language of instruction on three cognitive levels of thinking in math and science. The research questions are:

1. To what extent is the achievement of Lebanese students in science and math influenced by the language of instruction at the elementary level?
2. Do students studying in their first language (L1) (Arabic) achieve better results in questions requiring higher cognitive levels of thinking than students studying in the second language (L2) (English)?

1.4 Operational Definitions

First language (L1):

In this study the term “first language” is used to mean the language first learned by the individual, his/her primary and home language, which is Arabic. In this study the complexity between the Lebanese Arabic dialect used in daily life and the modern standard Arabic is disregarded. The first language used in this study is the modern standard Arabic.

Second language (L2):

The term second language used in the current study refers to the language that students learn in addition to the language they learn as children, which is English since the first language is considered the modern standard Arabic.

Higher Order Thinking

Higher order thinking is described in several ways (Lewis & Smith, 1993). A useful distinction between lower and higher order thinking is given by Maier (1937) who defines lower order thinking as used for reasoning or productive behavior which is related to solving problems by recalling or applying similar past experiences. On the other hand, he defines higher order thinking as the learned or productive behavior which requires a new combination of previous experiences to solve a problem (Maier, 1933). Higher order thinking has also been defined as the process of interpolation, extrapolation, and reinterpretation (Barlett, 1958). For the purposes of this study, the definition for lower and higher order thinking is the one stated by Newman that lower order thinking is described by performing application of previously acquired information and higher order thinking involves interpreting, analyzing, and manipulating information (Newman, 1990).

1.5 Significance of the Study

The study is to be conducted in Lebanese schools which work to achieve the goals of the Lebanese Curriculum. The implications of this study would allow educators to seek new teaching strategies which would reinforce the relation between the language of instruction and achievement in science and math and benefit from their interdependence to increase the academic achievement. Another aim of this study is to investigate the performance of Lebanese students in solving questions of different cognitive levels of thinking. Following on from this, policy makers would have to consider the language of instruction of math and science at the elementary level in Lebanese schools, if, as this research suggests, the language of teaching significantly affects students' academic achievement in these subjects. They would

have to consider alternative models of bilingual education in order to enhance students' understanding of math and science concepts and also increase high achievements in solving problems which involve higher cognitive levels of thinking skills in L1 and L2.

1.6 Summary

Many studies have emphasized the significance of the language of instruction in raising the academic achievement. Several studies have shown that the first language should be the language of instruction of science and math at the elementary level. Other studies showed the positive results of studying in the second language where the first language is mastered first, before learning the second language. The aim of this study is to investigate the relation between the language of instruction and the students' performance in Lebanese schools and also show the extent to which students' achievement in different cognitive levels is related to the language of instruction. Educators should take these results into consideration when choosing the language of instruction at the elementary level in order to control students' achievement and cognitive abilities not only at that stage but also at higher academic levels.

The next chapter elaborates on the research and debates found in literature pertinent to learning math and science in L1 and/or L2.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

According to the previous chapter, there is a debate about the choice of the language of instruction of math and science at the elementary level. In the context of Lebanon, where the second language is the language of math and science instruction in many schools, this question is of particular importance.

According to the description posted by UNESCO, some schools in Lebanon teach science and math in Arabic (L1) at the elementary level. These schools undergo late transition to studying in English or French (L2) in grade 6. Meanwhile, other schools in Lebanon teach math and science in the L2 at all academic levels. However, studying in both, L1 and L2 is recommended for students in Lebanon to be able to express and practice their scientific pursuit in both Arabic and foreign languages (Amin, 2009). This suggestion is supported by the prescribed learning outcomes of the Lebanese curriculum which are to be achieved by schools in Lebanon following the Lebanese national curriculum. The Lebanese scientific curriculum addresses the need to teach math and science in L1 since using the learned scientific knowledge and skills in the learner's everyday life situations is one of its objectives (ECRD, 1996a). This objective is fulfilled when students learn science and math in the language they use in their daily life in order for them to apply what they learn in similar situations in Lebanese society. Learning in the second language is also suggested by the Lebanese curriculum since it aims to develop the learners' scientific curiosity and allow them to be open to ideas of scientists from different cultures (ECRD, 1996a). Learning in the second language

helps in achieving this goal since scientific research is mostly published in a foreign language (BouJaoude & Sayah, 2000).

There is strong endorsement for both L1 and L2 to be used as the language of instruction in Lebanon, but no evidence regarding the academic achievement of students in math and science are found. According to literature, several studies have shown positive results of studying math and science in the first language of the learner. Other studies have shown positive effects of studying in the second language in the context of first and second language proficiency of the learner. However, similar positive results of both cases may not appear in the case of Lebanese schools. According to using the first language, similar positive results for using the first language may not appear since the Lebanese students' first language is not the modern standard Arabic taught in schools (Amin, 2009). Concerning learning in L2, similar positive results may not also be observed in Lebanon since studying in L2 in Lebanese schools is taking place at the beginning of school years before the students' achievement of their first language proficiency. For this reason, the review of different studies in literature should be discussed and a study in Lebanese schools needs to be conducted to examine the effect of the language of instruction on the students' achievement in math and science.

In this literature review, several relevant research studies which explore the effect of the language of instruction in math and science learning conducted outside Lebanon have been analyzed. These studies focused on three main themes. The first is the interdependence of language and math/science instruction. The second is the benefits and challenges of learning in the first language and the drawbacks of learning in the second language. The third theme concerns two factors affecting the

success of immersion programs of bilingualism in raising the students' academic achievement.

2.2 The First theme: The Interdependence of language and science and math instruction

A strong relationship has been identified between the language and the students' performance in science and math (Ríordáin & O'Donoghue, 2009). Language is An important element of not only learning, but also thinking, understanding and communicating in science and math. This is addressed by the goals of the Lebanese curriculum, the socio-cultural theories, and the results of several studies (ECRD, 1996b).

The language of instruction plays a significant role in achieving many aims of the Lebanese scientific curriculum. For example, the goals of the Lebanese curricula of math and science highlight an important role for language through several objectives (ECRD, 1996a). These objectives require using the appropriate language to understand and discuss science and math concepts in class, and then use them in everyday life (ECRD, 1996b). Discussing thoughts, sharing ideas, and linking scientific and mathematical concepts to real life experiences need a practical and clear language of communication. Having good communication skills facilitates using facts and principles in the domains of health, environment and technology in real life outside the classroom (ECRD, 1996a).

Socio-cultural theories of thinking and learning have viewed modes of thinking as being closely associated with styles of language use. According to Vygotsky (1962), cognitive development involves an active internalization of several learning processes that have taken place as a result of mutual interaction between

children and members of their society. This highlights the significance of language in allowing communication between individuals for the purposes of building knowledge. Bruner (1986) linked modes of thinking and usage of language. According to Bruner (1986), in order for students to think scientifically, they need to master the ability to think in and use the language fluently when they are exploring and analyzing scientific ideas.

Moreover, research studies have revealed that language is related to thinking, learning, and cognitive development (Stubbs, 1976). Math and science learning requires understanding and communicating of concepts to be meaningful to students so that they can use it in their real life situations. The flexibility and proficiency of language use was the key to achieve this goal in math (Capps & Pickreign, 1993). A high correlation between the level of language proficiency and students' achievement in solving math problems was also recognized in Hispanic first grade levels (Secada, 1991). On the other hand, a limited proficiency in the language of instruction hindered students' scientific reasoning skills and limited their interaction with each other (Lee, 2005). A qualitative research conducted on English language learners in a Chinese high school in Australia explained the learning difficulties Chinese students were facing in Chemistry classrooms (Tobin & McRobbie, 1996). Difficulties in understanding the lesson content existed because they lacked proficiency in the language of instruction (Tobin & McRobbie, 1996). The study showed a potential academic failure of these students in Chemistry because of their language difficulties (Tobin & McRobbie, 1996).

Akerson (2007) presented many interdisciplinary activities that help students express and explain science and math content in a proper language. These activities suggest that when students practice reading and researching scientific topics in

language sessions yields mutual benefits for math, science, and language. Research studies have shown that subject matter learning was particularly successful when integrated with language skills (Tan, 2011). Tan (2011) examined the process of science and math content and language integration in Malaysia. Positive results of integrating content and language were found to be attained when teachers cooperate and believe in the interdependence of language and math and science. A similar perspective appeared in a theoretical framework to examine comprehension of word problems through an integrated perspective of linguistics and mathematics which was proposed by Huang and Normandia (2008). In this theoretical framework, teachers used language mastered by students to help them comprehend math word problems.

2.3 The Second Theme: The Benefits and Challenges of Learning in the First Language (L1) and the Drawbacks of Learning in the Second Language (L2)

There is a variety of literature that specifies two main reasons behind using L2 as a language of instruction including students' access to international resources and the language of instruction used at most universities (Za'rour & Nashif, 1977; McFerren, 1984; BouJaoude & Sayah, 2000). Other literature stresses the significance of using L1 in communicating and sharing scientific and math concepts and experiences, reflecting a nation's origin and history, and increasing the students' academic achievement. In this section, a review of several studies investigating the benefits and challenges of learning math and science in L1, and the drawbacks of learning these subjects in L2 is presented.

According to Lee (2005), students are motivated to learn math and science when they have an active role in the learning process. They become engaged by sharing their experiences in classroom and allowing what they learn to be applied in their real life situations. This is facilitated when learners employ their first language tools in communicating what they learn. Students would have difficulties in participating in class discussions when it is not in their first language, even after they learned the second language (Gorgorio & Planas, 2001). Using the second language in class discussions would limit their engagement in science and math learning since students would be hindered from expressing their thoughts freely in the classroom. Students wouldn't be able to share their scientific knowledge with their peers and link it to their daily life experiences if they were not using the same common first language (Za'rour & Nashif, 1977). Jordanian Secondary school students were more comfortable and interested in explaining new examples and scientific discoveries with their peers who had a common L1 in a study conducted in Jordan (Za'rour & Nashif, 1977). When students are fluently expressing their thoughts in math, their math performance will be reinforced (Gfeller & Robinson, 1998).

In addition to class participation and sharing discoveries with their peers, students need to understand, manipulate, and fluently discuss science and math concepts. Results were shown in Nigeria where a difficulty in understanding material taught in the second language in six secondary schools was detected (Adegoke, & Ibode, 2001). Other studies revealed similar results regarding the difficulties in science and math learning when the second language is the language of instruction (Ayodele & Itsuokor, 1988; Rumberger, 1995; Akinwumiju & Fabunmi, 2001). Understanding math and science concepts requires the mastery of the language of instruction by the teachers and learners, whether it is L1 or L2, but it was

documented that L1 was mastered by all people since it is the language that is predominantly used in daily life (Gorgorio & Planas, 2001).

A strong relationship was shown between using the first language as the language of instruction and the progress of the students' academic achievement (Bankston & Zhou, 1995). For example, the academic achievement of Chinese students in chemistry learning was negatively affected when English (L2) was the language of instruction (Tobin & McRobbie, 1996). The academic achievement in science and math was based on subject understanding and class interaction which was not fully accomplished in the students' second language (Lee, 2005). Similar results were revealed in studies conducted in Malaysia where the students' mathematics performance was better when the test was in their first language which was the language of instruction (Zakaria & Abd Aziz, 2011). Students' math performance was held back by problems they faced in understanding new English terminologies. Low averages were also achieved by Philippine students in math and science when L2 was the language of instruction (Gonzalez & Sibayan, 1998). Also it was shown that students studying in their first language performed better in arithmetic than students learning in their second language (English or French) (Gfeller & Robinson, 1998).

A large scale study which examined the progress of 12,000 schools in China over three years showed similar results. Chinese students performed better in math achievement tests when Chinese is the language of instruction (Marsh, 2000). Another study conducted in China showed that students learning in their first language (Chinese) achieved better results than students learning in their second language (English) or in a mixed-code instruction in both languages (Lo, 1991).

Using the first language as the language of instruction had an effect on the students' achievement in different cognitive levels of thinking, not only the overall academic achievement in math and science. A series of studies were conducted in Tasmania, India, and the Philippines to compare the highest level of cognitive ability of students studying science in their first language with those studying science in the second language (Lynch, Chipman, & Pachaury, 1985). The highest level of cognitive ability of students in Tasmania (Australia) was higher than that of those in India and the Philippines when the language of instruction was English (Lynch, Chipman, & Pachaury, 1985). Although it was argued that some languages like the indigenous languages used in the Philippines, were not suitable to correctly express scientific concepts, students' performed better in questions requiring high cognitive levels when the test was in their L1 (Lynch, 1996a, 1996b). These studies assured that using the first language in science instruction would allow students to develop higher levels of cognitive abilities (Lee, 2005). Higher cognitive activities for effective science learning were difficult to be achieved when the language of instruction wasn't the students' first language (Gonzalez & Sibayan, 1998).

This increase in math and science achievement motivated students to learn, reduced the rate of dropouts, and motivated students to major in science (Strevens, 1991). Philippines students were motivated to major in science after they achieved better academic results when using L1 in science learning (Strevens, 1991). On the other hand, using L2 as a language of instruction allowed many students with weak language skills to move away from majoring in science (Strevens, 1991).

The findings of the studies explored above suggest that using the first language as the language of instruction in math and science allows students to participate in the class discussion and apply easily what they learn to their real life.

According to research, using the first language as the language of instruction in math and science raises the students' academic achievement and could in turn motivate students to major in the sciences at universities.

2.4 The Third theme: Factors Affecting the Success of Immersion Programs in Raising Students' Academic Achievement

This section reviews literature that discusses two main factors which control the success of immersion programs of bilingualism in raising the students' academic achievement. Immersion program is a method of applying bilingualism in a way that involves learning in two languages (L1 and L2). Literature identifies three types of bilingualism: non-balanced bilingualism, balanced bilingualism, and advanced bilingualism.

An immersion program presents methods of teaching in the second language as the medium of classroom instruction. These programs work on developing bilingualism, developing the learners' second language proficiency in addition to his first language. The success of immersion programs in math and science learning is related to two main factors: the learner's language proficiency in L1 and L2, and the time of immersion program (whether it is early or late). Another factor which affects in the successful of immersion programs would be the degree of linguistic homogeneity of L1 and L2. When the learners' first language and second languages have a high linguistic homogeneity, a quick replacement between the learners' first language and the second language takes place (Fishman, 1966; Veltman, 1983). On the other hand, when the students' linguistic assimilation is not proceeding rapidly enough to follow up with the scientific and math curricula, high dropout rates have

been observed due to the language difficulties faced in math and science classrooms (Ridge, 1981; Baron, 1991; Berrol, 1995; Stein, 1986).

The first main factor affecting the academic results of students following immersion programs is the students' level of language proficiency. The levels of language proficiency of L1 and L2 are leading to three different types of bilingualism and different academic results as well. The unbalanced bilingualism is the case when students still do not attain the proficiency in one of these languages (Hakuta, 1987). Balanced bilingualism is the case when students attain the language proficiency in L1 and L2 (Ríordáin & O'Donoghue, 2009). Advanced bilingualism is applied when students are studying in the second language and working to achieve the proficiency in L1 simultaneously (Bankston & Zhou, 1995).

The effects of each type of bilingualism on the students' achievement in math and science vary. Several studies on unbalanced bilingualism (where students were in the process of becoming bilinguals) were conducted to test its effect on the students' academic achievement. Low academic achievement resulted in tests examining the creativity of thinking of unbalanced bilinguals in Singapore (Torrance, Gowan, Wu, & Aliotti, 1970). Similar results were reported in math achievement for unbalanced Chinese bilinguals (Gowan & Torrance, 1965; Curtis & Millar, 1988).

Several studies compared the academic achievement of students studying in the first language to those studying in the second language. The academic achievement of L1 students is revealed to be higher than that of unbalanced bilingual students who are not proficient in the second language used in instruction (Peal & Lambert, 1962; Mouw & Xie, 1999). Similar results were obtained when comparing the performance of secondary monolingual British students to that of unbalanced bilingual Asian students in performing basic scientific applications in a study

conducted in the UK (Curtis & Millar, 1988). Mono-lingual British students achieved higher results in these tests since they offered more scientific ideas and explained applications related to their real life more fluently than bilingual Asian students (Curtis & Millar, 1988). Researchers clarified that low achievement of Asian students did not indicate a difficulty in understanding science, but it showed a difficulty in learning and expressing scientific ideas in the second language (Curtis & Millar, 1988).

Moreover, it was shown that students learning two languages would experience “mental confusion” of learning a second language which hinders their academic progress (Saer, 1922, 1923; Smith 1923). The degree of intelligence of native speakers was found to be higher than that of unbalanced bilinguals in standardized tests (Darcy, 1953; MacNab, 1979) but other researchers have argued about the validity of these studies since they had no controlling variables on the socio-economic status of the sample (Xie & Mouw, 1999).

Referring to the other type of bilingualism, balanced bilingualism, positive results on the students' academic achievement were observed. Balanced bilingualism supplied the child with fluency in expressing his/her thoughts and critical thinking skills to cognitively develop his/her academic potentials. This implied that bilingual students would be mastering L1 as well as L2. It was revealed that a relationship existed between learning a second language in early childhood and divergent thinking skills (Cummins & Gulutsan, 1974). Also a positive relationship was shown between balanced bilingualism and students' cognitive achievement and their ability to analyze and solve complex problems (Hakuta & Diaz, 1985). Lambert (1990) stressed that balanced bilingual students had a stronger memory than those who were monolingual. The results of the academic achievement of balanced bilinguals were

proved to be almost the same as that of students studying in L1 (Swain & Lampkin, 1982). The positive effect of balanced bilingualism on the cognitive perspective of academic achievement was accomplished by inducing cognitive development of bilingual students who can switch easily between two linguistic mediums (Cummins, 1977; Peal & Lambert, 1962). A study conducted in Main Land Puerto Rico which examined the effects of studying in the second language on the cognitive abilities of kindergarten and first grade students showed positive correlations between balanced bilingualism and students' cognitive ability (Hakuta, 1987).

Explanations for positive results of balanced bilingualism included cognitive flexibility because balanced bilingual students have two codes for every concept (Xie & Mouw, 1999; Ben-Zeev, 1977; Bialystok, 1988; Duncan & De Avilla, 1979; Lindholm & Aclan, 1991; Willig, 1985). As a result of these studies, balanced bilingualism was considered to have a positive impact on the child's cognitive development (Peal & Lambert, 1962, Cummins, 1979). Other researchers identified some unobservable factors like students' intelligence and motivation to learn the second language which affected also the students' academic achievement (MacNab, 1979; Reynolds, 1991).

The significance and the ability to promote academic excellence of the third type of bilingualism, advanced bilingualism, were emphasized by many studies (Bankston & Zhou, 1995). Excellent results were attained in a study conducted in a Vietnamese high school in New Orleans which examined the effects of students' first language skills on raising their academic achievement (Bankston & Zhou, 1995). One of the studies conducted in Florida presented a negative influence of advanced bilingualism because of a high level of proficiency in English of many students (Portes & Schauffler, 1994). The aim of the study was to examine the level of

English language preference and proficiency of Latin American and Caribbean students. The students' high level proficiency in English created a language gap between the students' language and that of their parents (Portes & Schauffler, 1994). This was due to the parents' slower pace in mastering English. The parents of these students faced difficulties in monitoring their children's academic performance and behavior that was necessary for their academic achievement (Portes & Schauffler, 1994).

The second main factor affecting the academic results of students following immersion programs is the time of the immersion program (whether it is an early immersion program or a late immersion program). Early immersion programs occur when the teaching of math and science in the second language starts in the first and second grade levels. On the other hand, late immersion programs are established when math and science are taught in the first language from grade one till grade 5 then in grade 6 a transition into teaching in the second language takes place. Studies have shown that students in early immersion programs achieved higher grades in mathematics than students studying in their first language (Bournot-Trites & Reeder, 2001; Turnbull, Hart, & Lampkin, 2000; De Courcy & Burston, 2000; Barik & Swain, 1976). Late immersion programs showed a negative influence on achievement math and science (Marsh, 2000). Students belonging to the total immersion program achieved a significant growth in IQ scores and attained good results in functional competence in L1 (Barik & Swain, 1976).

Although most immersion programs had positive effects on the cognitive skills of students, some students were worried about understanding the language of the problem. This distracted their attention and concentration, hindering their ability to solve the problem (Bournot-Trites & Reeder, 2001). Students also faced

difficulties in understanding word problems and expressing the analysis or the answers to these problems when L2 was the language of instruction. Teachers were aware of students' abilities to solve these problems and that the thinking process was occurring in the students' minds in L1 (Bournot-Trites & Reeder, 2001). For this reason teachers had to use simple language to explain word problems and help students express their thoughts. This limited the teachers' choice of different international math and science resources to solve math and science problems.

Successful immersion programs were related to mastering both languages, L1 and L2. Cummins (1976) explains that students should reach the threshold level of L1 and L2 in order for L1 and the students' cognitive development to benefit from L2. The second language had no negative effects on L1 but the two were interdependent in their proficiency. This was explained in the interdependence hypothesis of Cummins (1976) which emphasized the interrelation between the mastery of L1 and L2 and the students' cognitive development.

In Lebanon, a study to check the mastery of students' L1 and L2 in Lebanese schools is needed before suggesting the implementation of such immersion programs. This is due to the difference between L1 taught in schools (Modern Standard Arabic) and the Arabic language practiced by Lebanese in their daily life (Lebanese Arabic). Cummins (2000) differentiated between 'basic interpersonal communicative skills' and their 'cognitive/academic language proficiency' (Cummins, 1979, 2000). Applying early immersion programs in Lebanon would have achieved similar good results and reinforced Cummins' interdependence hypothesis if students in Lebanese schools master modern standard Arabic (which is the first language taught in schools) before entering school. Students in Lebanon use the Lebanese dialect as their first language and not Modern Standard Arabic (Amin, 2009).

Therefore, studying in L2 before the mastery of L1 may not attain positive results in the students' achievement (Cummins, 1976).

According to the results of the studies conducted on the effects of bilingualism on the academic achievement, the differences between types of bilingualism should be taken into consideration. Teaching math and science in the second language in L2 in Lebanese schools would not achieve similar positive results of bilingualism if proficiency in both languages (L1 and L2) wasn't achieved. The difference in the results depends on the students' level of language proficiency. When a bilingual student has a low level proficiency in both languages, negative cognitive effects are detected (Baker, 2001). If the bilingual student achieves a low proficiency in one of the languages (but not in both), no negative or positive influences on the cognitive achievement are recognized (Baker, 2001). Balanced bilinguals who master both languages achieve high results in cognitive and academic achievement (Baker, 2001). This supported the Cummins' Developmental Hypothesis (1979) which assured that the greater the level of proficiency of the students' first language, the stronger the transfer of skills in the students' second language (Dawe, 1983; Clarkson, 1992).

2.5 Summary

The interdependence between math/science and the language of instruction has driven educators to consider the importance of the language of instruction and its effect on students' achievement. Although many scientists believe that the choice of language of instruction has nothing to do with national relatedness (Salman, 1966), there are still many reasons behind using L1 in science and math instruction including relation to origin, greater academic achievement, and ease and clarity in

communication. Some Lebanese would argue that students wouldn't attain similar positive results of academic achievement when L1 was the language of instruction. This is because the first language of students in Lebanon is Lebanese Arabic, and not Modern Standard Arabic which is used as L1 in schools. However, this remains a question for research to answer. The effects of using L1 in math and science in Lebanese schools should be studied in depth. The appropriate language (L1 or L2) should be chosen to allow students to solve different word problems as well as develop critical thinking and reasonable problem solving skills (Clements & Bernard, 2005). A review of literature available has shown that there are positive effects of balanced bilingualism and early immersion programs. However this cannot be so easily applied in the case of Lebanon. The features of the bilingual program applied in Lebanon are similar to those of transitional bilingual education (TBE), which is practiced by the transition of non-English speakers from learning in their native language to learn in L2 and has achieved good results in the United States (Rossell & Baker, 1996). A hypothesis was formulated regarding programs of teaching in Lebanon. The good results of TBE in the United States suggest that teaching in L1 at the elementary stage in Lebanon and then transferring into teaching in L2 might yield better results than implementing early immersion programs. But for TBE to be implemented correctly in Lebanon, students should master first L1 then L2. However, it is debatable whether students in Lebanon do, in fact, master L1. According to the review of literature and to the status of the Lebanese first language, a research study is needed to explore whether using the first language in math and science would yield similar positive results as in other international studies. The next chapter presents the methodology adopted in the current study in order to answer the questions related to the study.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter presents the research design and methods used to achieve the goals set for this study. This chapter describes the sample, population, procedure, instruments used, and data collection method. An approach to data analysis and the measures needed to ensure validity and reliability are also presented. Several data collection means were used to answer the following research questions:

1. To what extent is the math/science achievement of Lebanese students affected by the language of instruction at the elementary level?
2. Would students learning in the first language at the elementary level achieve higher results on questions requiring higher cognitive levels of thinking over students studying in the second language?

The aim of this study is to analyze whether the science and math achievement of Lebanese students, whose first language is Arabic, is influenced by the language of instruction used at the elementary level. This study also aims to assess whether students studying in L1 at the elementary level achieve higher scores on questions requiring higher level thinking than students studying in L2. The research design of this study is a quantitative and comparative research method where the results of achievement tests of two groups of Lebanese students, who learn math and science in L1 and L2, were analyzed and compared. The instruments used to collect data for the study are achievement tests that were constructed for the current study and were administered at selected schools. The tests were constructed in order to cover topics studied by all students and at all three cognitive levels of thinking. This study

examined the science and math achievement of grade 5 and 11 students in a selected sample of six private schools in three different regions of Lebanon: Beirut, Saida, and Nabatieh. The schools sampled included those teaching science and math in the students' first language (Arabic) as well as those teaching these subjects in English at the elementary level. Grade 5 was chosen at the elementary level since it was the last grade level in which L1 students were taught math and science in their first language (Arabic) before transitioning to the second language. Grade 11 students were selected for the test administration because they would have had enough time to adjust to the new language.

3.2 Subjects

3.2.1 Selected Schools

A sample of six schools was selected from three regions of Lebanon: Beirut, Saida, and Nabatieh. All schools are private and of mixed gender schools that worked to meet the requirements of the Lebanese Curriculum. The textbooks used in these schools are the Lebanese National textbooks covering the learning outcomes stated by the Ministry of Education.

In order to control the factors affecting students' achievement, several criteria were used to check the common characteristics of the schools chosen in each region. These criteria were: school location, number of students at the school, number of students per classroom, percentage of non-Lebanese students, teaching resources, students' averages and proficiency in reading and comprehension (of the language of instruction), as well as their scientific, and mathematical literacy averages. The students' reading and comprehension averages would allow for controlling the variable of the level of proficiency in the language of instruction.

A paired sampling of groups of schools was done. Each school principal was interviewed to collect information about the school characteristics. The list of questions of the interview is included in Appendix A. The selected schools were either located in an urban area or a rural area. Both groups of L1 and L2 schools were matched on the basis of having either more than 1000 students or less than 1000 students in the school and either more or less than 25 students per classroom. The percentage of non-Lebanese students in selected schools was less than ten percent. Both schools had at least three of the four teaching resources available. These are: library, labs, Internet access, and a special education department. Having a special education department at the school helped in identifying the special students (whether they had language difficulties or were slow learners) and excluding their tests from the study.

In both Beirut and Nabatieh, a paired sampling of groups of students was done. Paired sampling was achieved by choosing pairs of groups of students from schools with similar characteristics except for their language of instruction at the elementary level. In Beirut, one school (S1-L1) whose students received math and science instruction in L1 and another school (S1-L2) whose students received instruction in L2 participated in the study. Similarly in Nabatieh, the selected school (S2-L1) taught math and science in L1 and the other school (S4-L2) whose students received instruction in L2 participated in the study. A paired sampling was planned in Saida, but the schools (S2-L1, S3-L1) teaching in L1 cancelled their participation in the study. These schools did not have spare time to allow their students (especially Grade 11) to take the test. In Saida, two schools (S2-L2 and S3-L2) teaching math and science in L2 at the elementary level participated in the study.

Every school had one or more sections at each of the grade levels, but both math and science were taught by the same teacher. School S1-L1, the school teaching in the first language at the elementary level located in Beirut, had 5 sections at grade 5 and one section at grade 11. School S2-L1, the school teaching in L1 and located in Nabatieh, had two sections at grade 5 and two sections at grade 11. School S1-L2, the L2 school located in Beirut, had one section at each of grade 5 and grade 11. School S2-L2, the second selected L2 school which was located in Saida, had three sections at grade 5 and two sections at grade 11. School S3-L2, the third selected L2 school located in Saida had three sections of grade 5. Grade 11 students of this school did not participate in the study. Finally, school S4-L2 had two sections at each of grade 5 and grade 11.

3.2.2 Participants

All selected students were born in Lebanon from Lebanese parents. They used the Lebanese dialect in communicating with their family members and peers. Moreover, the selected students were those who had been living in Lebanon for more than five years.

A questionnaire (Appendix B) was completed by each student before taking part in the test administration. The students' answers to this questionnaire highlighted their nationality and first language. The information collected included: country of birth, parents' nationality, language used with family members and peers, and number of years spent in Lebanon. Only students who were Lebanese and whose first language was Arabic were included in the study. Also this questionnaire helped in identifying the language of math/science instruction received by all students (5 and 11 graders) at the elementary level. Identifying the language of instruction at the

elementary level of grade 11 students served in assuring that all selected grade 11 students in L1 schools learned math/science in L1 at the elementary level, and that those in L2 schools learned in L2 at the elementary level.

The total sample was 525 students. The overall number of students in the group of schools having the first language as the language of instruction was 219. 151 students were in grade 5 and 68 students in grade 11 at L1 schools. The number of students in the other group receiving instruction in the second language of English was 306; 217 of those were in grade 5 and 89 students in grade 11 at L2 schools. Table 1 provides the distribution of grade 5 students across sections at every school and in the groups of schools.

Table 1:
Number of grade 5 students in each section of each school

School	Location	Section	No. of Students in the Section	Total No. of Students in School
S1-L1	Beirut	A	23	
		B	23	
		C	24	116
		D	23	
		E	23	
S2-L1	Nabatieh	A	17	35
		B	18	
S1-L2	Beirut	A	25	25
		A	24	
S2-L2	Saida	B	24	72
		C	24	
		A	23	
S3-L2	Saida	B	24	72
		C	25	
		A	24	
S4-L2	Nabatieh	B	24	48
Total L1 Schools	Beirut-Nabatieh	-	-	151
Total L2 Schools	Beirut-Saida-Nabatieh	-	-	217
All L1 and L2 Schools				368

School represents the selected school.

Location represents the location of school, whether it is located in Beirut, Saida, or Nabatieh.

Section represents the section(s) of the grade level in the specified school depending on the school's number of sections.

No. of students in the Section represents the number of students found in the indicated section of grade 5.

Total No. of Students is the number of participants of grade 5 from each type of school indicated.

S1-L1 represents the first selected school teaching in the first language at the elementary level and located in Beirut.

S2-L1 represents the second selected school teaching in the first language at the elementary level and located in Nabatieh.

S1-L2 represents the first selected school teaching in the second language at the elementary level and located in Beirut.

S2-L2 represents the second selected school teaching in the second language at the elementary level and located in Saida.

S3-L2 represents the third selected school teaching in the second language at the elementary level and located in Saida.

S4-L2 represents the forth selected school teaching in the second language at the elementary level and located in Nabatieh.

A stands for the first section of grade 5 at the specified school.

B stands for the second section of grade 5 at the specified school.

C stands for the third section of grade 5 at the specified school.

D stands for the forth section of grade 5 at the specified school.

E stands for the fifth section of grade 5 at the specified school.

Total L1 Schools represent all of the schools teaching in the first language at the elementary level.

Total L2 Schools represent all of the schools teaching in the second language at the elementary level. All L1 and L2 Schools stand for both types of schools, schools teaching in the first and second language at the elementary level.

Table 2:

Number of grade 11 students in each section of each school

School	Location	Section	No. of Students in the Section	Total No. of Students in School
S1-L1	Beirut	A	32	32
S2-L1	Nabatieh	A	18	36
		B	18	
S1-L2	Beirut	A	24	24
S2-L2	Saida	A	17	35
		B	18	
S3-L2	Saida	-	-	-
S4-L2	Nabatieh	A	15	30
		B	15	
Total L1 Schools	Beirut-Nabatieh	-	-	68
Total L2 Schools	Beirut-Saida-Nabatieh	-	-	89
All L1 and L2 Schools				157

School represents the selected school.

Location represents the location of school, whether it is located in Beirut, Saida, or Nabatieh.

Section represents the section(s) of the grade level in the specified school depending on the school's number of sections.

No. of students in the Section represents the number of students found in the indicated section of grade 11.

Total No. of Students is the number of participants in grade 11 from each type of school indicated.

S1-L1 represents the first selected school teaching in the first language at the elementary level and located in Beirut.

S2-L1 represents the second selected school teaching in the first language at the elementary level and located in Nabatieh.

S1-L2 represents the first selected school teaching in the second language at the elementary level and located in Beirut.

S2-L2 represents the second selected school teaching in the second language at the elementary level and located in Saida.

S3-L2 represents the third selected school teaching in the second language at the elementary level and located in Saida.

S4-L2 represents the forth selected school teaching in the second language at the elementary level and located in Nabatieh.

A stands for the first section of grade 11 at the specified school.

B stands for the second section of grade 11 at the specified school.

C stands for the third section of grade 11 at the specified school.

D stands for the forth section of grade 11 at the specified school.

E stands for the fifth section of grade 11 at the specified school.

Total L1 Schools represent all of the schools teaching in the first language at the elementary level.

Total L2 Schools represent all of the schools teaching in the second language at the elementary level.

All L1 and L2 Schools stand for both types of schools, schools teaching in the first and second language at the elementary level.

3.3 Procedure

The data collection started by administering achievement tests to grade 5 and 11 students at every school. But before that, a short questionnaire was completed by all students. An English version (Appendix B) and an Arabic version (Appendix C) of this questionnaire were completed by students who were studying in L1 and L2 at the elementary level. Non- Lebanese students and Lebanese students having a first language other than Arabic were excluded from the study and their achievement tests were not considered.

The achievement tests were administered in the six schools to grades 5 and 11 students on different dates between the end of April 2013 and the beginning of May 2013. At L1 schools (S1-L1 and S2-L1), grade 5 students administered T1'and T2', and grade 11 administered T3 and T4 achievement tests. At L2 schools (S1-L2, S2-L2, S3-L2, and S4-L2), grade 5 students administered T1 and T2, and grade 11 administered T3 and T4. All participants had the same test duration (forty-five minutes).

3.4 Instruments

The instrument used to collect the quantitative data to answer the research questions was an achievement test in each of math and science. The math and science achievement tests were designed for grade 5 and grade 11 students. All students of the selected groups were receiving English as the language of instruction in science and math at the intermediate and the secondary levels. For this reason, the language of instruction used in all achievement tests of grade 11 was English. Six achievement tests were designed: a grade 5 English science achievement test (**T1**) (**Appendix D**), a grade 5 Arabic version of the science achievement test (**T1'**) (**Appendix E**), a

grade 5 English math achievement test (**T2**) (**Appendix F**), a grade 5 Arabic version of the math achievement test (**T2'**) (**Appendix G**), a grade 11 English science achievement test (**T3**) (**Appendix H**), and a grade 11 English math achievement test (**T4**) (**Appendix I**). **T1** and **T2** were translated to Arabic since grade 5 students at L1 schools receive instruction in Arabic, while **T3** and **T4** were not translated since all grade 11 students at L1 and L2 learn math and science in English. **T1**, **T2**, **T3**, and **T4** were administered in schools using L2 (English) as the language of instruction at the elementary level. **T1'**, **T2'**, **T3**, and **T4** were administered in schools using L1 (Arabic) as the language of instruction at the elementary level.

The following steps were followed to design the achievement tests.

3.4.1 Preparing the list of objectives

The first phase involved preparing the list of science and math objectives for the achievement tests for grade 5 and 11. The objectives from the Lebanese curriculum were used to align the test items since the selected schools in the study were receiving instruction to meet the requirements of the Lebanese program required by the Ministry of Education. But due to the differences in the students' needs, teachers' preparation and pace in the science and math classes' teachers, at every school was at a different point in the curriculum. Another factor was the implementation date of the achievement tests during the academic year. Schools in Lebanon have different academic calendars. Many schools end their academic year in the middle of May while others do at the end of June. Because a list of common test objectives for every achievement test was required, the list of covered math and science objectives in grade 5 and grade 11 were collected from all of the selected schools. The overlapping objectives across schools and the Lebanese curriculum for

each of the considered grade levels were selected and used to construct achievement tests for both grade levels that would be appropriate for all schools.

The list of math and science tests' objectives of Grade 5 and 11 which were to be covered by the date of administration of the achievement tests were collected from each school. A check list of all the science and math objectives from the Lebanese curriculum for both grade levels was prepared. The objectives in common became the list of objectives for the achievement tests.

3.4.2 Designing six achievement tests

The second phase included designing the science and math achievement tests in addition to a questionnaire to be answered by the students before the exam. An English version (Appendix B) and an Arabic version (Appendix C) of this questionnaire were prepared. The Arabic version was attached to the test packet of grade 5 students studying in L1. The English version was attached to the test packet of grade 5 students studying in L2 and to that of all students of grade 11. The grade 5 English science achievement test (**T1**) and grade 5 English math achievement test (**T2**) were developed by grade 5 Science and math teachers who did not teach at any of the selected schools. Grade 11 science achievement test (**T3**) was divided into three separate parts: biology, physics, and chemistry similar to what was required by the Lebanese curriculum. The biology part, physics part, and the chemistry part were designed by a biology teacher, a physics teacher, and a chemistry teacher respectively (Grade 11 teachers). These three parts formed the science achievement test of Grade 11 (**T3**). The grade 11 math achievement test (**T4**) was designed by a math teacher who teaches grade 11. All participating teachers who designed the test items were specialists in the content area addressed. They were teaching at other

schools that were not part of the study and that had programs similar to the ones studied.

The grade 5 Arabic science achievement test (**T1'**) was prepared by translating T1 into Arabic by a grade 5 science coordinator who taught science in Arabic. Similarly, the grade 5 Arabic math achievement test (**T2'**) was prepared by translating T2 into Arabic by a grade 5 math teacher who taught math in Arabic. The duration of each achievement test was forty-five minutes.

The language of the six achievement tests was checked and evaluated in order to control the language of the tests from affecting the results. The level of language of the achievement tests was evaluated by three coordinators: an English coordinator at the elementary level, an English coordinator at the secondary level, and an Arabic coordinator at the elementary level. The elementary English coordinator evaluated the level of language of T1 and T2 which were in English. The elementary Arabic coordinator evaluated the level of language of T1' and T2' which were in Arabic. The secondary English coordinator evaluated the language level of T2 and T4 which were in English. According to their evaluations, the level of the language for each of the six achievement tests was appropriate.

All the test items designed were multiple choice questions since they are considered to be versatile, reliable and valid for the following reasons. Multiple choice questions were used to assess various levels of learning outcomes, from basic recall to application, analysis, and evaluation, and are scored objectively free from infer rater reliability issues. Multiple choice questions can focus on a relatively broad representation of course material, thus increasing the validity of the assessment. Test items were designed to test three different cognitive levels of thinking (**C1**, **C2**, and **C3**). The number of items assessing each cognitive level for each achievement test is

listed in Table 3. The first cognitive level (**C1**) test items reflect the basic level of thinking: the ability to remember and understand. Remembering involved recalling, recognizing, listing, describing, retrieving, naming, and finding information. Understanding included explaining, interpreting, summarising, paraphrasing, and classifying ideas or concepts (Madaus, G. F., Woods, E. M., & Nuttall, R. L., 1973).

The second cognitive level (**C2**) items examined students' ability to apply and analyze. Applying included using, implementing, carrying out, executing, and using information in another familiar situation. Analyzing involved the breaking of information into parts to explore understandings and relationships, comparing, organizing, deconstructing, interrogating, and finding relations between concepts (Madaus, G. F., Woods, E. M., & Nuttall, R. L., 1973).

The third cognitive level (**C3**) items assessed the students' ability to evaluate and synthesize. Evaluating included justifying a decision or course of action, checking, hypothesising, critiquing, experimenting, and judging. Synthesizing examined the students' ability to generate new ideas, products, or ways of viewing things, to design, construct, plan, produce, and to invent new ideas (Madaus, G. F., Woods, E. M., & Nuttall, R. L., 1973).

Table 3:

Number of Items of T1, T2, T3, and T4 in Each Cognitive Level (C1, C3, and C3)

Achievement Test	Subject	Number of Test Items			Total
		C1	C2	C3	
T1/T1'	Science	5	12	4	21
T2/T2'	Math	5	5	5	15
T3	Biology	3	3	2	19
	Chemistry	2	2	1	
	Physics	2	2	2	
T4	Math	3	4	3	10

(T1/T1' is Grade Five Science Achievement Test)

(T2/T2' is Grade Five Math Achievement Test)

(T3 is Grade Eleven Science Achievement Test)

(T4 is Grade Eleven Math Achievement Test)

C1 is the first cognitive level of thinking

C2 is the second cognitive level of thinking

C3 is the third cognitive level of thinking

Total is the total number of test items

3.4.3 Piloting achievement tests

The third phase was piloting the achievement tests. A group of 20 students from grade 5 and 11 was selected from each region of the study (Beirut, Saida, and Nabatieh) and sat for the math and science achievement tests (T1, T2, T3, T4, T1', and T2'). The schools involved in the pilot were not involved in the study but were in alignment with the requirements of the Lebanese curriculum. Several changes in the language of test items and the test duration were implemented as a result of the piloting procedure. The modified achievement tests were the ones used at the selected schools for data collection.

3.4.4 Validity and Reliability

The validity of the designed achievement instrument was achieved for both content and external validities. Content validity was achieved in this study since the test items assessed the objectives highlighted by the research questions and that were in direct alignment with the Lebanese curriculum for the respective grade level and school curriculum. Three sets of test items were designed; each set was testing a

specific cognitive level of thinking to investigate whether L1 students achieved higher scores in questions requiring higher cognitive level thinking than L2 students. These tests were designed by teachers and coordinators who were experts in teaching the same content to students of the respective grade levels to insure the appropriateness of the content of the instruments. These teachers were knowledgeable about the significance and the procedure of designing test items at different levels of thinking. Translation of test items to Arabic was done by teachers who were already using Arabic as a language of instruction in teaching and assessing their students. Thus, content validity was achieved. External validity of the study was achieved since the instrument designed can be used to test the achievement of all students enrolled in Lebanese schools following the requirements of the Lebanese curriculum. Moreover, the selected sample represented the population, since the study was conducted in three different areas of Lebanon: a rural area (Nabatieh), an urban area (Saida), and in the capital (Beirut).

In order to ensure good reliability measures, the following steps were taken. The final version of the instrument was piloted with encouraging results. Piloting took place to ensure that the test items were accessible and clear and that the time allotted for the test was appropriate. Results indicated that the instrument can be applied to a spectrum of students having similar characteristics. All the tests administered were proctored by the same number of teachers and in the presence of the researcher to make sure that no distractors existed. Tests were administered at the same time of the day in all schools, making sure that test conditions were the same. Objective scores resulted since multiple choice question items were used. The cognitive level for every test item was specified by two judges. Both judges were knowledgeable about the different cognitive levels and were experts in designing and

evaluating science and math exams. They agreed on the classification of the test item in three cognitive levels of thinking with a percentage agreement of 90%. Negotiations related to the different classification of some test items between both took place and they agreed on the assigned cognitive level of those test items. Language specialists evaluated the level of language proficiency of the test items to be appropriate.

3.5 Data Analysis Method/ Framework and Procedure

The results of the achievement tests were analyzed as follows:

3.5.1 Analysis of the exercises of the books used

The books used by the selected schools are the Lebanese national books that are assigned by the Ministry of Education. Some schools used additional resources, but the Lebanese National books were the main books used by these schools. One lesson was selected from every science/math book (for grade 5 and 11) and the lesson's exercises (**Appendices J, L, N, P, R, and T**) were classified into three cognitive levels of thinking. The percentages of each of the three levels were calculated. The main aim of analyzing the exercises from the Lebanese National books was to check the cognitive level of thinking the students were practicing. This will help explain the results students achieve at the different cognitive levels of the achievement tests.

3.5.2 Grading the achievement tests for each school

The students' tests were scored and data for each school was compiled in Excel spread sheets. Answers for each of the items were recorded. One point was

awarded for a correct response while zero points was awarded for an incorrect answer one.

The tests for each of the schools were corrected and the percentage score of each of the cognitive levels (C1, C2, and C3) was calculated for each student. The overall score on the test for each student was calculated. The percentages of the scores (his/her C1, C2, C3, and total score) of each student were calculated.

3.5.3 Calculating the Scores of Each Group of Schools

As mentioned before, schools under study were divided into two main groups at each grade level. Grade 5 participants were divided into two main groups: the first group (L1 students) included all the students learning science and math in the first language (L1) at the elementary level and the second group (L2 students) included all the students learning math and science in the second language (L2). Likewise grade 11 students were divided into an L1 group and an L2 group of students. The mean values of each of the math and science achievement tests were calculated for grade 5 and 11 of both groups of students. The mean values of the scores of each category of math and science questions for each of the cognitive levels were calculated for both groups of students.

3.5.4 Comparing the calculated mean values of each group of schools

A series of one way ANOVAs (analysis of variance) to compare the mean values of science and math tests of L1 and L2 groups of students was performed. This method served in analyzing the mean values of each test and cognitive level of thinking by measuring the difference between these values and comparing them to a critical value. Results demonstrate whether there is a significant relationship between

the language of instruction at the elementary level and the students' performance on math and science achievement tests.

A two way ANOVA comparing the students' performance at the three cognitive levels of thinking for both groups of L1 and L2 was conducted. Results investigated whether the relationship between the three values of the three cognitive levels of each group, and between those levels across the group is significant. Moreover, results would show whether there is a significant relationship between the language of instruction at the elementary level and the students' performance in the three cognitive levels of thinking in math and science. This comparison helped in deciding whether the language of instruction was hindering their achievement in items requiring high cognitive levels of thinking at each grade level. This procedure of data analysis was applied to the results of both achievement tests (math and science).

3.6 Summary

This chapter presented a detailed explanation of the research design and method used to collect and analyze data. A quantitative approach was used to examine the effects of teaching math and science in the first language (Arabic) at the elementary level on students' achievement. For this reason, math and science achievement tests were designed to be administered to students at both the elementary and secondary levels. The results of the tests of 11 graders were compared to check those that scored higher (students who used to study in L1 or those who used to study in L2 at the elementary level). Another aim of the study was to check who would score higher in solving problems of high cognitive level. For

this reason, test items of different cognitive levels were designed and piloted by a group of students.

The next chapter presents the results of the analysis of the math and science achievement tests administered and the interpretation of the data collected.

CHAPTER FOUR

DATA ANALYSIS

4.1 Introduction

This chapter presents the results of the math and science achievement tests administered in each of the selected L1 and L2 students. First, the analysis of the Lebanese math and science text books used by grade 5 and grade 11 students is presented. Then, it follows the analysis of the results of the science and math achievement tests which were administered to grades 5 and 11 at L1 and L2 schools.

The book exercises for a specific lesson from the book for each subject were selected. Math and science teachers at each of grade 5 and 11 were asked to classify the book exercises according to the cognitive level of thinking that each exercise addresses. The percentages of exercises belonging to each category of cognitive level of thinking were calculated for each subject. The percentages of C1, C2, and C3 exercises were used to identify the cognitive levels of exercises that the students are used to solve and to help in interpreting the results of the administered tests at each grade level.

Science and math achievement tests were administered in schools teaching these subjects in Arabic at the elementary level (S1-L1 and S2-L1) and in those teaching in English (S1-L2, S2-L2, S3-L2, and S4-L2). The tests were corrected and scored. Data was collated by recording the statistics of each school on an excel sheet. The score of every test item in the multiple choice test for each student was recorded. The C1, C2, and C3 items were corrected and their scores were computed for later data analysis and interpretation. The percentage of each value of scores was also calculated. The values of the average of scores (mean value) and the standard

deviation (S.D) related to C1, C2, C3, and total test scores were then calculated for each school. The calculated means of the groups of schools were compared to decide on the effectiveness of the language of instruction using the analysis of variance statistical method (ANOVA).

4.2 The Levels of Questions in Lebanese Text Books

This analysis provides identification of the cognitive levels of the exercises that Lebanese national text books address. Moreover, it also allows for interpretation of the students' results for each of the administered tests. According to the ECRD (1997), the Lebanese curriculum general objectives state that Lebanese students are expected to master the skills needed to apply what they learn in schools to any real life situation. This requires the development of different cognitive levels of thinking to enable students to recall what they learned, apply it in similar situations, and come up with a new approach to solve different types of problems. For Lebanese students to master these skills, they should be taught to solve exercises at different levels of thinking in order to be able to apply the acquired concepts in real life situations. The Lebanese books assigned by the Ministry of Education and in the hands of Lebanese students and teachers in our schools should therefore be offering such exercises. An analysis of the exercises provided in the Lebanese national books is performed in this section.

An analysis of the levels of exercises of the Lebanese science grade 5 book, math grade 5 book, science books of grade 11 (Biology, Physics, and Chemistry), and the math book of grade 11 was done. The teacher of each subject classified the exercises of one lesson into first, second, and third cognitive levels of thinking (C1, C2, and C3).

4.2.1 Science book of grade 5

The chapter about “Plants” was selected from the grade 5 science text book since the objectives of this chapter were covered by all of the selected schools. The exercises (**Appendix J**) in this chapter were classified into three main cognitive levels of thinking by a grade 5 science teacher. Based on the teacher’s classification of the science exercises for this lesson (**Appendix K**), the percentages of C1, C2, and C3 questions were calculated and listed in Table 4.

Table 4:

The Percentages of Grade 5 Science Exercises belonging to each cognitive level of thinking.

Exercises	Percentage of Exercises		
	C1	C2	C3
Grade 5 Science Exercises	50%	50%	0%

Percentage of Exercises is the percentage of exercises in the lesson

Exercises are the types of the classified exercises

Grade 5 Science Exercises are the exercises of the selected science lesson (Plants)

C1 is the first cognitive level of thinking

C2 is the second cognitive level of thinking

C3 is the third cognitive level of thinking

According to the results displayed in Table 4, 50% of the lesson exercises assessed the first cognitive level of thinking and the other 50% assessed the second cognitive level of thinking. This result revealed that the exercises in the science book of grade 5 are mainly of two cognitive levels (the first and the second). Some exercises assess the knowledge of the students and their ability to memorize information like the first and second exercises. In these exercises, the students had to recall the definition and the characteristics of plants that they have studied. The rest of the exercises were application questions that assessed the ability of the students to apply the rules they learn in the lesson to very similar situations. The third cognitive level questions are not included in these science text books.

4.2.2 Math book of grade 5

The lesson selected from the grade 5 book is “Subtraction of Fractions”. The exercises for this lesson (**Appendix L**) were classified by a grade 5 math teacher into three cognitive levels of thinking (**Appendix M**). The percentages of each category of exercises were calculated and presented in Table 5.

Table 5:

The Percentages of Grade 5 Math Exercises Belonging to each Cognitive level of thinking

Exercises	Percentage of Exercises		
	C1	C2	C3
Grade 5 Math Exercises	33.3%	41.7%	25%

Percentage of Exercises is the percentage of exercises in the lesson

Exercises are the types of the classified exercises

Grade 5 Math Exercises are the exercises of the selected math lesson (Subtraction of Fractions)

C1 is the first cognitive level of thinking

C2 is the second cognitive level of thinking

C3 is the third cognitive level of thinking

According to the results shown in Table 5 most (41.7%) of the math lesson exercises measured the second levels of thinking. Exercises assessing the first cognitive level of students’ thinking constitute 33.3% of the exercises. 25% of the math exercises measure the third cognitive level of thinking.

4.2.3 Science book of grade 5

The science content of grade 11 is divided into three main subjects: biology, chemistry, and physics.

One lesson, “The Diversity of Organisms and The Uniqueness of the Individual” of the grade 11 biology book was selected to evaluate the level of its exercises. The exercises (**Appendix N**) of this lesson were classified into three cognitive levels by a secondary biology coordinator. The results of the classification of these exercises (**Appendix O**) allowed the calculation of the percentages of

exercises testing each cognitive level of thinking (Table 6). Similarly, one lesson of each of the chemistry and physics books was chosen and its exercises were classified by a secondary chemistry teacher and a secondary physics teacher respectively. The exercises of the chemistry lesson chosen titled “Redox reactions” (**Appendix R**), and that in physics titled “Musical Sound- Waves” (**Appendix P**) were classified. After classifying the exercises of each lesson (**Appendix S** and **Appendix Q**), the percentages of categories of levels of thinking were calculated and presented in Table 6. Table 6 shows the percentages of C1, C2, and C3 questions in each of the biology, chemistry, and physics lessons. It also presents the overall percentages of the science exercises of grade 11.

Table 6:

The Percentages of Grade 11 Science Exercises Belonging to each Cognitive level of thinking

Exercises	Percentage of Exercises		
	C1	C2	C3
Grade 11 Biology Exercises	53.3%	33.3%	13.3%
Grade 11 Physics Exercises	60%	13.3%	26.7%
Grade 11 Chemistry Exercises	23%	61.5%	15.5%
Total	45.43%	36%	18.5 %

Percentage of Exercises is the percentage of exercises in the lesson

Exercises are the types of the classified exercises

Grade 11 Biology Exercises are the exercises of the selected Biology lesson

Grade 11 Physics Exercises are the exercises of the selected Physics lesson (Waves)

Grade 11 Chemistry Exercises are the exercises of the selected Chemistry Lesson (Redox Reactions)

Total is the total science exercises of grade 11 (Biology, Physics, and Chemistry)

C1 is the first cognitive level of thinking

C2 is the second cognitive level of thinking

C3 is the third cognitive level of thinking

According to the results shown in Table 6, 53.3% of the biology exercises in the lesson tested the first cognitive level of thinking. The exercises assessing the second cognitive level of thinking constitute 33.3% of the biology lesson exercises. On the other hand, the exercises evaluating the third cognitive level of thinking constituted only 13.3% of the biology lesson exercises. It also shows that 60% of the

physics lesson exercises addressed the first cognitive levels of thinking. The percentage of C2 and C3 physics exercises in the lesson is 13.3% and 26.7% respectively. While for the chemistry lesson exercises, most of those (61.5%) measured the second level of thinking, as they require the students to apply the rules they learned to balance different Redox reactions in different media. Exercises testing the first levels and the third levels of thinking constituted 23% and 15.5% respectively of the lesson exercises.

4.2.4 Math book of grade 11

The lesson chosen from the math book of grade 11 is “Calculation on Polynomials”. The exercises for this lesson were classified (**Appendix T**) by a secondary math teacher. The results of the teacher’s classification (**Appendix U**) allowed the calculation of the percentages of exercises for each category, displayed in Table 7 below.

Table 7:
The Percentages of Grade 11 Math Exercises Belonging to each Cognitive level of thinking

Exercises	Percentage of Exercises		
	C1	C2	C3
Grade 11 Math Exercises	27.59%	58.62%	13.79%

Percentage of Exercises is the percentage of exercises in the lesson

Exercises are the types of the classified exercises

Grade 11 Math Exercises are the exercises of the selected Math lesson

C1 is the first cognitive level of thinking

C2 is the second cognitive level of thinking

C3 is the third cognitive level of thinking

The results of Table 7 show that the percentage of exercises assessing the first and the second cognitive levels of thinking are more in number in the book than exercises assessing higher levels of students’ thinking.

4.3 Science and Math Achievement for Grade 5 of L1 and L2 Students

Science and Math achievement tests were administered to grade 5 in each of L1 and L2 schools, except for one school in the group of L2 schools (it was administered to grade 5 only). That was because the principal of the secondary section of this school had cancelled their participation in the study. 145 students of grade 5 sat for a science achievement test in Arabic (T1'), since Arabic is the language of instruction in these schools (S1-L1 and S2-L1). 74 grade 5 students took the same achievement test but in English (T1), since they study science in English (S1-L2, S2-L2, S3-L2, and S4-L2). A math achievement test was administered at the same schools, but on a different date, so the number of participants was not the same as that of the science achievement tests (due to several absences). In L1 schools, 151 students took the math achievement test (T2') in Arabic, the language of instruction at these schools. 70 students sat for the math test (T2) in English (L2). The scores of participants from Saida schools (S2-L2 and S3-L2) were excluded from the data analysis, after L1 schools in Saida cancelled their participation at the last minute.

The total scores of the science achievement tests (T1 and T1') and those of math (T2 and T2') in each of the considered schools (S1-L1, S2-L1, S1-L2, and S4-L2) are represented in Table 8 below. The math and science achievement tests contained questions related to the three different cognitive levels of thinking, C1, C2, and C3, whose scores are also presented in the Table 8.

Table 8

The Results of Grade 5 Science and Math Achievement tests in L1 and L2 Schools

School	Location	Science			Math				
		Total	%C1	%C2	%C3	Total	%C1	%C2	%C3
		Score				Score			
S1-L1	Beirut	47%	63%	45%	31%	57%	53%	57%	62%
S2-L1	Nabatieh	44%	58%	43%	30%	53%	73%	50%	40%
S1-L2	Beirut	29%	32%	30%	22%	54%	64%	48%	51%
S4-L2	Nabatieh	29%	18%	36%	18%	39%	63%	36%	24%

School represents the school selected.

Location represents the location of the school.

Science presents the scores of grade 5 science achievement tests in each school in grade 5.

Math presents the scores of grade 5 math achievement tests in each school in grade 5.

S1-L1 represents the first school selected teaching in the first language at the elementary level which is located in Beirut.

S2-L1 represents the second school selected teaching in the first language at the elementary level which is located in Nabatieh.

S1-L2 represents the first school selected teaching in the second language at the elementary level which is located in Beirut.

S4-L2 represents the forth school selected teaching in the second language at the elementary level which is located in Nabatieh.

Total Scores represent the total test score of grade 5 science/math achievement test of the specified school.

% C1 is the students' score in questions of first cognitive level of thinking in the specified school.

% C2 is the students' score in questions of second cognitive level of thinking in the specified school.

% C3 is the students' score in questions of third cognitive level of thinking in the specified school.

According to the results of Table 8, the total science achievement test scores of L1 schools (47% and 44%) are higher than the total scores of L2 schools (29% and 29%). The scores of schools studying in Arabic (S1-L1 and S2-L1) and one L2 school (S1-L2) which was located in Beirut were higher than those of S4-L2.

According to table 8, the scores at all three cognitive levels of thinking of L2 schools were higher than those of L1 schools.

4.3.1 Comparing the results of the total scores of grade 5 science and math achievement tests in students learning in Arabic (L1) and students learning in English (L2)

The results in this and the following section were classified into two groups: the L1 group that includes students studying in Arabic at the elementary level, and the L2 group that includes students learning in English. A series of ANOVAs comparing the mean values and standard deviations of the test scores of both groups of students according to the language of instruction received at the elementary level was performed.

The average mean scores and the standard deviation of L1 and L2 grade 5 students' science achievement test were calculated and presented in Table 9. The p-value is also presented as evidence of whether the difference between the two scores is statistically significant.

Table 9

Results of Grade 5 Science Achievement Test of L1 and L2 Students

The Results of Grade Five Science Achievement Test (T1 and T'1)

Subject	L1 Student		L2 Students		P-Value
	Mean (X)	SD	Mean (X)	SD	
Science	46.0	12.33	28.7	11.61	<0.001

Subject: the subject of the achievement test

Science: the subject of this achievement tests

L1 Students: are students that learn in the first language at the elementary level

L2 Students: are students that learn in the second language at the elementary level

Mean (X): is the mean value of the total scores of the achievement test

SD: is the standard deviation

P-Value: the statistical measurement which indicates whether the difference between mean values of L1 and L2 scores in science achievement test is statistically significant or not

Comparing the mean values of science scores of L1 students and L2 students shown in Table 9, one can notice that the mean value of L1 scores (46.0) is greater than the mean value of L2 scores (28.7). Results showed a significant relationship between the language of science instruction at the elementary level and grade 5 students' performance; $p<0.05$. According to the mean values indicated, a significant

relationship exists between studying science in Arabic and their academic achievement in science at grade 5.

The mean values and the standard deviation of grade 5 math achievement tests of L1 and L2 groups of students are displayed in Table 10 below.

Table 10
Results of Grade 5 Math Achievement Test of L1 and L2 Students

Subject	The Results of Grade Five Achievement Test (T2 and T'2)				P-Value
	L1 Students		L2 Students		
	Mean (X)	SD	Mean (X)	SD	
Math	56.0	24.22	43.3	19.9	<0.001

Subject: the subject of the achievement test

Math: the subject of this achievement tests

L1 Students: are students that learn in the first language at the elementary level

L2 Students: are students that learn in the second language at the elementary level

Mean (X): is the mean value of the total scores of the achievement test

SD: is the standard deviation

P-Value: the statistical measurement which indicates whether the difference between mean values of L1 and L2 scores in math achievement test is statistically significant or not

According to the results shown in Table 10 above, the relation between the language of math instruction and the total test scores of math was statistically significant; $p<0.05$. The mean average scores of L1 students, 56.0 was greater than that of L2 students (43.3) revealing that teaching math in the first language at the elementary level has a positive impact on the fifth grade students' academic performance.

Therefore, the effect of the language of instruction on the science and math achievement of grade 5 students was shown, where students studying math and science in Arabic achieved higher scores than those studying in English.

4.3.2 Comparing the Results of the three Cognitive Levels of Math and Science Grade 5 Achievement Tests

Each of the math and science achievement test contained questions at three different cognitive levels of thinking. The scores of the three categories for grade 5

math and science achievement tests are presented in table 8. The average mean and the standard deviation for the science and math achievement tests of grade 5 L1 and L2 groups of students were calculated and presented in this section.

Comparing the average mean and standard deviation of three cognitive levels for grade 5 science achievement tests of L1 and L2 students are shown in Table 11 below.

Table 11

The Results of the three Categories of questions of cognitive levels of thinking of the Science Achievement Test of L1 and L2 Students

Science	Cognitive Level	The Results of the Cognitive Levels of the Science Achievement Tests of Grade Five				P-Value
		L1 Students Mean (X)	SD	L2 Students Mean (X)	SD	
	C1	62.01	20.23	22.97	19.77	C<0.001
	C2	44.30	15.36	34.23	15.52	L<0.001
	C3	30.70	22.91	19.26	20.50	Int<0.001

Cognitive Level: the subject of the achievement test

C1: the first cognitive level of thinking

C2: the second cognitive level of thinking

C3: the third cognitive level of thinking

Science: the subject of this achievement tests

L1 Students: are students that learn in the first language at the elementary level

L2 Students: are student that learn in the second language at the elementary level

Mean (X): is the mean value of the total scores of each category of cognitive level of thinking of the achievement test

SD: is the standard deviation

P-Value: the statistical measurement which indicates whether the difference between mean values of L1 and L2 scores of the science achievement tests is statistically significant or not

C: is the p-value which is the difference between the mean values of the three cognitive levels within one group of schools

L: is the p-value of the difference between the overall cognitive values of L1 and that of L2

Int: is the p-value of the difference between the interaction between each of the three cognitive levels between the two groups

A series of two-way ANOVAs comparing the mean values of the three cognitive levels of thinking of the two different groups was performed. First, the effect of the language of instruction on the difference in the values of scores of the three cognitive levels in each group of L1 and L2 students was studied. Comparing the mean values of C1, C2, and C3, we see that the difference between these three values was statistically significant, as L1 and L2 students scored relatively higher in C1 questions than C2 and C3.

Secondly, the three values of C1, C2, and C3 of L1 students were compared to those of L2 students. The results of Table 11 showed that the mean values of the three cognitive levels of L1 were higher than those of L2.

Thirdly, the effect of the language of instruction on the students' achievement in science was studied by comparing the values of each cognitive level for each group. According to the results in Table 11, it was shown that there is a significant relationship between studying in Arabic and achieving higher scores on the three cognitive levels of thinking in science. The difference between the values of C1, C2, and C3 of each group was measured and shown in Table 12.

Table 12
The difference between the Values of Cognitive Levels of L1 and L2 Students in Grade 5 Science Achievement Tests

Interaction Between the Cognitive Levels in Grade Five Science Achievement Test of L1 and L2 Students			
C1	C2	C3	
P-Value	<0.001	<0.001	<0.001
C1: the first cognitive level of thinking			
C2: the second cognitive level of thinking			
C3: the third cognitive level of thinking			
P-Value: the statistical measurement which indicates whether the difference between mean values of each cognitive level of C1, C2, and C3 scores between L1 and L2 groups is statistically significant or not			

The results in Table 12 show that studying in Arabic has a significant effect on the students' achievement especially when it involved solving questions requiring higher cognitive levels of thinking in science. The difference between C1, C2, and C3 values of each group of students is statistically significant.

The mean values and the standard deviation of the students' scores on the three cognitive levels of the math achievement tests are present in Table 13.

Table 13

The Results of the three Categories of questions of cognitive levels of thinking of the Math Achievement Test of L1 and L2 Students

The Results of the Cognitive Values of the Math Achievement Test of Grade Five						
Math	Cognitive Level	L1 Students		L2 Students		P-Value
		Mean (X)	SD	Mean (X)	SD	
	C1	57.73	34.62	61.43	22.92	C<0.001
	C2	55.67	29.72	41.14	25.68	L<0.001
	C3	56.62	35.06	27.71	27.93	Int<0.001

Cognitive Level: the subject of the achievement test

C1: the first cognitive level of thinking

C2: the second cognitive level of thinking

C3: the third cognitive level of thinking

Science: the subject of this achievement tests

L1 Students: are students that learn in the first language at the elementary level

L2 Students: are students that learn in the second language at the elementary level

Mean (X): is the mean value of the total scores of each category of cognitive level of thinking of the achievement test

SD: is the standard deviation

P-Value: the statistical measurement which indicates whether the difference between mean values of L1 and L2 scores of the science achievement tests is statistically significant or not

C: is the p-value which is the difference between the mean values of the three cognitive levels within one group of schools

L: is the p-value of the difference between the overall cognitive values of L1 and that of L2

Int: is the p-value of the difference between the interaction between each of the three cognitive levels between the two groups

Results in Table 13 indicate that the mean values of the three cognitive levels in each group of students (L1 and L2) were different, as the values of the first cognitive level in both groups are greater than the values of the second and third cognitive levels of thinking.

The overall students' scores on C1, C2, and C3 questions were compared for the two groups, and the difference between their values was statistically significant, as the values of L1 students were higher than those of L2 students on all of the three levels of questions.

Every mean value of each cognitive level was compared across the two groups. The effect of the language of instruction on the values of the three cognitive levels was shown as L1 students achieved higher values than L2. Table 14 showed

the results of analyzing the differences between the values of each cognitive level of thinking.

Table 14

The difference between the Values of Cognitive Levels of L1 and L2 in Grade 5 Math Achievement Tests

	The Results of the Interaction Between Math G 5/L2 and L1		
	C1	C2	C3
P-Value	0.621	<0.001	<0.001

C1: the first cognitive level of thinking

C2: the second cognitive level of thinking

C3: the third cognitive level of thinking

P-Value: the statistical measurement which indicates whether the difference between mean values of each cognitive level of C1, C2, and C3 scores between L1 and L2 groups is statistically significant or not

According to Table 14, grade 5 students in L1 and L2 grade 5 students achieved close values on questions of the C1 category. On the other hand, the difference between the values of C2 and C3 of L1 and L2 schools was statistically significant and advantageous to L1 students.

4.4 Results of Science and Math Achievement Tests for Grade 11

The grade 11 science achievement test (T3) was divided into three parts: biology, physics, and chemistry, as mentioned in the Lebanese Science curriculum for grade 11. The test was administered to 68 students of L1 schools and 57 students of L2 schools. The grade 11 math achievement test (T4) was administered to 68 students of L1 schools and 54 students of L2 schools. Both achievement tests were in English, since grade 11 students of both groups, L1 and L2, study science and math in the second language (English). The total test scores of T3 and T4 achievement tests for each of the selected schools were represented in Table 15. The results of the three cognitive levels of grade 11 science and math achievement test (T3 and T4) of the schools considered were also presented in Table 15.

Table 15

The Results of Grade 11 Math and Science Achievement Tests (T3 and T4)

School 1	Location	Grade Level	Total Score	Science			Math			
				%C 1	%C 2	%C 3	Total Score	%C 1	%C 2	%C 3
S1-L1	Beirut	11	57%	68%	59%	33%	39%	61%	36%	25%
S2-L1	Nabatieh	11	56%	68%	54%	33%	42%	66%	34%	35%
S1-L2	Beirut	11	43%	58%	32%	28%	31%	36%	35%	21%
S4-L2	Nabatieh	11	53%	67%	54%	24%	47%	64%	47%	35%

School represents the school selected.

Location represents the location of the school.

Science presents the scores of the science achievement tests in each school in grade 11.

Math presents the scores of the math achievement tests in each school in grades 11.

S1-L1 represents the first school selected teaching in the first language at the elementary level which is located in Beirut.

S2-L1 represents the second school selected teaching in the first language at the elementary level which is located in Nabatieh.

S1-L2 represents the first school selected teaching in the second language at the elementary level which is located in Beirut.

S4-L2 represents the forth school selected teaching in the second language at the elementary level which is located in Nabatieh.

Total Scores represent the total test score of the science/math achievement test of the specified school.

% C1 is the students' score in questions of first cognitive level of thinking in the specified school.

% C2 is the students' score in questions of second cognitive level of thinking in the specified school.

% C3 is the students' score in questions of third cognitive level of thinking in the specified school.

According to Table 15, L1 schools scored higher than L2 schools on the overall science test scores for grade 11. The results indicated that L1 schools scored consistently higher than L2 schools on the three cognitive levels of thinking in science. Math results revealed that students at L1 schools did not achieve as well as L2 students in grade 11. Moreover, most of the scores on the three cognitive levels of thinking in math of L1 were better than L2.

4.4.1 Comparing the results of the total scores of grade 11 science and math achievement tests in students learning in Arabic (L1) and students learning in English (L2)

The mean values and the standard deviations of total test scores for grade 11 science for L1 and L2 students were calculated, compared, and presented in Table 16. The difference between the mean values of their scores was measured.

Table 16

Results of Grade 11 Science Achievement Test of L1 and L2 Students

Subject	The Results of Grade 11 Science Achievement Test (T3)				P-Value
	L1 Students	Mean (X)	L2 Students	SD	
Science	56.6 (68)	15.2	48.5 (57)	10.55	0.001

Subject: the subject of the achievement test

Science: the subject of this achievement tests

L1 Students: are students that learn in the first language at the elementary level

L2 Students: are students that learn in the second language at the elementary level

Mean (X): is the mean value of the total scores of the achievement test

SD: is the standard deviation

P-Value: the statistical measurement which indicates whether the difference between mean values of L1 and L2 scores of the science achievement tests is statistically significant or not

According to the values in Table 16, a significant relationship between the language of instruction and the students' performance in math at the elementary level was revealed. Comparing the mean values of both groups, L1 students scored higher than L2 students on the science achievement tests. As a result, studying science in Arabic allows students to achieve better in math at grade 11. The mean values of the total test scores for all grade 11 schools are presented in Table 17.

Table 17

Results of Grade 11 Math Achievement Test of L1 and L2 Students

Subject	The Results of Grade Eleven Math Achievement Test (T4)				P-Value	
	L1 Students	Mean (X)	SD	L2 Students		
Math	40.4 (68)	13.90		40.0 (54)	15.63	0.894

Subject: the subject of the achievement test

Math: the subject of this achievement tests

L1 Students: are students that learn in the first language at the elementary level

L2 Students: are students that learn in the second language at the elementary level

Mean (X): is the mean value of the total scores of the achievement test

SD: is the standard deviation

P-Value: the statistical measurement which indicates whether the difference between mean values of L1 and L2 scores of the math achievement tests is statistically significant or not

According to Table 17, the mean values of scores of both groups were about the same (~40). Moreover, there was no significant relationship between the language of instruction and students' performance on the grade 11 math test; $p>0.05$.

4.4.2 Comparing the Results of the three Cognitive Levels of Math and Science

Grade 11 Achievement Tests

The mean values of the three categories of questions for the grade 11 math and science achievement tests were calculated and the relationship between them for each group and between the two groups of students was studied. Results of the two groups of students are shown in Table 18.

Table 18

The Results of the three Categories of questions of cognitive levels of thinking of the Science Achievement Test of L1 and L2 Students

Science	The Results of the Cognitive Levels of the Science Achievement Test of Grade 11				
	Cognitive Level	L1 Students		L2 Students	
		Mean (X)	SD	Mean (X)	SD
	C1	68.24	19.62	62.75	13.96
	C2	56.51	22.00	44.55	16.83
	C3	33.24	22.56	25.33	18.71

Cognitive Level: the subject of the achievement test

C1: the first cognitive level of thinking

C2: the second cognitive level of thinking

C3: the third cognitive level of thinking

Science: the subject of this achievement tests

L1 Students: are students that learn in the first language at the elementary level

L2 Students: are students that learn in the second language at the elementary level

Mean (X): is the mean value of the total scores of each category of cognitive level of thinking of the achievement test

SD: is the standard deviation

L2 Schools: are the schools that teach in English at the elementary level

P-Value: the statistical measurement which indicates whether the difference between mean values of L1 and L2 scores of the science achievement tests is statistically significant or not

C: is the p-value which is the difference between the mean values of the three cognitive levels within one group of schools

L: is the p-value of the difference between the overall cognitive values of L1 and that of L2

Int: is the p-value of the difference between the interaction between each of the three cognitive levels between the two groups

According to Table 18, the values of C1, C2, and C3 were different for each group of students. The relationship between the language of instruction and the students' performance at the first, second, and third cognitive levels, was statistically significant. On the other hand, when comparing the mean values of each cognitive level, it was shown that the difference between the mean values was not statistically significant. This required a detailed analysis of the differences in values of both groups at each category of cognitive level of thinking. This analysis was conducted and its results are displayed in Table 19.

Table 19

The difference between the Values of Cognitive Levels of L1 and L2 Students in Grade 11 Science Achievement Tests

The Results of the Interaction Between Science G 11/L2 and L1		
	C1	C2
P-Value	0.079	0.001

C1: the first cognitive level of thinking

C2: the second cognitive level of thinking

C3: the third cognitive level of thinking

P-Value: the statistical measurement which indicates whether the difference between mean values of each cognitive level of C1, C2, and C3 scores between L1 and L2 groups is statistically significant or not

According to the results shown in Table 19, the difference between the mean values of C1 of both groups was not statistically significant, although L1 students scored higher in solving C1 questions than L2 (according to Table 15 above). The difference between the mean values of C2 and C3 were statistically significant, where L1 students scored greater than L2 students. That shows that although the difference between the scores L1 and L2 students was not significant, L1 students scored greater than L2 students in questions requiring higher cognitive levels of thinking.

The mean values of the three cognitive levels for grade 11 math were presented in Table 20. Relationship between the mean values of the three cognitive levels was studied.

Table 20

The Results of the three Categories of questions of cognitive levels of thinking of the Math Achievement Test of L1 and L2 students

Math	Cognitive Level	The Results of the Cognitive Levels of the Math Achievement Test of Grade 11				P-Value	
		L1 Students		L2 Students			
		Mean (X)	SD	Mean (X)	SD		
	C1	63.73	30.87	51.85	24.80	C<0.001	
	C2	35.29	17.16	41.67	21.17	L=0.833	
	C3	30.51	19.24	28.70	21.94	Int<0.001	

Cognitive Level: the subject of the achievement test

C1: the first cognitive level of thinking

C2: the second cognitive level of thinking

C3: the third cognitive level of thinking

Science: the subject of this achievement tests

L1 Students: are students that learn in the first language at the elementary level

L2 Students: are students that learn in the second language at the elementary level

Mean (X): is the mean value of the total scores of each category of cognitive level of thinking of the achievement test

SD: is the standard deviation

P-Value: the statistical measurement which indicates whether the difference between mean values of L1 and L2 scores of the science achievement tests is statistically significant or not

C: is the p-value which is the difference between the mean values of the three cognitive levels within one group of schools

L: is the p-value of the difference between the overall cognitive values of L1 and that of L2

Int: is the p-value of the difference between the interaction between each of the three cognitive levels between the two groups

According to the values shown in Table 20, the difference between the values of C1, C2, and C3 for each group was significant, as the students of each group scored higher in C1 than in C2 and C3.

When comparing the values of the cognitive levels across the two groups of students, the difference between the values was not statistically significant, as the achievement of L1 students in C1 and C3 was better than that of L2 students. But L2 students scored higher than L1 students on questions of second cognitive level of thinking.

When comparing each value of the three cognitive levels of both groups, the difference was shown to be statistically significant. Detailed results of measuring the difference between the values of each cognitive level are shown in Table 21.

Table 21

The difference between the Values of Cognitive Levels of L1 and L2 Students in Grade Eleven Math Achievement Tests

Interaction Between MATH G 11/L2 and L1		
	C1	C2
P-Value	0.02	0.016

C1: the first cognitive level of thinking

C2: the second cognitive level of thinking

C3: the third cognitive level of thinking

P-Value: the statistical measurement which indicates whether the difference between mean values of each cognitive level of C1, C2, and C3 scores between L1 and L2 groups is statistically significant or not

The detailed analysis of the difference between the mean values of each cognitive level was done. The differences between the mean values of the first and the second cognitive levels are shown to be statistically significant, showing that the language of instruction at the elementary level has an effect on the students' math performance in questions requiring first and second cognitive levels of thinking. On the other hand the difference between the mean values of the third cognitive level is not statistically significant. This showed that the level of achievement of L1 students in solving C3 questions might be affected when the language of instruction of math is English.

4.5 Conclusion

According to the results of this study, students learning in the first language (Arabic) at the elementary level achieved higher scores in math and science than students learning in the second language (English) at the fifth grade level. It was also concluded that grade 11 students learning in the first language scored greater than grade 11 students learning in the second language in science. The achievement of grade 11 students from L1 was similar to that of L2 students on the math test.

According to the analysis of results of the three cognitive levels of thinking on the science and math achievement tests, it was concluded that grade 5 students in L1 schools achieved higher scores than those who studied in L2. The science results of grade 11 students showed that L1 students achieved higher scores in the three categories of cognitive levels of thinking than L2 students. Concerning the results of the three categories of cognitive levels of thinking in math, grade 11 students studying in the first language achieved better results in questions requiring first and third cognitive levels of thinking than L2 students.

CHAPTER FIVE

CONCLUSIONS

5.1 Introduction

The study aims at examining the effect of the language of instruction of math and science at the elementary level on the Lebanese students' achievement in these two subjects. It also aims at studying the influence of the language of instruction on the students' achievement in specific areas of cognitive levels of thinking in math and science at two different grade levels. Several studies have shown the effect of the language of instruction on the students' academic achievement and the development of their cognitive abilities in math and science (Tobin & McRobbie, 1996; Capps & Pickreign, 1993; Stubbs, 1976; Ríordáin & O'Donoghue, 2009). Many schools in Lebanon are teaching math and science in the second language, and few are teaching in the first language. Many international studies revealed that using the first language as the language of instruction in math and science promotes the academic achievement in these subjects (Gorgorio & Planas, 2001; Za'rour & Nashif, 1977). Other studies recommended the use of a second language in the learning of math and science in the context of mastery of the first language before learning the second language (Lambert, 1990; Xie & Mouw, 1999). A study needed to be conducted on Lebanese students to test whether the results of international studies apply in their case. For this reason, a quantitative study was conducted on two groups of schools in Lebanon which are similar except their language of instruction at the elementary level, to assess and compare their achievement in math and science. Grade 5 and 11 students of each of the two groups of schools administered math and science achievement tests. The results of the achievement tests were analyzed and the effect

of the language of instruction on the test score and the score of the three cognitive levels was measured.

This chapter discusses the results of the administered achievement tests, and the answers to the two research questions. General conclusions of the results of the study, along with the study's limitation and difficulties faced by the researcher are included in this section. This chapter also presents recommendations for schools in Lebanon and recommendations for future research.

5.2 Discussion of Results Based on Research Questions

5.2.1 Research question one

The first research question is: To which extent is the science and math achievement of Lebanese students influenced by the language of instruction at the elementary level?

According to the results of the test of grade 5, L1 students achieved higher scores than L2 students on the science achievement test. Similar results were shown when analyzing the total test scores of their math achievement tests, L1 students scored greater in math than L2 students.

The total scores of grade 11 students of both groups were also shown to be greater for L1 students on both math and science achievement tests. Students who were used to studying in their first language at the elementary level had a higher conceptual understanding than students who studied in the second language at their elementary level. It would be possible that this conceptual understanding allowed them to apply what they learned and provided a strong scientific and math base which allows them to achieve better at higher grade levels.

An alignment between these results and the review of literature of several international studies existed (Marsh, Hau & Kong, 2000; Lo, 1991; Bankston & Zhou, 1995; Tobin & McRobbie, 1996; Lee, 2005). Several studies revealed that students studying in their first language achieve better academically than students studying in the second language (Bankston & Zhou, 1995; Tobin & McRobbie, 1996; Lee, 2005). The reason for this is students' fluency in expressing their thoughts in first language as well as their ability to engage in the lessons without worrying about their language difficulties. On the other hand, students studying in the second language face difficulties in understanding the lesson and in expressing their points of view in science and math. Usually these students would have to ask their teachers to repeat the explanation of the lesson in their first language so that they would understand it well (Gfeller & Robinson, 1998; Devi, 2003; Adegoke, B.A. & Ibode, 2001).

These results also agree with the results obtained by studies conducted to test the effect of bilingualism on the students' academic achievement. Bilingualism happens to help raise the students' academic achievement only when the mastery of the first language of the students is achieved before studying in the second language (Lambert, 1990; Xie & Mouw, 1999; Ben-Zeev, 1977; Bialystok, 1988; Duncan & De Avilla, 1979; Lindholm & Aclan, 1991; Willig, 1985; Hakuta & Diaz, 1985; Swain & Lampkin, 1982). No evidence on the Lebanese students' mastery of their first language was provided before studying in the second language at the elementary level. It is possible that L2 students did not achieve high results since they have not mastered their first language before studying math and science in L2. Thus, the difference between their results and that of students of L1 was significant statistically, L1 students achieved higher than L2 students.

In conclusion students studying in their first language at the elementary level achieve higher scores in math and science at the elementary and the secondary levels than students who studied in the second language at the elementary level.

5.2.2 Research question two

The second research question is: Do students studying in Arabic at the elementary level achieve better results in questions requiring higher cognitive levels of thinking than students studying in the second language?

In this study, it was revealed that students learning math and science in their first language (Arabic) achieved better than students learning in their second language (English) on the exercises requiring high cognitive levels of thinking. According to the results of grade 5 students, their science achievement tests indicated higher achievement for L1 students in the three cognitive levels categories. The differences between the mean values of each category of questions of different cognitive level were statistically significant. This shows that students learning in their first language at the elementary level have a greater ability to recall scientific and math information, apply them in similar situations, and synthesize a solution to a scientific or math problem than students who learn in the second language.

The results of L1 and L2 students' achievement at the first cognitive level of thinking in math were close, as for the difference between their mean values it was not statistically significant. But the achievement of L1 students on C2 and C3 levels of questions was better than that of L2 students. This was shown statistically, as for the differences between the mean values of both groups in these two categories are considered significant statistically. This showed that even if L1 and L2 students achieve similar results on questions requiring the first cognitive levels of thinking,

still L1 students are more able to manipulate their knowledge in math and science to solve questions of higher cognitive levels of thinking than L2 students.

As for the results of grade 11 science achievement tests, L1 students achieve higher results on the three categories of questions of different cognitive levels of thinking than L2 students. The differences between the mean values of the two categories of questions of higher cognitive levels between L1 and L2 groups were statistically significant; the mean values of L1 scores in these cognitive levels were greater than those of L2. The difference between the mean values of the first cognitive level category was not statistically significant, although the mean value of L1 students was greater than L2 students.

The result of grade 11 math achievement tests recorded greater mean values for L1 students, as the difference between the mean values of the first and second cognitive levels category of questions was statistically significant. Although the difference between the mean values in the third cognitive level between both groups was not statistically significant, L1 students achieved a greater score than L2 students in the category of questions requiring third cognitive levels of thinking.

The results of grades 5 and 11 math and science achievement tests align with the review of the literature, as it was shown that studying in the first language allows students to develop higher cognitive thinking skills (Lee, 2005; Lynch, Chipman, & Pachaury, 1985a; Gonzalez, 1998). Explanations for these results would be that students studying in their first language are motivated to share their real life experiences with their teachers and peers and more readily willing to interact in the class room, without worrying about the language they need to use to express their thoughts. This increase in the motivation to learn math and science would allow the students to be engaged in the learning process, which may be the reason for higher

academic achievement and will to learn. Their motivation to engage in the learning process and their scientific/math curiosity would be the reason for them to understand basics of science/math concepts. This would raise their academic achievement in questions requiring first cognitive levels of thinking and promote the students' cognitive development as well. They would be more able to solve questions requiring higher cognitive levels of thinking. Better results would also motivate them to learn more. These results were also observed when L1 students were learning in L2, in grade 11. Although L2 students are used to studying in the second language more than L1 students, L2 students still achieve lower results than L1 students in grade eleven. This shows that the effect of studying in the first language at the elementary level is more efficient in achieving higher results in science and math at secondary levels. Those who study these subjects in the second language might not be as equipped in solving high cognitive levels of thinking on science and math questions as L1 students.

The existence of a statistically significant difference between the results of the three cognitive levels of thinking within each group of schools is worth mentioning. The mean values of the first cognitive level of thinking were the greatest among the three cognitive levels of each exam in each group of schools. The mean values of the third cognitive level were the lowest in all of the tests for both groups of schools. This is explained by the type of questions the students are used to solve in the math and science books assigned by the Ministry of Education. According to the procedure of book analysis of the exercises for the science and math books of grade 5 and 11, it was concluded that these exercises assess mostly the first and the second cognitive levels of thinking. Students learn through inquiry, if the items of inquiry

failed to induce the students' higher thinking skills, the process of the learners' cognitive development is altered.

5.3 Recommendations

According to this study, Lebanese students achieved higher results when their first language (Arabic) was the language of instruction in math and science at the elementary level and achieved higher results in solving higher cognitive levels questions than L2 students. This suggests that L1 should be the language of math and science instructions at the elementary level so that Lebanese students develop higher cognitive levels of thinking in math and science at the elementary and secondary level. Studying in the first language allows Lebanese students to express their thoughts fluently in the classroom and facilitates the application of active authentic learning strategies. Moreover, students would be able to apply what they learn outside the classroom and discuss their thoughts with their peers and teachers without the barriers of the second language difficulties which is one of the main objectives of the Lebanese science curriculum. Students might face challenges related to the usage of international resources and the sharing of updated information which is mostly published in the second language. This is also included in the objectives of the Lebanese curriculum which aims at motivating students to have the scientific curiosity to search for new different sources of information. According to these aims of the Lebanese curriculum, learning math and science in both, the first language and the second language at the elementary level is suggested to achieve the objectives of the Lebanese curriculum. Studying in their first language would promote the Lebanese students' cognitive development and studying in the second language empowers them at universities where sciences and math are taught in the

second language. Schools in Lebanon need to adopt a new plan in which students study math and science in L1 and L2 in order to achieve the goals of the Lebanese science and math curricula taking into consideration the student's level of language proficiency. In this educational plan, Lebanese students would have to master their first language before learning math and science in the second language. Transition to learning in L2 should occur after L1 is mastered, because the mastery of the second language depends on the mastery of the first language. Working to achieve the mastery of the second language should take place as students are in the process of learning math and science in L2. Until such programs are available, educators in general and principals in particular should pursue teaching Lebanese students in the first language (Arabic) as long as it allows Lebanese students to achieve higher at the elementary and secondary level.

English, science, and math teachers can also play a positive role to raise the students' achievement in math/science and English. They would work together to apply interdisciplinary programs which allow science/math to benefit from its interdependence with language. In this case, students would improve the language they use in science/math, and would be motivated to discuss scientific/math topics in English classrooms.

At the ministerial level, new math and science books are recommended to be chosen by the education department in Lebanon. These books should contain exercises assessing different cognitive levels of thinking. In addition to having a variety of exercises, different word problems should be introduced to let the students get acquainted with different math/science problems.

5.4 Difficulties and Limitations to the Study

5.4.1 Difficulties of the study

Certain difficulties were faced by the researcher in the process of data collection. The difficulties are related to finding private L1 schools in Lebanon, some schools' commitment to participate in the study, the schools' different academic yearly plans, and the circumstances of the country.

The first difficulty faced by the researcher is finding schools that still teach in the first language (Arabic) at the elementary level. The majority of schools in Lebanon teach science and math in English at the elementary level, and those who teach in Arabic were in the process of shifting to teaching in the second language. The schools selected in this study are the only private schools teaching in Arabic at the elementary level in Beirut, Saida, and Nabatieh.

Another difficulty is convincing Lebanese schools to participate in the study. Nine schools agreed to participate in the study, but two L1 schools and one L2 school in Saida, and one L2 school in Nabatieh cancelled their participation just before the date of administering the test for unknown reasons.

The study was conducted in six different schools which pursue different academic calendars. This affected the framing of the list of selected objectives of the achievement tests. Some schools started their academic year in September and others in October. This affected their pace in covering the learning outcomes. In other words, these schools had not covered the learning objectives that ought to be mastered by the date of sitting for the achievement tests.

This caused many changes in the dates of the achievement tests, which led to a change in the list of selected objectives as well. The cooperating teachers and coordinators had to design other tests of added objectives to be fair to all participants.

The unstable country's circumstances caused a lot of off days, which was a reason for some schools to refuse participating in the study because they were not able to offer extra sessions for administering the tests, especially in grade eleven.

5.4.2 Limitations of the study

One limitation is related to the instrument used. The test items of the achievement tests administered are multiple choice questions, which is not a perfect tool to assess students' ability to solve high cognitive levels of thinking questions. Although there are no evidence whether an answer is a guess or not, due to the absence of argumentation, multiple choice questions are still utilized for the objectivity they provide during corrections.

Another limitation of the study is controlling the participants' level of language proficiency. If the level of language proficiency of students was different, this would affect their results in the achievement tests. Although one of the criteria which the schools were selected upon is the students' language average, this cannot be used as a reliable comparing tool to control the variable of language proficiency, as every school has its own grading system. A language test to measure the participants' language proficiency should have been administered, and the students of a specific level of language proficiency should have been selected. In this case the factor of language proficiency would have been controlled. In addition to that the spoken language of the students (Lebanese Arabic) is still different from the language of the Arabic achievement tests (modern standard Arabic). This leads to another limitation of this study, since the complexity between whether the first language in Lebanon is the modern standard Arabic or it is the Lebanese Arabic dialect is disregarded in this study.

One important limitation of this study is controlling the teaching strategies, lesson plans, lesson duration, and the language used by the teacher during lesson explanation in the selected grade levels (5 and 11) of the selected L1 and L2 schools. Although the same math/science teacher taught all the sections at the same school, still the students of every school received the same lesson but using different teaching methods. This would affect the students' mastery and understanding of the material, as well as their performances on tests. For example, L2 students would not be receiving instruction in L2 if their science teacher is using code switching during the lesson explanation and re-explaining the concept in Arabic. Such limitation of the study would be avoided if qualitative research methods were used (class observation and teachers' lesson plans evaluation).

5.5 Recommendations for Future Research

Lebanese students use the Lebanese dialect in their daily life and not the standard Arabic. So, basically their first language is the Lebanese Arabic and not the standard Arabic that is used in books and in tests. Also the Lebanese Arabic is the language being mostly used in class by the teacher and the student in L1 classes. L2 students had their teachers repeat most of what is taught in L2 using the Lebanese Arabic through code switching. This study did not take into consideration the complexities of the difference between the Lebanese Arabic and the modern Arabic. Future research is recommended to see whether Lebanese students would achieve higher results when they are tested in Lebanese Arabic. Listening tests are recommended, since these students are used to oral communication, discussion, sharing, and learning information and experiences using this language, Lebanese

Arabic. A longitudinal study is also recommended to check the development of proficiency in math as students develop their linguistic skills.

A mixed qualitative-quantitative research study to examine the effect of using the first language at the elementary level on the students; academic achievement is recommended. Such type of study would offer more explanations to the quantitative results. Many factors might affect the students' achievement other than the language of instruction, such as the teaching strategies, the language used in lesson explanation, and the use of code switching. A bigger sample size is recommended from more different areas of Lebanon, so that the results of the study may be generalized. Including subjective questions to objective test items in order to assess students' ability to solve questions high cognitive levels of thinking is also suggested. Moreover, students' answers to subjective questions would allow the researcher to reflect on the effect of the language of instruction on students' understanding of questions and writing of answers. Studying the students' socio economic status would also be recommended to control the factors which would affect the results of the study.

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APPENDICES

Appendix A: Principal's Interview

Kindly find the following list of questions to be answered by providing a brief answer or by choosing one of the given choices.

1. Specify the location of the school.

2. What is the total number of students in your school?

- Greater than 1000 students
- Less than 1000 students

3. What is the number of students per classroom?

- Greater than 30 students
- Between 25 and 30 students
- Between 20 and 25 students
- Between 15 and 25 students

4. Does the school have a library?

- Yes
- No

5. Does the school have a science laboratory?

- Yes
- No

6. Is there internet excess in each classroom?

- Yes
- No

7. Does the school have a department of a special education?

- Yes
- No

Appendix B: Students' Questionnaire

Kindly find the following list of questions to be answered by circling the right answer.

1. Where you a student in this school last year?

- Yes
- No

2. Where you born in Lebanon?

- Yes
- No

3. Was your father born in Lebanon?

- Yes
- No

4. Was your mother born in Lebanon?

- Yes
- No

5. Which language do you mostly use to speak with your mother?

- English
- French
- Lebanese
- Armenian
- Other

6. Which language do you mostly use top speak to your father?

- English
- French
- Lebanese
- Armenian
- Other

7. Which language do you usually use to speak to your siblings (brothers and sisters)?

- English
- French
- Lebanese
- Armenian
- Other

8. How many total years have you been living in Lebanon?

- More than five years
- Less than five years

9. Which language did you use to study math and science at the elementary level?

- Arabic
- English
- Other

10. Which language do you mostly use to speak to your peers at school?

- English
- French
- Lebanese
- Armenian
- Other

استبيان الطلاب Appendix C:

يرجى الإجابة على الأسئلة أدناه بوضع دائرة حول الجواب المناسب قبل البدء في حل مواد الاختبار

1. هل كنت طالباً في هذه المدرسة في العام الماضي؟

* نعم

* كلا

2. هل ولدت في لبنان؟

* نعم

* كلا

3. هل ولد والدك في لبنان؟

* نعم

* كلا

4. هل ولدت والدتك في لبنان؟

* نعم

* كلا

5. ما اللغة التي تستخدم في الغالب في الكلام مع والدك؟

* الإنجليزية

* الفرنسية

* اللبنانيّة

*الأرمنية

* أخرى

6. ما اللغة التي تستخدم في الغالب للتحدث مع والدك؟

* الإنجليزية

* الفرنسية

* اللبنانيّة

*الأرمنية

* أخرى

7. ما اللغة التي تستخدم في الغالب للتحدث مع إخوتك؟

* الإنجليزية

* الفرنسية

* اللبنانيّة

*الأرمنية

* أخرى

8. ما هو عدد السنوات التي قضيتها في لبنان؟

* أقل من 5 سنوات

* أكثر من 5 سنوات

9. ما هي اللغة التي استخدمتها لدراسة الرياضيات والعلوم في المرحلة الابتدائية؟

* اللغة الإنجليزية

* اللغة العربية

لغة أخرى

10. ما هي اللغة التي تستخدم في الغالب للتحدث مع زملائك في المدرسة؟

* الإنجليزية

* الفرنسية

* اللبنانيّة

*الأرمنية

* أخرى

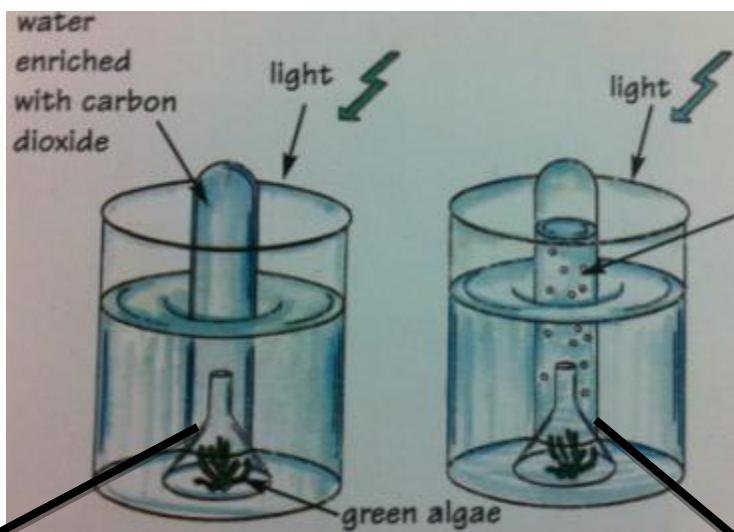
Appendix D: Grade Five Science Achievement Test-English Version

(T1)

Answer the multiple choice questions below by circling the letter of the best choice which answers the questions or completes each phrase.

Question I Plants and their Habitats

Observe
below of
use it to
three
below.



the figure
green algae and
answer the
questions

- 1) What is the process performed by the green algae?
 - A. Respiration
 - B. Transpiration
 - C. Photosynthesis
 - D. Germination

- 2) Name the gas X which is the gas produced in tube B.
 - A. Oxygen
 - B. Carbon dioxide
 - C. Air
 - D. Carbon dioxide and Oxygen

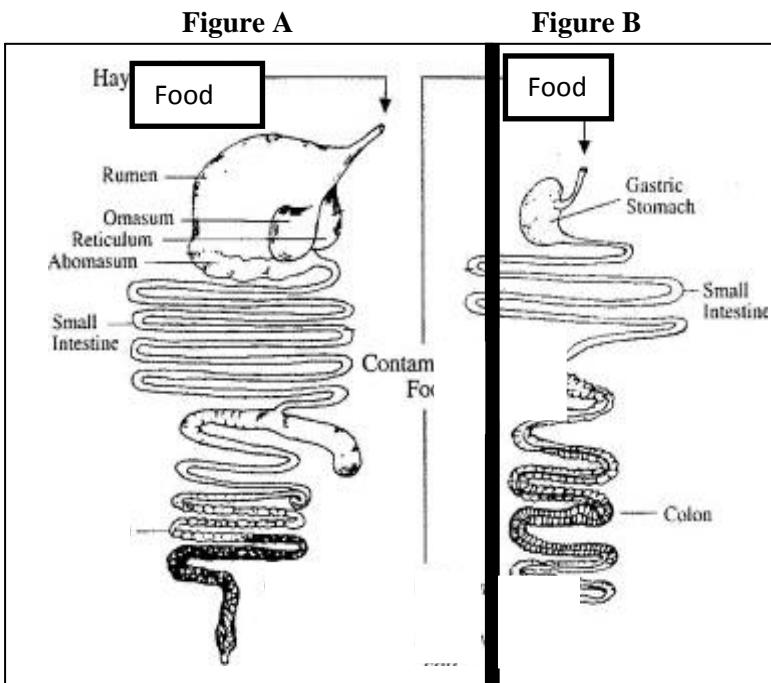
- 3) Why is this process important for the life of human beings and animals?
 - A. This process is important for the life of human beings and animals since it provides them with nutrients and minerals.
 - B. This process is important for the life of human beings and animals since it provides them with gases they need to survive.
 - C. This process is important for the life of human beings and animals since it allows them to produce their own food.

- D. This process is only important for plants, and not for human beings or animals.

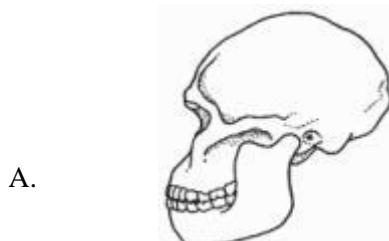
Question II Green leaves contain small green structures. What is the function of these small green structures?

- A. The small green structures take in carbon dioxide from the air.
- B. The small green structures give off oxygen from the plant into the air.
- C. The small green structures give green plants their green color and stores starch produced by the plant.
- D. The small green structures uses light, carbon dioxide, and water to produce starch and Oxygen

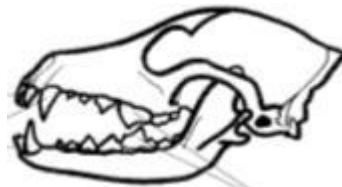
Question III Animals are divided into three groups according to their diets. The following two figures A and B contain two types of digestive tracts respectively. Each type of digestive tract belongs to a certain type of animals.



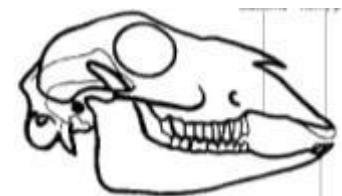
- 1) The digestion of plant fibers takes more time than meat digestion. Which figure shows the digestive tract of a vegetarian?
 A. Figure A
 B. Figure B
 C. Figure A and B
 D. None of the figures
- 2) Which of these jaws belong to the animal having the digestive system in figure A?



B.



C.



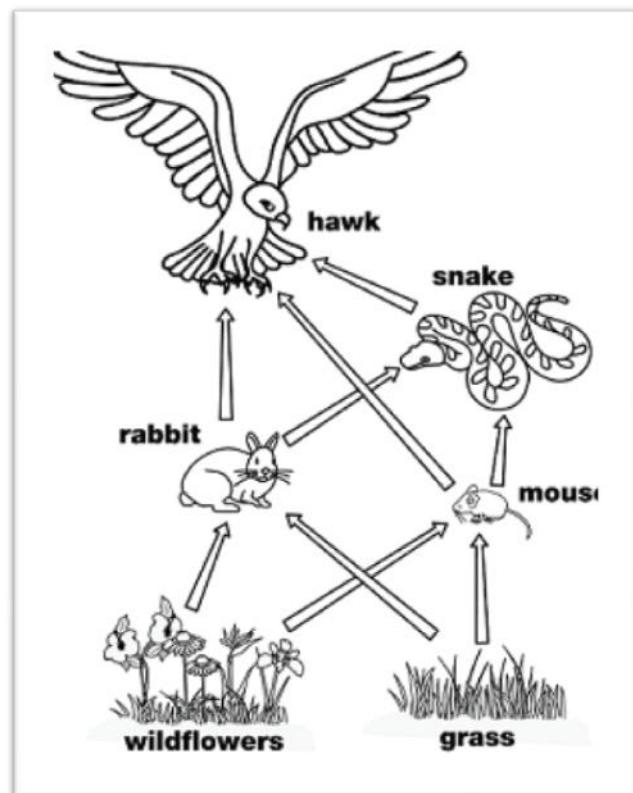
- D. None of the above is a right answer.

Question IV Plants are continually growing by using more minerals. If the amount of mineral salts found in the soil is limited, another source of minerals is needed to provide plants with the needed minerals.

Which of the following can be a source of mineral salts?

- A. Consumers
- B. Herbivores
- C. Decomposers
- D. Producers

Question V A food web shows how energy is passed on from one living thing to the next. It shows the feeding habits of different animals that live together in an ecosystem. Use the following figure of a food chain to answer the following questions.



- 1) Name the living things in the food web that are producers.
 - A. Rabbit, mouse, snake, and hawk
 - B. Grass and wildflowers
 - C. Rabbit, mouse, and snake
 - D. Rabbit, mouse, snake, and grass

- 2) Name the living things in the food web that are consumers.
 - A. Rabbit, mouse, snake, and hawk
 - B. Grass and wildflowers
 - C. Rabbit, mouse, and snake
 - D. Rabbit, mouse, snake, and grass

- 3) Which living things does the snake eat?
 - A. Rabbit, mouse, snake, and hawk
 - B. Grass and wildflowers
 - C. Rabbit and mouse
 - D. Rabbit, mouse, and grass

- 4) Which living things does the hawk eat?
 - A. Rabbit, mouse, snake, and hawk
 - B. Grass and wildflowers
 - C. Rabbit, mouse, and snake
 - D. Rabbit, mouse, snake, and grass

Question VI The Digestive system

- 1) What is the purpose of the digestive system?

- A. To help your blood to move through the body
 - B. To help you breathe
 - C. To help your body make food
 - D. To help your body break down food
- 2) In the case of diarrhea, feces are eliminated in the form of liquid. In this case which organ is not functioning normally?
- A. Mouth
 - B. Stomach
 - C. Small Intestine
 - D. Large Intestine

Question VII The Respiratory System

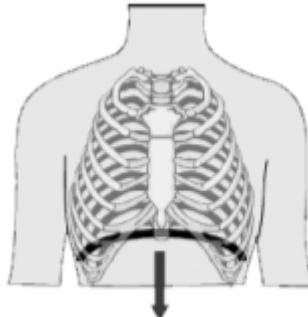
Use the table below of the percentages of gases in the inhaled and exhaled air to answer the questions below.

	Oxygen Gas	Nitrogen Gas	Carbon dioxide Gas
Inhaled Air	20.5 %	79 %	0.03 %
Exhaled Air	16.5 %	79 %	X

- 1) Compare the percentages of Oxygen in the inhaled air and in the exhaled air and explain.
- A. The percentage of Oxygen in the inhaled air is greater than that in the exhaled air since oxygen is needed for respiration to take place.
 - B. The percentage of Oxygen decreased since Oxygen is the only nonfatal gas in the air.
 - C. The percentage of Oxygen in the exhaled air is less than that in the inhaled air since it is exchanged by Carbon dioxide gas.
 - D. The percentage of Oxygen is greater in the exhaled air since it is cleaner than the inhaled gas.
- 2) X is the percentage of Carbon dioxide found in the exhaled air. Predict the value of X.
- A. X is $> 0.03\%$
 - B. X is $< 0.03\%$
 - C. X is 4 %
 - D. X is 4.03 %
- 3) Write the correct sequence of the pathway through which the inhaled air travels after entering the body.
- A. Larynx, pharynx, trachea bronchioles
 - B. Pharynx, larynx, trachea, bronchioles
 - C. Pharynx, larynx, bronchioles, trachea
 - D. Pharynx, trachea, larynx, bronchioles
- 4) Which process does not occur in the nasal cavity?
- A. Trapping of large foreign bodies
 - B. Exchange of gases
 - C. Humidification of inhaled air

D. Warming of inhaled air

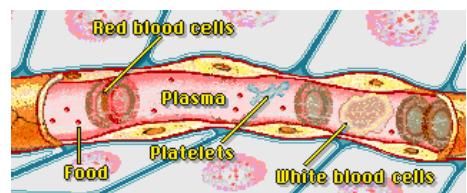
- 5) Describe what is happening to the diaphragm in the diagram below:



- A. The Diaphragm contracts and flattens as the lungs fill up with air.
- B. The Diaphragm contracts and flattens as air is released from the lungs.
- C. The Diaphragm relaxes and moves upward as air the lungs fill up with air.
- D. The Diaphragm relaxes and moves upward as air is released from the lungs

- 6) Which part of the blood carries the minerals, vitamins, sugar, and other foods to the body's cells?

- A. Plasma
- B. Platelets
- C. Red Blood cells
- D. White blood cells



- 7) What happens when a clot occurs in an undamaged blood vessel?

- A. You would bleed to death.
- B. A scab will form on the skin surface.
- C. Platelets stick to the edges of the cut and to one forming a plug.
- D. The flow of blood to tissues beyond the clot may be cut off.

- 8) What happens to blood when it is pumped into the thin-walled blood vessels of the lungs?

- A. Platelets are exchanged for plasma.
- B. Carbon dioxide is replaced with oxygen.
- C. Blood fills the lungs and causes coughing.
- D. Nothing, because the lungs are just a place blood goes through on its way back to the heart.

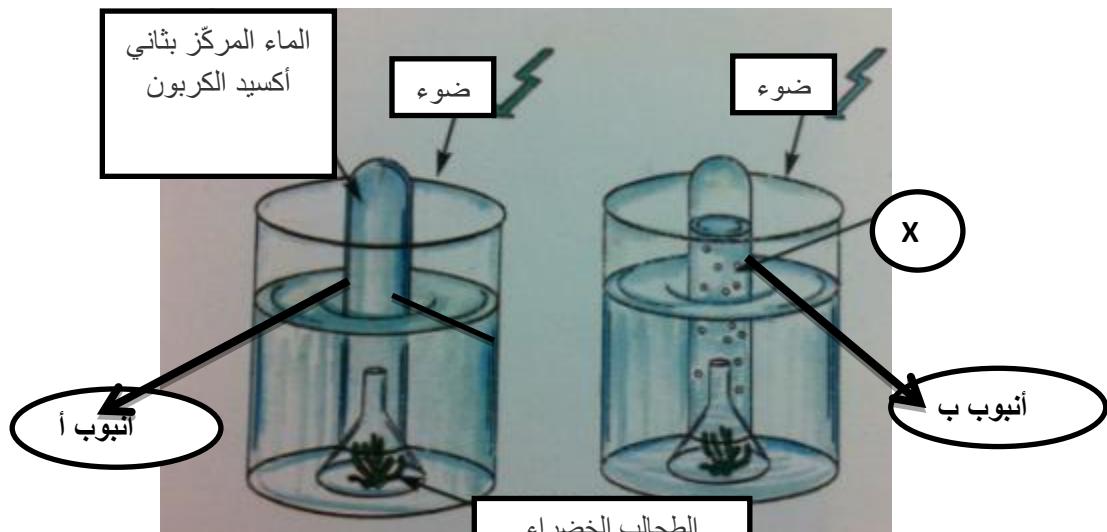
Appendix E: Grade Five Science Achievement Test-Arabic Version

(T1')

ابدء بالإجابة على الأسئلة متعددة الخيارات أدناه بوضع دائرة حول الخيار الأفضل الذي يجيب على الأسئلة أو يكمل كل عبارة.

الأسئلة:

السؤال الأول: لاحظ الشكل أدناه من الطحالب الخضراء واستخدامها للإجابة على الأسئلة الثلاثة أدناه:



1. ما هي العملية التي تقوم بها الطحالب الخضراء؟

- أ- التنفس
- ب- النتح
- ج- الضوئي
- د- إنبات

2. اسم الغاز X والذي هو الغاز المنتج في أنبوب B:

- أ- أكسجين
- ب- ثاني أكسيد الكربون
- ج- هواء
- د- ثاني أكسيد الكربون والأوكسجين

3. لماذا هذه العملية الهامة لحياة البشر والحيوانات؟

- أ- هذه العملية مهمة لحياة البشر والحيوانات لأنها توفر لهم المواد الغذائية والمعادن.
- ب- هذه العملية مهمة لحياة البشر والحيوانات لأنه توفر لهم الغازات التي يحتاجون إليها من أجل البقاء.

ج- هذه العملية مهمة لحياة البشر والحيوانات لأنها تتيح لهم لإنتاج غذائهم بأنفسهم.

د- هذه العملية مهمة فقط للنباتات، وليس للإنسان أو الحيوان.

السؤال الثاني: الأوراق الخضراء تحتوي على جسيمات صغيرة خضراء. ما هي وظيفة هذه الهياكل الصغيرة في الخضراء؟

أ- الجسيمات الخضراء الصغيرة تأخذ في ثاني أكسيد الكربون من الجو.

ب- الجسيمات الخضراء الصغيرة تنتج الأكسجين من النباتات إلى الهواء.

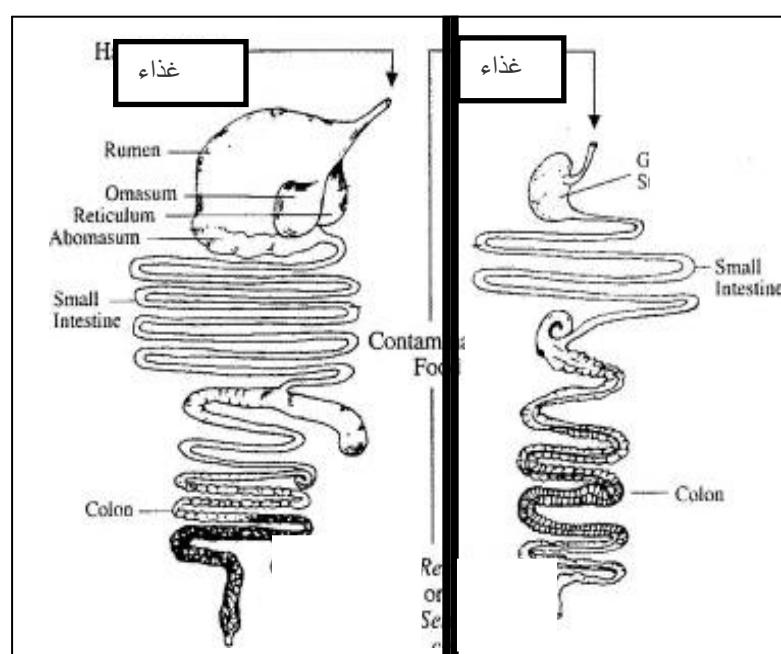
ج- الجسيمات الخضراء الصغيرة تعطي النباتات الخضراء لونها الأخضر وتخزن النشاء التي ينتجه النبات.

د- الجسيمات الخضراء الصغيرة تستخدم الضوء، ثاني أكسيد الكربون، والماء لإنتاج النشاء والأوكسجين.

السؤال الثالث: تنقسم الحيوانات إلى ثلاثة مجموعات وفقاً لوجباتهم الغذائية. الرسمين التاليين (أ و ب) يحتويان على نوعين مختلفين من أنواع الجهاز الهضمي ينتمي إلى نوع معين من الحيوانات.

رسم بياني أ

رسم بياني ب



1. على هضم الألياف النباتية يأخذ وقتاً أكثر من هضم اللحوم. أي رسم يظهر الجهاز الهضمي للنباتيين؟

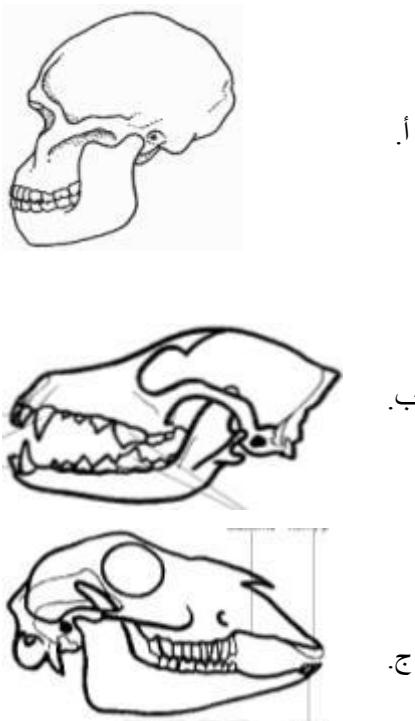
أ- الشكل أ

ب- الشكل ب

ج- الشكل أ و ب

د- ولا شكل

2. أي فك ينتمي للحيوان صاحب الجهاز الهضمي في الرسم البياني (أ)؟

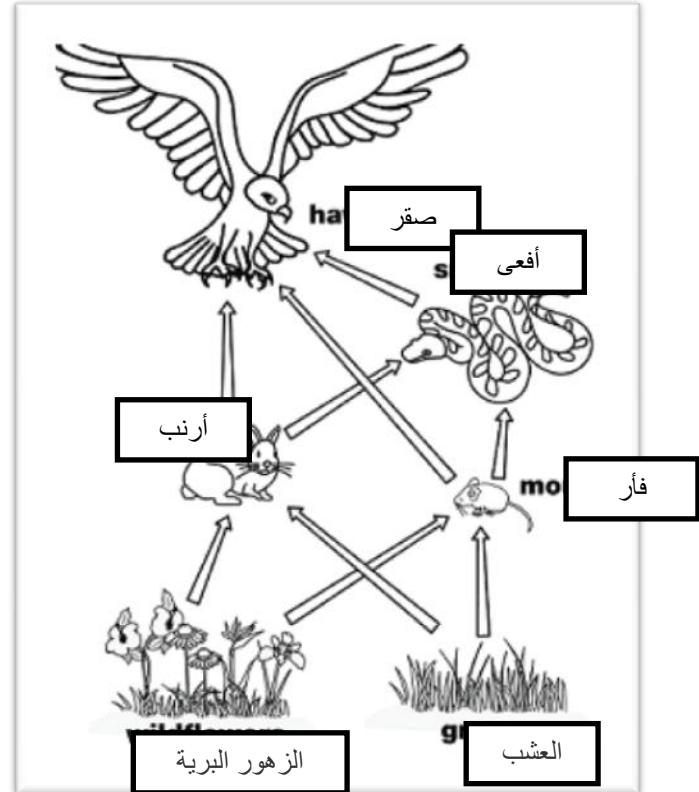


د. لا شيء مما سبق هو الجواب
الصحيح.

السؤال الرابع: تنمو النباتات باستمرار باستخدام معادن كثيرة. وإذا كانت كمية الأملالح المعدنية الموجودة في التربة محدودة، ف تكون النباتات بحاجة لمصدر آخر من المعادن لتوفير حاجتها من المعادن الازمة. أي مما يلي يمكن أن تكون مصدراً من الأملالح المعدنية؟

- أ. آكلي اللحوم
- ب. آكلي النباتات
- ج. المحلات
- د. المنتجين

السؤال الخامس: تظهر الشبكة الغذائية أدناه كيف يتم انتقال الطاقة من كائن حي إلى آخر. وهي توضح عادات مختلفة لتنمية الحيوانات التي تعيش معاً في نظام بيئي.
استخدام الشبكة الغذائية للإجابة على الأسئلة التالية.



1. أسماء الكائنات الحية المنتجة في الشبكة الغذائية هي:

- أ- الأرنب، الفأر، الأفعى، والصقر
- ب- العشب والزهور البرية
- ج- الأرنب، و الفأر ، و الأفعى
- د- الأرنب، الفأر، الأفعى، والعشب

2. أسماء الكائنات الحية المستهلكة هي:

- أ- الأرنب، الفأر، الأفعى، والصقر
- ب- العشب والزهور البرية
- ج- الأرنب، و الفأر ، و الأفعى
- د- الأرنب، الفأر، الأفعى، والعشب

3. الكائنات الحية التي لا تأكل الأفعى هي:

- أ- الأرنب، الفأر، الأفعى، والصقر
- ب- العشب والزهور البرية
- ج- الأرنب، و الفأر ، و الأفعى
- د- الأرنب، الفأر، الأفعى، والعشب

4. الكائنات الحية التي لا تأكل الصقر هي:

- أ- الأرنب، الفأر، الأفعى، والصقر

- بـ العشب والزهور البرية
- جـ الأرنب، و الفأر، و الأفعى
- دـ الأرنب، الفأر، الأفعى، والعشب

السؤال السادس: الجهاز الهضمي

1. ما هي وظيفة الجهاز الهضمي؟

- أـ يساعد في عملية نقل الدم في الجسم
- بـ يساعد على التنفس
- جـ يساعد الجسم على انتاج الغذاء
- دـ يساعد الجسم على هضم الغذاء

2. في حالة الإسهال، يتم التخلص من البراز على صورة حالة سائلة. ما هو الجزء الذي لا يعمل بشكل طبيعي؟

- أـ الفم
- بـ المعدة

- جـ الأمعاء الدقيقة
- دـ الأمعاء الغليظة

السؤال السابع: الجهاز التنفسي

يظهر الجدول أدناه نسب الغازات الموجودة أثناء الشهيق و الزفير. استخدم الجدول الإجابة على الأسئلة التالية.

ثاني أكسيد الكربون	النيتروجين	الأكسجين	هواء الشهيق
%0.03	%79	%20.5	
X	%79	%16.5	هواء الزفير

1. عند مقارنة نسبة الأوكسجين الموجودة أثناء الشهيق و الزفير نجد أن:

أـ نسبة الأوكسجين في الشهيق هي أكثر من تلك التي في هواء الزفير لأن هناك حاجة إلى الأوكسجين للتنفس

بـ نسبة الأوكسجين انخفضت لأنه يعتبر الغاز الوحيد الغير المميت الموجود في الهواء.

جـ نسبة الأوكسجين أثناء الزفير هو أقل من تلك التي في هواء الشهيق لأنه يتم تبادلها بغاز ثاني أكسيد الكربون.

دـ نسبة الأوكسجين أكبر في هواء الزفير لأنه أنظف من الهواء أثناء الشهيق.

2. تمثل النسبة المئوية لغاز ثاني أكسيد الكربون الموجود أثناء الزفير. حاول التنبؤ بقيمة X:

أـ X هو <%0.03>

بـ X هو <%0.03>

جـ X هو <%4>

دـ هو <%4.03>

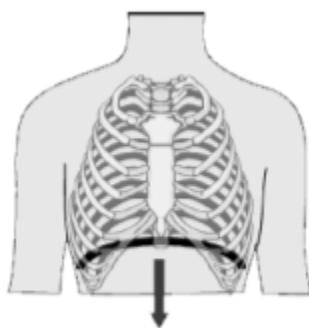
3. اكتب التسلسل الصحيح لمسار الهواء الشهيق بعد دخول الجسم.

- أ- الحنجرة، البلعوم، القصبة الهوائية، القصبات
- ب- البلعوم، الحنجرة، القصبة الهوائية، القصبات
- ج- البلعوم، الحنجرة، القصبات، القصبة الهوائية
- د- البلعوم، القصبة الهوائية، الحنجرة، القصبات.

4. أي من تلك العمليات لا تحدث في تجويف الأنف؟

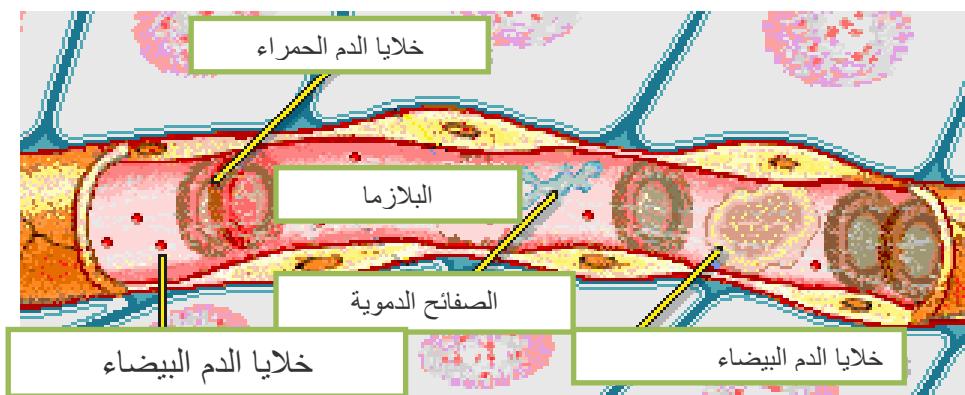
- أ- محاصرة من أجسام غريبة كبيرة
- ب- تبادل الغازات
- ج- ترطيب هواء الشهيق
- د- تسخين هواء الشهيق

5. صف ما يحدث الحجاب الحاجز في الرسم البياني أدناه:



- أ- يتقلّص الحجاب الحاجز ويسطح وتمتلئ الرئتين بالهواء.
- ب- يتقلّص الحجاب الحاجز ويسطح و يتم اخراج الهواء من الرئتين.
- ج- يسترخي الحجاب الحاجز ويتحرّك صعوداً و تملأ الرئتين بالهواء.
- د- يسترخي الحجاب الحاجز ويتحرّك صعوداً كما يتم اخراج الهواء من الرئتين

6. أي جزء من الدم يحمل المعادن والفيتامينات والسكر، وغيرها من الأطعمة إلى خلايا الجسم؟



أ- البلازما

ب- الصفائح الدموية

ج- خلايا الدم الحمراء

د- خلايا الدم البيضاء

7. ماذا يحصل عند حدوث تجلط في الأوعية الدموية التالفة؟

أ- نزيف حتى الموت.

ب- تشكل ندوب على سطح الجلد.

ج- التصاق الصفائح لحواف الجرح وتشكل قابس.

د- انقطاع تدفق الدم إلى الأنسجة

8. ما الذي يحدث للدم عندما يتم ضخه في الأوعية الدموية رقيقة الجدران في الرئتين؟

أ- يتم تبادل الصفائح الدموية البلازما.

ب- يتم استبدال غاز ثاني أكسيد الكربون بالأكسجين.

ج- يملأ الدم الرئتين ويؤدي إلى السعال.

د- لا يحدث شيء، وذلك لأن الرئتين هي مجرد مكان يمر به الدم للوصول إلى القلب.

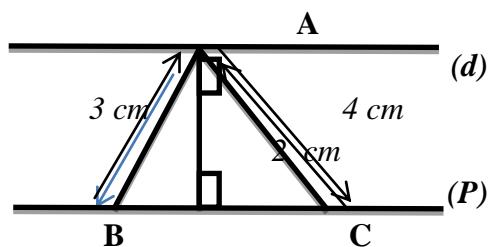
Appendix F: Grade Five Math Achievement Test-English Version (T2)

Start answering the multiple choice questions below by circling the letter of the best choice which answers or completes each phrase.

Questions

- 1) A number is said to be divisible by 4 if _____.
 - a. The sum of its digits is divisible by 4
 - b. Its ones digit is a multiple by 4
 - c. The number formed by its ones and tens digit is a multiple of 4
 - d. The number is even
- 2) Which of the following numbers is divisible by 9?
 - a. 723
 - b. 489
 - c. 108
 - d. 109
- 3) The divisors of 36 are _____.
 - a. 1, 2, 3, 4, 9, 36
 - b. 1, 2, 3, 4, 6, 9, 36
 - c. 1, 2, 3, 4, 6, 8, 9, 12, 18, 36
 - d. 1, 2, 3, 4, 6, 9, 12, 18, 36
- 4) A light house emits a green signal every 30 seconds and a red signal every 40 seconds. After how many seconds will the light house emit both green and red signals?
 - a. 70 seconds
 - b. 120 seconds
 - c. 10 seconds
 - d. 35 seconds
- 5) $7 \times 100,000,000 + 9 \times 10,000,000 + 1,000,000 + 5 \times 100$ is the expanded form for:
 - a. 7,915
 - b. 7,091,500
 - c. 7,091,000,500
 - d. 7,910,000,500
- 6) One hundred and three tenths is equal to:
 - a. 10030
 - b. 103
 - c. 100.03
 - d. 100.3
- 7) Which of the following numbers is divisible by 2, 3 and not by 9?
 - a. 954
 - b. 123

- c. 912
d. 239
- 8) From a 24-slices pizza, Rana ate 4 slices while Zeina ate 5 slices more than double that of Rana, and Lana ate 9 slices less than triple that of Rana. Then, the number of slices left over is _____.
- a. 6
b. 20
c. 8
d. 4
- 9) Which fraction shows the part of the circle that is shaded?
- a. $\frac{2}{9}$
b. $\frac{2}{8}$
c. $\frac{2}{7}$
d. $\frac{7}{9}$
- 10) Which of the following numbers is between 2.3 and 2.4?
- a. 2.03
b. 2.31
c. 2.2
d. 2.5
- 11) Which of the following products is equal to 2400?
- a. 60×4
b. $6 \times 40 \times 2 \times 5$
c. 600×40
d. $8 \times 3 \times 10$
- 12) In the adjacent figure, (d) is given parallel to (P).
The distance between point A and (P) is _____.
- a. 3 cm
b. 4 cm
c. 2 cm
d. 0 cm
- 13) An angle whose sides are perpendicular is a (an) _____ angle.
- a. Acute
b. Right
c. Obtuse
d. Straight

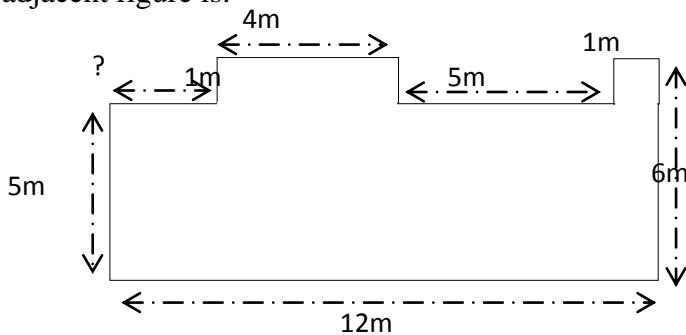


14) Nader bought 3 tables and 18 chairs for 153,000 L.L. If the price of each chair is 6,000 L.L., then the price of each table is:

- a. 15,000 L.L.
- b. 45,000 L.L.
- c. 147,000 L.L.
- d. 49,000 L.L.

15) The length of the missing side in the adjacent figure is:

- a. 3m
- b. 9m
- c. 10m
- d. 2m



Appendix G: Grade Five Math Achievement Test-Arabic Version (T2')

ابدء بالإجابة على الأسئلة متعددة الخيارات أدناه بوضع دائرة حول الخيار الأفضل الذي يجيب على الأسئلة أو يكمل كل عبارة.

الأسئلة:

1. الأرقام التي تقبل القسمة على 4 هي الأرقام التي:

أ. حاصل جمع أعدادها يقبل القسمة على 4.

ب. آحادها من مضاعفات الأربعة.

ت. العدد المؤلف من آحادها و عشراتها هو من مضاعفات الأربعة.

ث. تكون مزدوجة.

2. أي من هذه الأعداد تقبل القسمة على 9؟

أ. 732

ب. 489

ت. 108

ث. 109

3. قواسم العدد 36 هي:

أ. 36, 9, 4, 3, 2, 1

ب. 36, 9, 6, 4, 3, 2, 1

ت. 36, 18, 12, 9, 8, 6, 4, 3, 2, 1

ث. 36, 18, 12, 9, 6, 4, 3, 2, 1

4. منارة تصدر اشارة خضراء كل 30 ثانية و اشارة حمراء كل 40 ثانية. متى تصدر المنارة كلا الإشارتين معاً؟

أ. 70 ثانية.

ب. 120 ثانية.

ت. 10 ثوان.

ث. 35 ثانية.

5. $7 \times 100X + 1000000 + 10000000X + 9 + 100000000X = 7915$ هي نشر لأي من الأعداد التالية:

أ. 7915

ب. 7091500

ت. 7091000500

ث. 7910000500

6. أي من الأعداد التالية تساوي مئة و ثلاثة أعشار؟

أ. 10030

ب. 103

ت. 100.03

ث. 100.3

7. أي من العداد التالية تقبل القسمة على 2 و 3 ولكنها لا تقبل القسمة على 9؟

- أ. 954.
- ب. 123.
- ت. 912.
- ج. 239.

8. من بيتزا مؤلفة من 24 قطعة، أكلت رنا 4 قطع و أكلت زينة 5 قطع أكثر من ضعف عدد قطع رنا. أما لانا فأكلت 9 قطع أقل من ثلاثة أضعاف عدد قطع رنا. ما هو عدد قطع البيتزا المتبقية؟

- أ. 6
- ب. 20
- ت. 8
- ث. 4



9. أي من هذه الكسور تمثل المساحة الملونة من الرسم التالي؟

- أ. $\frac{2}{9}$
- ب. $\frac{2}{8}$
- ت. $\frac{2}{7}$
- ث. $\frac{7}{9}$

10. أي من الأعداد التالية تقع بين 2.3 و 2.4؟

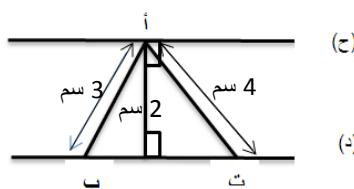
- أ. 2.03
- ب. 2.31
- ت. 2.2
- ث. 2.5

11. أي من الإحتمالات التالية حاصل ضربها 2400؟

- أ. 4×60
- ب. $5 \times 2 \times 40 \times 6$
- ت. 40×600
- ث. $10 \times 3 \times 8$

12. في الرسم المقابل، الخطان (د) و (ح) هما خطان متوازيان. المسافة بين النقطة أ و الخط (د) هي:

- أ. 3 سم.
- ب. 4 سم.
- ت. 2 سم.
- ث. 0 سم.



13. أي من الزوايا التالية أضلاعها متساوية؟

- أ. الزاوية الحادة.
- ب. الزاوية القائمة.
- ت. الزاوية المنفرجة.

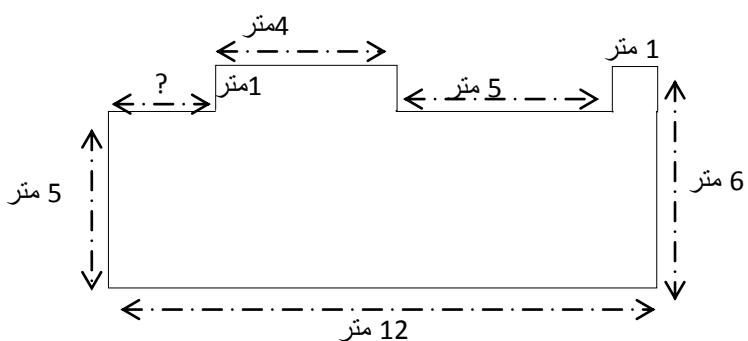
ث. الزاوية المستقيمة.

14. إشتري نادر 18 كرسي وثلاث طاولات بـ 153000 ل.ل. إذا كان سعر الكرسي الواحد 6000 ل.ل. ما هي تكلفة الطاولة الواحدة؟

- أ. 15000 ل.ل.
- ب. 45000 ل.ل.
- ت. 147000 ل.ل.
- ث. 49000 ل.ل.

15. ما هو طول الضلع المجهول في الرسم المقابل؟

- أ. 3 متر
- ب. 9 متر
- ت. 10 متر
- ث. 2 متر



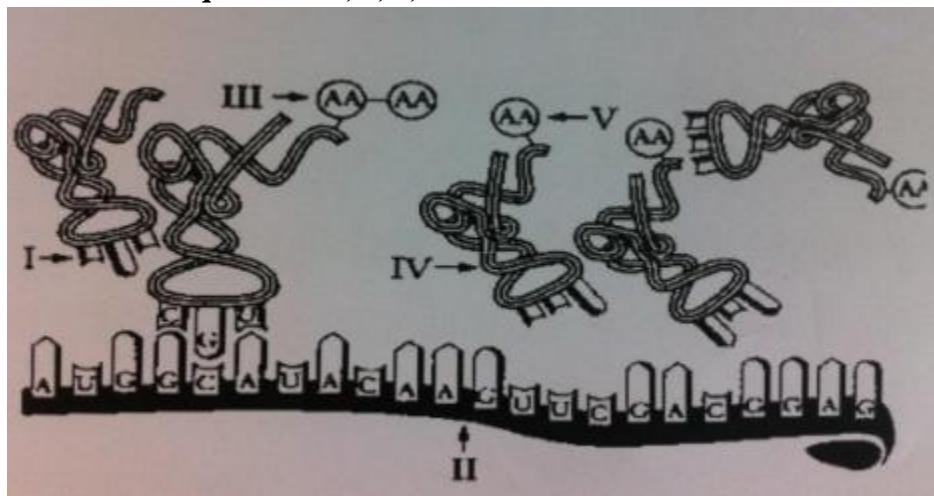
Appendix H: Grade Eleven Science Achievement Test (T3)

This test consists of three parts: Biology, Physics, and Chemistry.

Circle the letter of the choice which best answers the question or completes the statement on the answer sheet attached at the end of the test packet.

Part 1: Biology

The diagram below represents an essential process in the life activity of a cell. Refer to this diagram to answer questions 1, 2, 3, and 4.



- 1. Which of the above structures are composed of RNA?**
 - a. I and III
 - b. II and III
 - c. II and IV
 - d. III and IV

- 2. Anticodons are represented by the following structures:**
 - a. I
 - b. II
 - c. III
 - d. IV

- 3. DNA replication results in two DNA molecules, _____.**
 - a. each with two new strands
 - b. one with two new strands and the other with two original strands
 - c. each with one new strand and one original strand
 - d. each with two original strands

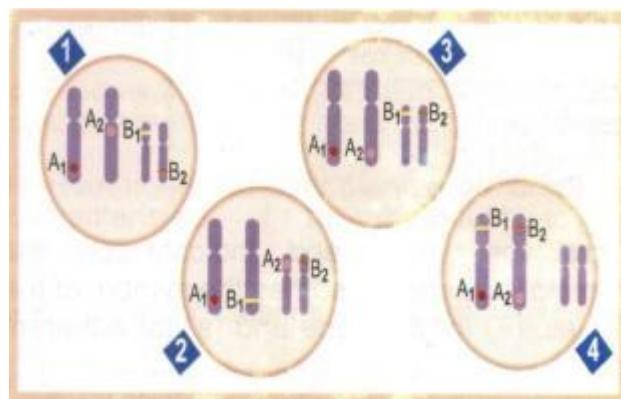
4. Which of the following are found in both DNA and RNA?

- a. ribose, phosphate groups, and adenine
- b. deoxyribose, phosphate groups, and guanine
- c. phosphate groups, guanine, and cytosine
- d. phosphate groups, guanine, and thymine

5. Why does the genetic code have to be a triplet code?

- a. Because there are more base pairs than amino acids.
- b. There is no reason
- c. So there are enough codes for the 20 amino acids
- d. So that each amino acid is coded by one base

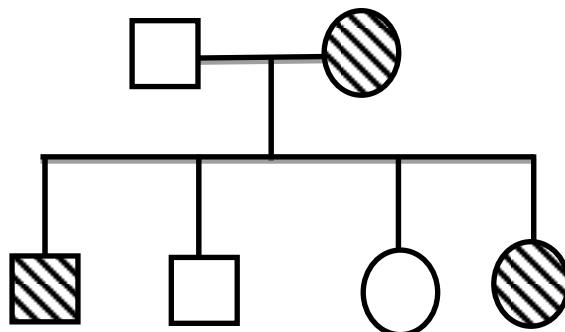
6. Given two different genes A and B, for each, there are two alleles: A₁ and A₂ for gene A, and B₁ and B₂ for gene B. The genes A and B are located on two pairs of different chromosomes.



Which drawing reveals the correct representations of the chromosomal positions of these genes for an individual?

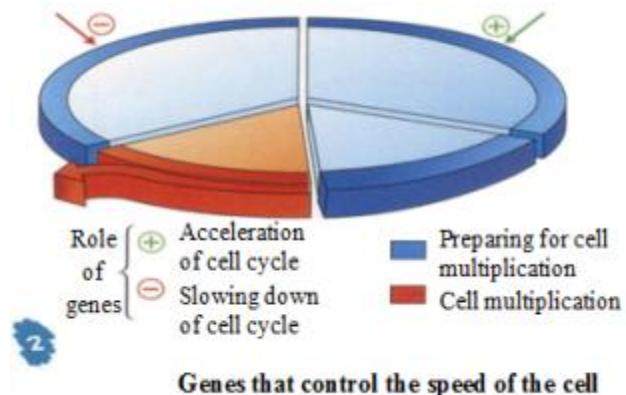
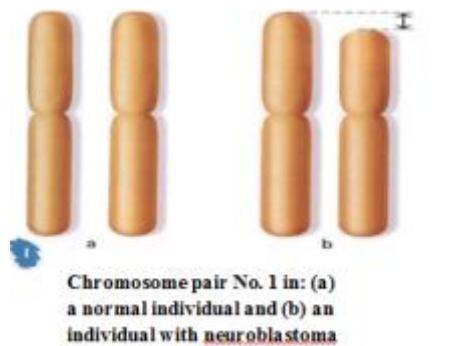
- a. Figure 1
- b. Figure 2
- c. Figure 3
- d. Figure 4

7. The figure below represents the pedigree of a family having some of its members suffering from a disease which is carried by the X chromosome.



Which statement is correct?

- a. The Disease allele is recessive, and the mother is a heterozygous
 - b. The Disease allele is recessive, and the mother is homozygous
 - c. The Disease allele is dominant, and the mother is heterozygous
 - d. The Disease allele is dominant, and the mother is homozygous
8. Neuroblastoma is a rare type of cancer that affects certain cells in the nervous system of infants. The study of chromosomes in these infants reveals a certain abnormality as shown below.



Which of the following is the main cause for neuroblastoma?

- a. Deletion of a segment of one the homologous chromosome pair No. 1, which contains the gene involved in the acceleration of cell cycle
- b. Deletion of a segment of one the homologous chromosome pair No. 1 , which contains the gene involved in the slowing down of cell cycle
- c. Insertion of a segment on one of the homologous chromosome pair No. 1, which contains the gene involved in the acceleration of cell cycle
- d. Insertion of a segment on one of the homologous chromosome pair No. 1 , which contains the gene involved in the slowing down of cell cycle

End of the Biology Part

Part 2: Physics

1. A point is moving in a circular path with a given radius R. If the instantaneous velocity of this point is doubled, then the magnitude of its normal acceleration:

- a) Is doubled
- b) Becomes four times greater
- c) Is reduced to the half
- d) Remains the same

2. In a uniform varied circular motion, the angular acceleration is:

- a) Proportional to the time
- b) Normal to velocity vector
- c) Constant
- d) Zero

3. A particle M moves by a uniform motion on a circle of radius R. Its velocity vector is then inversely proportional to:

- a) The period of the motion
- b) The frequency of the motion
- c) The angular velocity of M
- d) The angular acceleration of M

4. The wavelength of a vibratory motion increases with:

- a) The amplitude
- b) The square of the amplitude
- c) The frequency
- d) The period

5. A white spot rotates around the axis of a black disc at a rate of fifty rounds per second. It is illuminated by a stroboscope emitting flashes of frequency of 25 Hz. The disc appears to be:

- a) Stationary with one spot
- b) Stationary with two spots
- c) Stationary with four spots
- d) Rotating in slow motion

6. Sources S₁ and S₂ emit waves of amplitudes: a₁=1 cm and a₂=1.5 cm. Point M which belongs to a fringe of minimum amplitude:

- a) Vibrates with amplitude 0.5 cm
- b) Vibrates with amplitude 2 cm
- c) Vibrates with amplitude 2.5 cm
- d) Doesn't vibrate

End of the Physics Part

Part 3: Chemistry

Given Information:

Solution A of Potassium Permanganate ($KMnO_4$) was prepared by dissolving 0.70 g of potassium permanganate salt in 100 ml of distilled water.

- *Molar Masses: M(K)=39 g/mol, M(Mn)= 54.94 g/mol, M(O)= 16 g/mol*
- *Solubility of $KMnO_4$ is 63.8 g/L at 20°C*

Questions:

1. Solution A of Potassium Permanganate ($KMnO_4$) was prepared by dissolving 0.70 g of potassium permanganate salt in 100 ml of distilled water.

Which of the statements below describes solution A of potassium permanganate solution prepared above knowing that the solubility of potassium permanganate salt is 63.8 g/L at 20°C?

- (A) It's an unsaturated solution of potassium permanganate at 20°C.
 - (B) It's a saturated solution of potassium permanganate at 20°C.
 - (C) It's a supersaturated solution of potassium permanganate at 20°C.
 - (D) It needs more heat to be a homogenous solution.
- 2. Solution A of Potassium Permanganate ($KMnO_4$) was prepared by dissolving 0.70 g of potassium permanganate salt in 100 ml of distilled water.**

The Molar Masses of the elements making up potassium permanganate are: M(K)=39 g/mol, M(Mn)= 54.94 g/mol, M(O)= 16 g/mol

What is the molar concentration of solution A?

- (A) 0.0432 mol/L
- (B) 0.0443 mol/L
- (C) 0.0043 mol/L
- (D) 0.00044 mol/L

3. Few milliliters of potassium dichromate were added to Iron (II) sulfate solution. The reaction between the two solutions produces Ferric ions and Cr³⁺ ions. The balanced oxidation half reaction and the reduction half reaction respectively are: (L2)

- (A) $\text{Cr}_2\text{O}_7^{2-} \rightarrow \text{Cr}^{3+} + 5\text{e}^-$ and $\text{Fe}^{2+} + 1\text{e}^- \rightarrow \text{Fe}^{3+}$
- (B) $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow \text{Cr}^{3+} + 7\text{H}_2\text{O}_{(l)}$ and $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + 1\text{e}^-$
- (C) $\text{Fe}^{2+} + 1\text{e}^- \rightarrow \text{Fe}^{3+}$ and $\text{Cr}_2\text{O}_7^{2-} \rightarrow \text{Cr}^{3+} + 5\text{e}^-$
- (D) $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + 1\text{e}^-$ and $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow \text{Cr}^{3+} + 7\text{H}_2\text{O}_{(l)}$

4. Given the balanced equation of the reaction between potassium permanganate and Iron (II) sulfate: $\text{MnO}_4^- + 8\text{H}^+ + 5\text{Fe}^{2+} \rightarrow \text{Mn}^{2+} + 5\text{Fe}^{3+} + 4\text{H}_2\text{O}_{(l)}$

20 ml of potassium permanganate solution of molar concentration 0.03 mol/L are added to 20 ml of Iron (II) sulfate solution of concentration 0.08 mol/L. When the reaction ceases, the amounts of permanganate ions and Ferrous ions (in moles) are respectively:

- (A) $n(\text{MnO}_4^-) = 6 \times 10^{-4}$ mol and $n(\text{Fe}^{2+}) = 1.6 \times 10^{-3}$ mol
- (B) $n(\text{MnO}_4^-) = 2.8 \times 10^{-4}$ mol and $n(\text{Fe}^{2+}) = 0$ mol
- (C) $n(\text{MnO}_4^-) = 9 \times 10^{-4}$ mol and $n(\text{Fe}^{2+}) = 0$ mol
- (D) $n(\text{MnO}_4^-) = 0$ mol and $n(\text{Fe}^{2+}) = 1 \times 10^{-3}$ mol

5. Use the balanced equation of the chemical reaction of thiosulfate and Iodine to answer the following question: $2\text{S}_2\text{O}_3^{2-} + \text{I}_2 \rightarrow 2\text{I}^- + \text{S}_4\text{O}_6^{2-}$

20 ml of sodium thiosulfate solution of molar concentration 0.03 mol/L are added to 20 ml of Iodine solution of concentration 0.08 mol/L.

The final molar concentration of the Iodide ions in solution is:

- (A) $[\text{I}^-] = 1.5 \times 10^{-2}$ mol/L
- (B) $[\text{I}^-] = 3 \times 10^{-2}$ mol/L
- (C) $[\text{I}^-] = 6.67 \times 10^{-3}$ mol/L
- (D) $[\text{I}^-] = 7.5 \times 10^{-3}$ mol/L

Appendix I: Grade Eleven Math Achievement Test (T4)

Questions

1. The $\lim_{x \rightarrow -\infty} \frac{(x+1)^4 + (x+2)^4 + \dots + (x+100)^4}{x^4 + 10^4}$ is equal to _____.

- a. 1
- b. 10^2
- c. 10^4

2. The curve (**C**) defined by $f(x) = 3x^2 - 5x + 1$ is above the curve (**C'**) defined by $g(x) = 2x^2 + x + 8$ for _____.

- a. $x < -1$ or $x > 7$
- b. $x < -7$ or $x > 1$
- c. $x < -7$ or $x > -1$

3. $P_2 x_{(n+1)} P_3 = \underline{\hspace{2cm}}$.

- a. $n(n-1)(n+1)$
- b. $n^2(n-1)^2(n+1)^2$
- c. $n^2(n-1)^2(n+1)$
- d. none of the above

4. A grade 7 student wants to circle the correct answers of the 7-multiple choice questions randomly. What is the probability of getting the full mark?

- a. $\frac{1}{28}$
- b. $\frac{1}{5040}$
- c. $\frac{1}{16384}$
- d. None of the above

5. If $\{Un\}$ is an arithmetic sequence whose common difference is $\frac{1}{3}$ and $U_3 = -u$, then U_{200} is _____.

- a. $\frac{185}{3}$
- b. $\frac{192}{3}$
- c. $\frac{213}{3}$

6. If $f(x) = |2x + 4|$, then the derivative of $f(x)$ is _____.

- a. 2
- b. -2
- c. -2 if $x \leq -2$ or 2 if $x \geq -2$

7. Given (E): $x^2 - 2x - (m-u) = 0$ where m is a real number. If (E) has two distinct real roots, then m is equal to _____.

- a. $m > 3$
- b. $m = 3$
- c. $m < 3$

8. Given a triangle ABC such that $\tan A = \frac{1}{2}$. The value of $\cos A$ is _____.

- a. $\frac{\sqrt{5}}{5}$
- b. $\frac{2\sqrt{5}}{5}$
- c. 2

9. If $f(x) = \frac{3x^2 - 1}{x + 2}$, the $f'(x)$ is _____.

- a. $6x$
- b. $\frac{6x}{(x+2)^2}$
- c. $\frac{3x^2 + 12x + 1}{(x+2)^2}$

10. In the space referred to an orthonormal system $(0, i, j, k)$, consider the points $A(2; 3; 1)$, $B(1; -2; 3)$, and $C(7; 4; 6)$. The vector $n(-9; 5; 8)$ is _____.

- a. normal to the plane (ABC)
- b. parallel to the plane (ABC)
- c. belongs to the plane (ABC)

Appendix J: Exercises of the Science lesson of Grade 5 Plants

1- Copy and fill in the blanks with the proper terms.

Water and minerals - light - carbon dioxide.

* Green plants need from the soil. They take from the air.

But they wither when placed away from

2- Copy and correct each of the following statements.

- Plants live as parasites on other living organisms in order to get their food.

- Parasitic plants can produce their own food by using water.

- During photosynthesis, green plants need oxygen and water for producing starch and carbon dioxide.

3- Which one is the intruder?

- Photosynthesis, chlorophyll, darkness, starch.

- Truffles, mushrooms, algae, choke-weed.

4- According to the conditions established in the table below, we grew some radish seedlings during one of the science periods. We left them in the class for observation.

Pot	Conditions
1	soil and water in the presence of light and air
2	water and mineral salts in the presence of light and air
3	dry soil in the presence of light and air
4	soil and water in the presence of light and air devoid of carbon dioxide
5	Water and mineral salts in the presence of air and in the dark

- In which of the above containers would seedlings grow and develop?
- Why didn't growth take place in each of the other pots? Justify your answer.

Appendix K: Science Teacher's Classification to the Exercises of Grade 5

Science Lesson (Appendix E)

Title of the Science Lesson: Plants			
Exercises	C1	C2	C3
Ex 1	X		
Ex 2	Part 1	X	
	Part 2	X	
	Part 3	X	
Ex 3	Part 1		X
	Part 2		X
Ex 4	Part 1		X
	Part 2		X
Number of Exercises	4/8	4/8	0/8

Appendix L: Exercises of Grade 5 Math Lesson: Subtraction of Fractions

Exercises

1 Calculate:

$$\begin{array}{l} \frac{6}{9} - \frac{1}{3} ; \quad \frac{7}{5} - \frac{3}{5} ; \quad \frac{3}{4} - \frac{1}{4} \\ \frac{3}{9} - \frac{5}{9} ; \quad \frac{6}{10} - \frac{2}{10} ; \quad \frac{24}{100} - \frac{30}{100} \end{array}$$

2 Calculate:

$$\begin{array}{l} \frac{3}{4} - \frac{1}{2} ; \quad \frac{1}{2} - \frac{1}{3} ; \quad \frac{5}{4} - \frac{1}{2} \\ \frac{3}{4} - \frac{2}{3} ; \quad \frac{9}{5} - \frac{3}{2} ; \quad \frac{2}{3} - \frac{3}{5} \end{array}$$

3 Choose the correct answer.

- $\frac{3}{7} - \frac{1}{6} = \frac{2}{1} ; \frac{23}{42} ; \frac{11}{42}$ or $\frac{4}{13}$
- $3 - \frac{9}{4} = \frac{3}{4} ; \frac{6}{4} ; \frac{21}{4}$ or $\frac{21}{8}$
- $\frac{29}{5} - 6 = \frac{6}{5} ; \frac{30}{5} ; \frac{9}{10}$ or $\frac{9}{5}$

4 Calculate:

$$\begin{array}{l} 1 - \frac{2}{3} ; \quad \frac{8}{3} - 2 ; \quad 3 - \frac{10}{7} \\ \frac{7}{2} - 1 ; \quad 2 - \frac{4}{5} ; \quad \frac{15}{4} - 3 \end{array}$$

5 Find the difference:

$$\begin{array}{ll} \frac{7}{3} - \frac{2}{6} & \frac{2}{6} - \frac{1}{7} \\ \frac{3}{2} - \frac{1}{9} & \frac{6}{5} - \frac{2}{3} \\ \frac{8}{5} - \frac{2}{15} & \frac{7}{5} - \frac{3}{7} \end{array}$$

6 Include each of the following fractions between two consecutive whole numbers. Then round:

$$\frac{3}{7} ; \frac{7}{4} ; \frac{9}{8} ; \frac{17}{3} ; \frac{24}{9} ; \frac{25}{8}$$

7

At what fraction of the track does cyclist A pass cyclist B?

1101

Self-Evaluation

1. a) Calculate:

$$\begin{array}{l} 3 - \frac{12}{5} ; \quad \frac{23}{4} - 5 ; \quad 7 - \frac{2}{3} ; \quad \frac{17}{8} - 2 \\ \frac{8}{4} - \frac{3}{12} ; \quad \frac{7}{9} - \frac{2}{6} ; \quad \frac{6}{7} - \frac{2}{6} ; \quad \frac{5}{3} - \frac{3}{5} \end{array}$$

b) For each of the obtained answers, find the nearest whole number.



Problems

- 1 A pool is filled to the $\frac{5}{6}$. We emptied it in two stages. We started emptying the half. What fraction of the water is left to empty?



- 2 In an oil barrel filled to the $\frac{2}{7}$, father pours a quantity of oil that corresponds to half of the capacity of the barrel. Then, mother withdraws the $\frac{5}{14}$.

What is the fraction that represents the quantity of oil remaining in the barrel?

- 3 Fadi bought 3 chocolate bars. He distributed to each of his 10 friends the quarter of a bar. What fraction of a bar of chocolate does he have left?

- 4 Lamia is reading a novel. The first day, she read $\frac{2}{9}$ of the novel. The second day, she read $\frac{1}{3}$ more than the first day. The third day, she read $\frac{2}{6}$ less than the second day.

At the end of the third day, had she finished reading this novel?

- 5 Sami and Samia want to buy a gift for their little sister. Sami can pay $\frac{2}{5}$ of the price of the gift and Samia $\frac{1}{3}$. Their father decides to pay the remaining amount.

What fraction should he pay?



- Using the kg as the unit, to what fraction of the kg correspond 200 g?
A confectioner packs candy in packets of 200 g. How many kg of candy must he estimate if he wants to fill 50 packets?

A runner must run 3 laps around a track in four stages.

- (e ran:
1 lap and a quarter (1st stage)
 $\frac{1}{4}$ lap (2nd stage)
 $\frac{1}{2}$ lap (3rd stage)
 $\frac{1}{4}$ lap (4th stage)

Did he run 3 laps around the track? If not, what fraction of the track does he have left to run?

- For his birthday, Sami offers each of his 22 guests $\frac{1}{6}$ of a strawberry pie. How many strawberry pies must his mother prepare?



Invent a problem where we must carry out this calculation to find the answer.

a) $\frac{17}{4} - \frac{3}{4}$ b) $6 - \frac{22}{5}$

Mother wants to make a dozen of napkins.

She counts $\frac{3}{4}$ meter of material for each napkin.

She bought 7 m of material. Is this length enough?

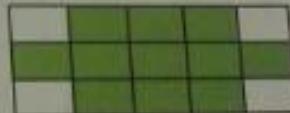
I think of a number. I add to it $\frac{3}{7}$, then I subtract $\frac{1}{5}$ of the obtained

answer. I get $\frac{19}{35}$. What number did I think of?

- For a feast, we prepared 3 small cakes divided into 8 pieces each. We offered 2 pieces to each of the 10 guests. Find the fraction of a cake that each guest received and the fraction of the remaining cake.

- A dressmaker needs $\frac{3}{4}$ of material that she has to make a dress, and $\frac{1}{5}$ to make a skirt.
After having made the dress with this material, can she still make the skirt? Justify your answer.

- In a kitchen garden, the cultivated area is represented in green in the following figure:



The owner says that the difference between the area of the cultivated part and the uncultivated part is worth the third of the total area.

Is he right? Justify your answer.

- A farmer sold $\frac{2}{6}$ of his crop, then $\frac{2}{5}$, and then $\frac{3}{15}$.



Did he sell all of his crop?
If not, what fraction of the crop does he have left?

Appendix M: Math Teacher's Classification of the Exercises of Grade 5

Math Lesson (Appendix G)

Title of the Math Lesson: Subtraction of Fractions			
	C1	C2	C3
Exercises	Ex 1	X	
	Ex 2	X	
	Ex 3	X	
	Ex 4	X	
	Ex 5	X	
	Ex 6	X	
	Ex 7		X
Self Evaluation	Part 1		X
	PART 2		X
Problems	Ex 1		X
	Ex 2		X
	Ex 3		X
	Ex 4		X
	Ex 5		X
	Ex 6		X
	Ex 7		X
	Ex 8		X
	Ex 9	X	
	Ex 10		X
	Ex 11	X	
	Ex 12		X
	Ex 13		
	Ex 14		X
	Ex 15		X
Number of Exercises	8/24	10/24	6/24

Appendix N: Exercises of Grade 11 Biology Lesson: The Diversity of Organisms and the Uniqueness of the Individual

EXERCISE 1

Mark the true statements and correct the false ones.

1. There are not two human beings with the same genetic program.
2. Transplant rejection is caused by the similarity of markers between the donor and the recipient.
3. The identity markers exist in all our cells.
4. The bone marrow contains stem cells for red blood cells only.

EXERCISE 2

Choose the correct answer(s)

1. Fetal and maternal blood
a- mix at the placental level.
b- mix at the umbilical cord level.
c- do not mix.
d- are not in direct contact.

2. The prokaryotic cell has
a- a nuclear membrane.
b- many linear chromosomes.
c- one free chromosome.
d- a cytoplasmic membrane.

3. The genetic information of eukaryotic cells is found in
a- the cytoplasm.
b- the chromosomes.
c- the cytoplasmic membrane.
d- the nucleus.

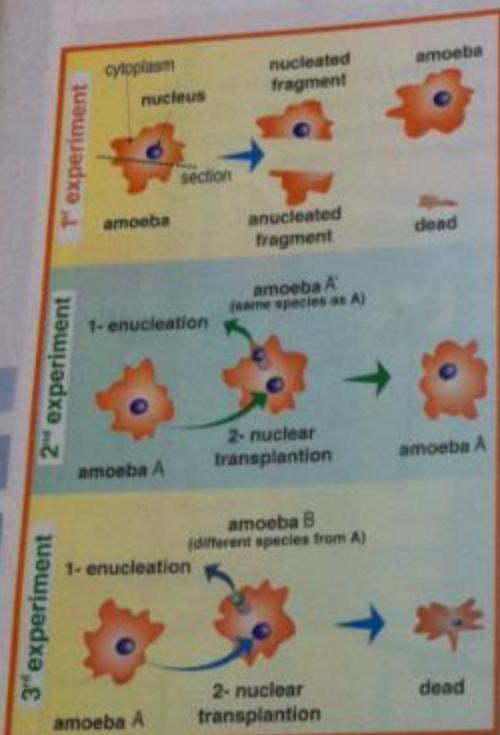
EXERCISE 3

The seaweed Acetabularia is an algae consisting of a single giant cell. Various sectioning and grafting experiments were performed on this algae.

1. Analyse the above experiments.
2. What can one deduce?

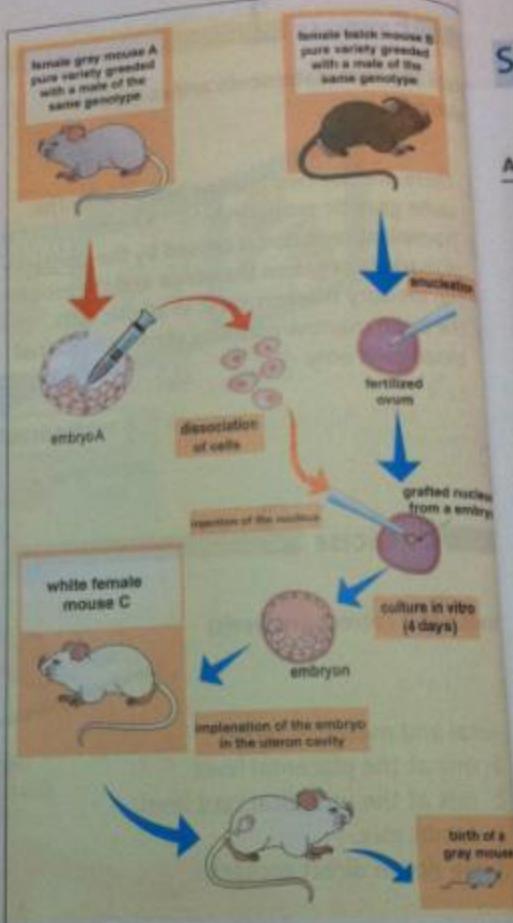
EXERCISE 4

Microsurgery experiments were performed on amoeba (unicellular eukaryote).



EXERCISE 5

Nuclear transplantation experiments on mice have led to the following results:



1. Describe and interpret the first experiment.
2. Compare and explain the results of the second and the third experiments.

1. How could we obtain a clone of individuals?
2. What is the role of each of the three mice used in this experiment?
3. What is the main information given by the birth of a grey baby mouse?
4. What are the aspired advantages of the mammal cloning technique?

Appendix O: Biology Teacher's Classification of the Exercises Grade 11

Biology Lesson (of Appendix I)

Title of the Lesson: The Diversity of Organisms and the Uniqueness of the Individual		C1	C2	C3
Exercise 1	Part 1	X		
	Part 2	X		
	Part 3	X		
	Part 4	X		
Exercise 2	Part 1	X		
	Part 2	X		
	Part 3	X		
Exercise 3	Part 1		X	
	Part 2			X
Exercise 4	Part 1		X	
	Part 2		X	
Exercise 5	Part 1		X	
	Part 2	X		
	Part 3		X	
	Part 4			X
	Number of Ex.s	8/15	5/15	2/15

Appendix P: Exercises of Grade 11 Physics Lesson (Musical Sounds-Waves)

TEST YOUR KNOWLEDGE

1 Explain the terms: Timbre of sound, fundamental sound and harmonics.

2 True or false; correct the wrong statements.

- A complex sound is sinusoidal.
- The timbre of a sound is related to its amplitude.
- The pitch of a sound is related to its frequency.
- The second harmonic of a pure sound of frequency f , has a frequency of $2f$.

3 Fill in the blanks:

- A sound of frequency 50 Hz has a pitch than a sound of frequency 500 Hz.
- The loudness of a sound depends on its.....
- Sounds of the same musical note played on different instruments have the same.....
- The oscilloscopes of the same musical note played on two different instruments have the same.....

APPLY YOUR KNOWLEDGE

4 Check the dictionary to find the meaning of the statement: "Two musical instruments play the unison".

5 Choose the best answer
A musical note, played on a guitar in air, propagates through the chord and through air. The note has:

- Same frequency but different wavelengths.
- Same frequency and same wavelength
- Same wavelength but different frequencies.
- Different frequencies and wavelengths.

6 The oscilloscope of the vowel O, pronounced by a person, is displayed on the screen of an oscilloscope. What do you observe on the screen if the same person pronounces the same vowel but with high intensity?

7 The frequency of a complex sound is 150 Hz.
a) Identify the pitch of this sound.
b) Calculate the frequency of its fourth

8 A tuning fork emits a sinusoidal sound wave of frequency 440 Hz. A musical instrument emits another sound of frequency 440 Hz, which contains all the even audible harmonics.

- Identify these two sounds.
- Do they have the same timbre? Justify
- Determine the frequencies of all harmonics emitted by the musical instruments.

9 An electric circular saw of 200 teeth rotating at a speed of 3000 r.p.m, cuts a piece of wood. What is the frequency of the heard sound?

10 The spectrum of a musical sound is represented in figure 6.12

Figure 6.12

receiver detects a sinusoidal potential difference of frequency 50 kHz.

- c) The emitter is now connected to a sinusoidal potential difference of frequency 12.5 kHz. The detector does

not give any response.

Interpret the above three experiments and give a conclusion concerning the functioning of the detector.

Appendix Q: Physics Teacher's Classification of the Physics Exercises of Appendix K

Title of the Lesson: Musical Sounds-Waves			
Exercises	C1	C2	C3
Ex 1	X		
Ex 2	X		
Ex 3	X		
Ex 4	X		
Ex 5	X		
Ex 6	X		
Ex 7	X		
Ex 8	X		
Ex 9	X		
Ex 10		X	
Ex 11			X
Ex 12		X	
Ex 13			X
Ex 14			X
Ex 15			X
Number of Ex.s	9/15	2/15	4/15

Appendix R: Exercises of Grade 11 Chemistry Lesson: Redox Reactions

MnO₄⁻ + Cl⁻ → ...

Exercises

1 Complete the following sentences:

- Water molecule of formula the o.n. of the atoms hydrogen and oxygen respectively are
- During a reaction: an atom is oxidized if its o.n..... and an atom is reduced if its o.n.....

2 Answer True or False.

- The o.n. of the oxygen atom is the same in O₂ and SO₂ molecules.
- The formation reaction of water:

$$H_2 + \frac{1}{2} O_2 \rightarrow H_2O$$

is not a redox reaction.

- In S₈, the o.n. of sulfur is equal to +VIII.
- During the redox reaction:

$$C + O_2 \rightarrow CO_2$$

the oxygen element is an oxidizing agent.

3 Match the terms column A to those column B.

A	B
a) Cl ₂	1) o.n of Cl = -I
b) HCl	2) o.n of Cl = +VII
c) ClO ₄ ⁻	3) o.n of Cl = 0

4 Choose the best answer:

- In H₂O₂ the o.n. of oxygen is equal to:
1) - II
2) - I
3) 0.
- The reduction of an atom involves a (an):
1) Increase of its o.n.
2) Decrease of its o.n.
3) Conservation of its o.n..

c) In the ClO⁻ ion, the o.n. of chlorine is:

- I
- 0
- +I.

5 Determine the o.n. of sulfur atom in the following species:

$$S, H_2S, H_2SO_4, SO_3^{2-}, SO_2, SO_3$$

6 Arrange the following chemical species in order of increasing o.n. of chlorine:

$$ClO_4^-, Cl_2, Cl^- , ClO_3^-, ClO_2^-, ClO^-.$$

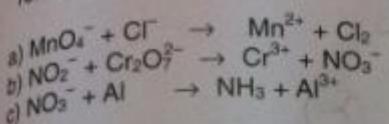
7 Which of the following reactions are redox reactions?

- Ag⁺ + Cl⁻ → AgCl
- 2SO₂ + O₂ → 2SO₃
- SO₃ + H₂O → H₂SO₄
- N₂ + 3H₂ → 2 NH₃
- 2 Mg + CO₂ → 2 MgO + C
- H⁺ + HO⁻ → H₂O
- 4HCl + O₂ → 2 Cl₂ + 2H₂O

8 Balance the following equations of redox reactions and indicate the oxidizing agent and the reducing agent:

- H₂S + O₂ → H₂O + SO₂
- H₂S + SO₂ → S + H₂O
- SiO₂ + Mg → MgO + Si
- ZnS + O₂ → ZnO + SO₂

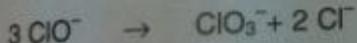
9 Balance, in an acidic medium, the following equations of redox reactions, using the half-reaction method:



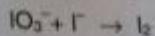
10 Use the o.n. method to balance, in an acidic medium, the half-reactions of the following redox couples:

- a) $\text{Cr}_2\text{O}_7^{2-} / \text{Cr}^{3+}$
b) $\text{MnO}_4^- / \text{Mn}^{2+}$
c) $\text{SO}_4^{2-} / \text{SO}_2$
d) $\text{O}_2 / \text{H}_2\text{O}_2$

11 In a disproportionation reaction, the atom of an element in one oxidation state (number) is simultaneously oxidized and reduced. Show that the following balanced equation is a disproportionation reaction.

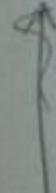


12 Show that the following equation corresponds to a disproportionation reaction.



13 Aluminum reacts with Fe_2O_3 and is transformed into Al_2O_3 whereas, the iron oxide is transformed into iron.

- a) Write the balanced equation of this reaction. Identify the oxidizing agent and the reducing agent.
b) If 16 kg of Fe_2O_3 is used. What is the quantity of aluminum needed to reduce all the oxide and what is the mass of the iron obtained?



Appendix S: Chemistry Teacher's Classification of the Chemistry Exercises of Appendix M

Title of the Lesson: Redox Reactions			
Exercises	C1	C2	C3
Ex 1	X		
Ex 2		X	
Ex 3	X		
Ex 4	X		
Ex 5		X	
Ex 6		X	
Ex 7		X	
Ex 8		X	
Ex 9		X	
Ex 10		X	
Ex 11			X
Ex 12			X
Ex 13		X	
Number of Exercises	3/13	8/13	2/13

Appendix T: Exercises of Grade 11 Math Lesson: Calculation on Polynomials

Testing your knowledge

Only one of the proposed answers is correct. Which one?

		A	B	C
1	A root of $P(x) = (x - b)^7 + (b - a)^7$ is...	$-a$	$+a$	0
2	$P(x) = x^{101} - x^{97} - 1$. The remainder of $P(x)$ by $x + 1$ is...	1	3	-1
3	A root of $A(x) = 2x^3 - x^2 - 5x - 2$ is...	-1	1	-2
4	$\frac{x^2 - 3x + 2}{x + 3} = ax + b + \frac{c}{x + 3}$, the constant c is ...	-16	20	32
5	$\frac{x^2 + ax + b}{x + 3} = x - 1 + \frac{2}{x + 3}$ then ...	$a = 2$ $b = -1$	$a = -2$ $b = 2$	$a = 0$ $b = -2$
6	The remainder of division of $(x^2 + x + 1)^2 - 1$ by $x^2 + x + 2$ is...	0	2	-1
7	If $x^3 + ax + 2$ is divisible by $(x - 1)^2$, then $a = ...$	-3	3	-1
8	The remainder of division of $x^n + 2$ by $x + 1$ is 1, in case $n = ...$	11	12	0
9	If 2 is a double root of $x^3 + ax^2 + 4$, then $a = ...$	3	2	-3
10	If $\frac{x^2 - 2x - 3}{x - 2} = x + \frac{a}{x - 2}$ then $a = ...$	-3	3	2
11	A factor of $A(x) = x^3 + 5x - 6$ is ...	$x - 1$	$x - 2$	$x + 1$
12	The remainder of division of $A(x) = x^4 + 4$ by $B(x) = x^2 + 2$ is ...	0	8	-8
13	The area of a rectangle is $x^4 + 3x^2 + 2$ where x is a given length. One of its dimensions is $x^2 + 2$. The other is ...	$x^2 + 3$	$x^2 + 1$	$x^2 + 2$

Exercises

- 9** Given
Calcu
- 10** Given
B(x)
a) Fi
b) S
- 11** a)
b)
c)
- 12**
- 1** Verify that $\frac{-1}{2}$ is a root of the polynomial $P(x) = 10x^3 + 19x^2 + 13x + 3$.
Determine the quotient of $P(x)$ by $2x + 1$.
- 2** Given the polynomial $P(x) = x^4 + 3x^3 + 4x^2 + mx + n$.
Determine the constants m and n for which the polynomial is divisible by $x^2 - 1$.
Find the quotient of $P(x)$ by $x^2 - 1$.
- 3** Given the polynomial $P(x) = x^6 + 2x^4 - 12x^3 + x^2 - 12x + 36$.
Prove that $P(x)$ is the square of a polynomial $Q(x)$ to be determined.
- 4** Given the polynomial $E_n(x) = (x + a + 1)^n - x^n - a^n - 1$ where $a \in \mathbb{R}$ and n odd natural integer. Prove that $E(x)$ is divisible by $(x + a)(x + 1)$.
Factorize $E_3(x)$.
- 5** Prove that $P(x) = x^4 + 4$ is divisible by $x^2 + 2x + 2$.
Factorize $P(x)$.
- 6** a) Find the values of the constants a and b if $(x - 2)$ and $(x - 3)$ are both factors of $P(x) = x^3 + ax^2 + bx + 4$.
b) Factorize $P(x)$.
c) Simplify the rational fraction $\frac{P(x)}{x^2 - 9}$.
- 7** Given the polynomial $F(x) = x^3 + ax^2 + bx - 2$. Calculate the constants a and b knowing that $x - 3$ is a factor of $F(x)$ and the remainder when $F(x)$ is divided by $x - 1$ is 4.
- 8** Given the polynomial $E(x) = x^3 + ax^2 + bx - 4$. Calculate the constants a and b when $E(x)$ is divisible by $x^2 - 4$, then factorize $E(x)$.

15 Given the trinomial $F(x) = ax^2 + bx + c$ where a, b, c are constants. Calculate a, b, c knowing that the remainders of division of $F(x)$ by $x - 1, x + 1$ and $x - 2$ are respectively 8, -6 and -4.

16 Simplify each of the following fractions :

a) $F(x) = \frac{x^4 - 5x^2 + 4}{x^3 - 4x^2 + x + 2}$

b) $G(x) = \frac{x^3 - 4x^2 + 2x + 4}{x^2 - 7x + 10}$

Appendix U: Math Teacher's Classification of Exercises of the Math Lesson (Appendix O)

		Title of the Lesson: Calculation on Polynomials		
		C1	C2	C3
Knowledge Part	Part 1	X		
	Part 2		X	
	Part 3	X		
	Part 4		X	
	Part 5	X		
	Part 6	X		
	Part 7		X	
	Part 8		X	
	Part 9	X		
	Part 10	X		
	Part 11	X		
	Part 12	X		
	Part 13		X	
Exercises	Ex 1		X	
	Ex 2		X	
	EX 3		X	
	EX 4		X	
	EX 5		X	
	Ex 6		X	
	EX 7			X
	Ex 8			X
	Ex 9		X	
	Ex 10		X	
	Ex 11		X	
	Ex 12		X	
	Ex 13		X	
	Ex 14			X
	Ex 15			X
	Ex 16		X	
Number of Exercises		8/29	17/29	4/29