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Exploring Learning Loss in Mathematics for Lebanese Secondary School Students during Economic and Health Crisis

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Abstract

The purpose of this research is to explore the effect of school closure during the economic and health crises on the learning loss of mathematics concepts of secondary students in public and private schools in Lebanon. This mixed research study used concurrent exploratory design involving quantitative data collection through teachers' questionnaires and qualitative through a comparison of the official examinations in mathematics and CERD documents before and after the crisis. Data analysis was conducted along descriptive and inferential statistics for the questionnaire while document analysis was used to compare suspended concepts between 2019-2022 as well as a thorough analysis of the official exams for grade 12 – General Sciences. A parallel study following the same methodology was implemented for biology. The results showed that there is a significant learning loss in mathematics content along the three targeted years. The official national exams analysis grounded on Bloom's taxonomy showed a decline in quality. Based on the teachers' perspectives, there is a discrepancy between learning loss in private and public schools as well as between different regions. The results of this study will inspire the policymakers to implement plans for remedy and holistic measures for mathematics learning loss.

Introduction

All aspects of life have been significantly touched by the COVID-19 pandemic. Learning has been significantly disrupted for many kids, and learning disparities became worse as a result of an increased reliance on parent-led and self-guided learning, staggered school attendance, and a lack of suitable home educational resources (World Bank, 2021). In Lebanon, the situation was even more complicated, in addition to what preceded, a catastrophic explosion at Beirut's port, an economic collapse and widespread misery, political impasse, teachers' strikes and escalating unrest are just a few of the disasters that Lebanese children and families have had to contend with (Mokuo, 2021). The Ministry of Education and Higher Education (MEHE) issued a distance learning plan for all public and private schools with broad recommendations on three routes due to school closures: They implemented various media means to raise awareness and to provide psychological support for parents and students. However, the concentration was on students who were in grade 9 or grade 12 classes that will sit for national exams in the same year. Online platforms were also recommended by MEHE, while some private schools used their own platforms, Microsoft Teams that was established with Microsoft was the official application used by public

schools. School administrators in elementary and secondary schools set up additional internet platforms (such as WhatsApp, Telegram, etc.) to facilitate access for kids including refugees.

Additionally, MEHE provided guidelines for instructors to use as a reference for their work during the teleworking time. These guidelines focused on three areas: planning and distributing lessons, checking in with students on their assignments, and grading and reporting. MEHE also supplied feedback forms so that educators, professionals, and others could share their opinions on the paths (Banati et al., 2020). In spite of all these measures, Smith and Ndeda (2021) reported that more than 1.2 million kids in Lebanon have missed school since the pandemic. Lebanese students have only likely attended school for a maximum of 11 weeks throughout the course of COVID-19, while Syrian children have attended school for even less weeks. Since October 2019, when demonstrations and civil upheaval impacted various sections of the nation, many kids in Lebanon have missed school. Multiple teachers went on strikes that same year for untimely salary payments further disrupted education. The fall of the currency, the explosion at the Beirut port, and COVID-19 lockdown measures all contributed to the learning crisis. Members of the same family shared the same portable phone to access online lessons, and sometimes need to utilize their neighbors' internet connection. Thus, the learning loss in Lebanon is threatening children's education and futures.

Learning Loss

The term "learning loss" refers to any particular or general loss of information and abilities as well as to reversals in academic progress, which are most frequently brought on by significant pauses or breaks in a student's education (Learning Loss, 2013). Based on this definition, the interruptions caused by the instable situation in Lebanon has a major impact on students' learning and needs to be diagnosed and solved.

Mathematics Learning Loss

Mathematics is a cumulative and linked subject. Concepts in the mathematics' curriculum must be introduced in a way that they build on one another. Rather than viewing mathematics as a collection of concepts, students should understand the connections between fundamental mathematical concepts. Students' understanding grows and deepens as they develop connections and abilities (NCTM, 2005). The spiral mathematics curriculum was implemented in many countries including Lebanon (CERD, 1997). The cognitive theory established by Jerome Bruner in 1960 serves as the foundation for the Spiral Curriculum. The theory is based on three key components:

- (1) The student returns to a topic, theme, or subject on multiple occasions throughout their academic careers;
- (2) The topic or theme becomes more complex with each encounter;
- (3) New learning is related to previous knowledge and is placed in context with the earlier knowledge.

The advantages cited by the spiral curriculum include reinforcement and solidification of material, a logical progression from simple ideas to complicated ideas, and applying the early knowledge to later course objectives (Johnston, 2012). Based on this analysis and due to the gap in learning in Lebanon in the past three years, it is certain that mathematics learning loss is major and needs direct and rigorous intervention.

The Research Problem

The curricula in Lebanon underwent several suspensions highly revealed in 1999 and 2018 which made students miss important concepts through their education in primary, intermediate and secondary classes. There is also clear evidence of inequity between private and public schools (Carascall, 2020). The degree to which the key goals and issues of the Lebanese curriculum were accomplished during the school year 2020–2021 was the subject of a research carried out by the Center of Educational Research and Development CERD (2022). The analysis revealed that, despite all obstacles, 65% of the program was completed. The Ministry of Education and Higher Education (MEHE) highlighted the Lebanese students' learning loss at the level of knowledge and skills due to the curriculum suspension because of the Corona pandemic and the economic crisis in Circular No. 39/m/2022, which was released on October 13, 2022. It also stressed the need to gradually return to the curriculum before the suspensions. The learning loss in mathematics is very important since it influences students at all stages in life whether at school, university or work.

Theoretical Framework

According to Bruner (1996) as cited in McLeod (2019), there should be an emphasis on the students' role in their learning, they should not rely solely on the teacher to explain a mathematical concept. Rather, students should figure it out for themselves by finding connections and similarities between various facts, concepts, and theories. Instead of instructing students to memorize facts, the role of a teacher should be to promote their learning. This means that a skilled teacher will create lessons that assist pupils in understanding the connections between different pieces of knowledge. A teacher must provide the information students require in order to accomplish this without organizing it for them. The discovery learning process can be aided by the usage of spiral curriculum. According to Bruner, a child's level of intellectual development is determined by how much proper teaching and practice—or experience—have been provided. Bruner's spiral curriculum entails a strategy that accentuates revisiting the same subject matter repeatedly over the course of a student's schooling. The student acquires deeper understanding of the subject with each review of the material. It provides the advantages of sustaining knowledge over time and utilizing existing knowledge to guide subsequent learning. Three guiding concepts that summarize Bruner's spiral approach to education being dependent on prior knowledge, cyclical and increasing in depth. Thus, students should revisit the same subject multiple times, they should learn the subject at a greater level and explore more complexity each time they revisit it. When a topic is revisited, a student's prior knowledge should be used so that they can build upon their existing knowledge rather than having to start from scratch (Drew, 2019). The inconsistencies in learning through the past years due to the pandemic and shift to remote teaching had a great impact on the quality of education (Kamil et al., 2020) as well as disparity between schools and regions (Herold, 2020). The Lebanese context was even worse due to the economic situation, the poor infrastructure, the teacher well-being as well as the inequity which influenced the quality and quantity of learning (Farhat, 2021).

Conceptual Framework

This study explores high school Lebanese students' learning loss in mathematics due to the curriculum suspension

and teachers' practices as well as the quality of Lebanese national official exams.

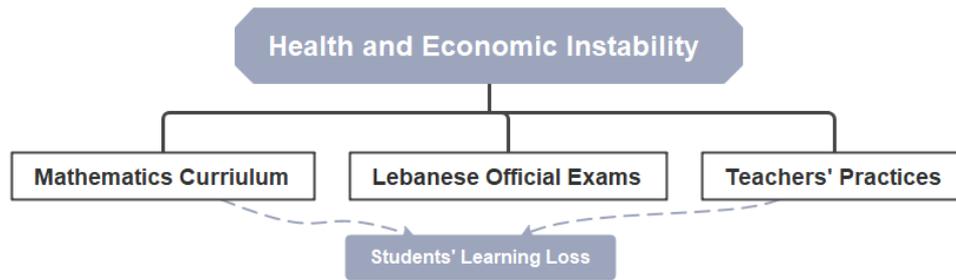


Figure 1. Conceptual Framework of Students' Learning Loss

Figure 1 represents the conceptual framework of the study. The research explored the influence of the health and economic situation in Lebanon on the suspension of mathematics curriculum as well as the quality of national mathematics exams. The effect of the instability on mathematics high school Lebanese curriculum progression and coverage based on the teachers' answers was also under study. These three factors had their main effect on students' learning loss.

Rationale

Concerns regarding the pandemic's potential short- and long-term consequences on students' academic achievement and social-emotional health have persisted over time. It is challenging for educators to discover the causes and suggest remedies for learning loss. Thus, this issue was a major concern for researchers around the world (Engzell et al, 2021; Moscoviz, & Evans, 2022). Mathematics learning loss was considered heavier than that in other subjects (Long et. al., 2021). However, few research was implemented in mathematics and its effect on quality and quantity of students' learning loss (Merentitis, 2021). In Lebanon, research targeted barriers of online teaching and learning and influence on accessibility to online resources (CERD, 2022). However, no research went deep to study the quality of assessment and content suspension. This study will fill a gap in this sense.

Significance

The results of this study will guide curriculum designers, national examinations committees and teachers to plan for learning loss remedy through recapitulating the important objectives missed during the Lebanese crisis. This study will highlight the objectives suspended in mathematics at the secondary level; the cognitive levels of knowledge in official exams as well as the objectives covered in class.

Purpose and Questions of Research

This study aims to investigate the impact of school closure due to Corona Pandemic and the economic crisis on

Lebanese students' learning. It specifically targets secondary students' learning loss in mathematics during the last three academic years: 2019-2020, 2020-2021 and 2021-2022. This study is designed in parallel to another study targeting learning loss in Biology. The research addressed the following questions:

- 1- What are the mathematics objectives/topics suspended by CERD in grades: 10, 11, and 12, during the last three academic years from 2019 till 2022?
- 2- To what extent is there learning loss in mathematics in Lebanese secondary schools, based on teachers' experience, during the last three academic years from 2019 till 2022? How do private and public schools compare?
- 3- To what extent is the level of the mathematics grade 12 general sciences official exam based on Bloom's taxonomy in 2021 and 2022 as compared to the national exams in 2019 and 2018?

Literature Review

Learning loss due to school closures are one of the biggest global threats (World Bank, 2022). Patrinos (2022) conducted an organized evaluation of the documentation used to identify learning loss over the course of a full year. Out of the eight investigations, the results showed that four revealed inequalities; of which three revealed that demography had an influence on learning loss. According to a newly released McKinsey report, on average, kids lost four months of learning between the examinations taken in 2021 by 1.6 million elementary school-aged children and the assessments taken in 2017, 2018, and 2019. Students overall dropped behind in reading and math by four and five months, respectively, according to the data. The report also discusses how the epidemic increased inequality and widened the attainment gap between kids from more wealthy backgrounds and those from less privileged backgrounds. In comparison to suburban districts, the learning loss, measured using cumulative months of math instruction, was not more significant in rural areas but highly significant with urban areas (Dorn et al., 2021). Chen et al. (2021) McKinsey survey showed that several student demographic subgroups have been particularly adversely damaged. Economic standing is also important. Teachers in schools where more than 80% of students come from low-income families reported an average learning loss of 2.5 months, as opposed to a reported loss of 1.6 months in schools where more than 80% of students come from households with incomes above the poverty line. The pandemic had its significant effects on math learning loss (Locke, 2021). The disparity between schools in Lebanon is prevalent since a long time. Frayha (2009) identified two major problems in the Lebanese educational system which are the influence of sects on education and social and quality disparities between schools and regions. On a social level, Lebanon has evolved into a dual system, with public education attracting lower middle-class and poor social groups while private education has engrossed middle-class and upper middle-class groups, with the exception of free private education, which is targeted at the very poor. Consequently, a large quality variation exists between private and public education, which has led many families to choose private schooling even if it comes with a significant increase in costs.

Learning Loss in Lebanon

CERD (2022) implemented a study about the ability of teachers to cover specified objectives/ topics during online

teaching. Basic issues such as technical problems were the major concern. Respondents' answers to technical barriers showed problems related to internet speed, and the presence of educational platforms. At the level of the education sector, the study showed statistically significant differences between the public and private sectors. At the governorate level, the study showed that there are statistically significant differences between the governorates, as the governorate of Akkar is the most suffering, while the Mount Lebanon governorate is the least suffering. Hammoud and Shuayb (2021) implemented a study on the challenges in online education. Only one-fifth of parents (19%) and one-quarter of instructors (27%) favored online education, according to the study's findings. However, around one third of the parents (34%) and teachers (35%) said that the primary worries for going back to online learning are power outages and a lack of dependable internet in the midst of the rising fuel crisis.

Mathematics Learning Loss

Schult et al. (2022) study compared exam results from fall 2020 to those from the previous three years in order to calculate the amount of learning that had been lost. Math test scores in grades K–8 in the fall of 2020 were significantly lower than test results from previous years. Students' math skills were equivalent to those required in lower classes. They were not able to cope with their class level math standards.

Haser et al. (2022) examined how mathematics learning loss occurred among Turkish middle school students during the COVID-19 school closures by exploring the methods, difficulties, and efforts of the math teachers as they attempted to assist their students' learning. The practices of the 19 public and 9 private middle school mathematics teachers interviewed revealed certain variances as well as the inequities that still persist between the schools, classrooms, and pupils. Loss of mathematics learning can be attributed to a variety of factors, including students' lack of engagement, teachers' restricted use of effective teaching strategies, socioeconomic position of families, and students' lack of cooperation with teachers.

Method

This study is a mixed research where both quantitative and qualitative data were collected. It implements a concurrent exploratory design. Quantitative data were collected through a teachers' questionnaire and qualitative data through open ended questions in the questionnaire and through document analysis of the curriculum and official exams.

Sample of the Study

The study targeted mathematics secondary teachers in both private and public schools from different Lebanese regions. The questionnaire was distributed through WhatsApp groups. Seventy-one teachers responded voluntarily. Table 1 shows the distribution of the teacher participants according to type of school and region they teach in. Most of the teacher respondents were from Mount Lebanon and the least from the North in spite of sending the questionnaire to the WhatsApp mathematics teachers' groups in all the regions. The majority of high

school teachers in Lebanon teach in both schools: public and private which is not common in the world. Teachers in Lebanon may be full time teachers in public schools and teach extra sessions in a private school due to the severe economic situation so teachers work extra hours to get more income.

Table 1. Profile of the Participants

		Mount Lebanon	South	Bekaa	Beirut	North	Total
Type of school	Public	3	4	4	2	2	15
	Private	9	0	2	7	2	20
	Both	16	9	4	4	3	36
Total		28	13	10	13	7	71

Data Collection Tools

Several data collection tools were utilized for triangulation purpose including a questionnaire, official documents related to mathematics curriculum, and official exam documents. A questionnaire was designed and validated by the researcher in collaboration with a biology educator and two math teachers with a teaching experience of more than 10 years. The questionnaire aimed to collect data related to mathematics learning loss from the perspective of both mathematics secondary teachers. Documents issued by CERD related to the mathematics objectives at each grade level in addition to the suspended objectives for secondary classes before, during and after the pandemic and the economic crisis were compared. The comparison was performed specifically for the mathematics content of: grade 10 the first secondary class which is common for all high school students; grade 11 scientific section, the second secondary class where the emphasis is on the scientific subjects; as well as the grade 12 general sciences section where emphasis is mainly on mathematics and physics. Moreover, the four official exams for grade 12 general sciences performed in 2018, 2019, 2021, and 2022 were analyzed and compared based on Bloom's taxonomy verbs in order to investigate the effect of school closure on the level of questions and consequently on the quality of official exams. It is worth noting that Lebanese official exams in 2020 were canceled due to the spread of Covid, as well as the outburst of the Lebanese Revolution. Consequently, all the students were promoted to subsequent grades in that year. Grade 12 students were admitted to the university without a high school certificate.

Questionnaire

The questionnaire targeted the mathematics secondary teachers which aimed at exploring teachers' practices before, during and after the crisis. The questionnaire is composed of four sections:

- 1- Demographic information: teaching experience, type of school, place of school.
- 2- Online learning: platform used, content covered, students' equality
- 3- Topics covered in mathematics during the academic years: 2018-2019, 2019-2020, 2020-2021, and 2021-2022, in grades 10, 11, and 12.
- 4- Open ended questions related to students' learning loss according to type of school (public or private), and region.

Data Analysis

The data collected from the questionnaire were analyzed using SPSS statistical package through descriptive and inferential analysis. The required and suspended mathematics objectives were compared. The official exams of Grade 12 general science implemented in 2021 and 2022 were compared to the two exams in 2018 and 2019 implemented before Corona Pandemic and the economic crisis. The documents of the official exams were analyzed based on the levels of Blooms' taxonomy.

Figure 2 lists some of the verbs used at each level of Bloom's taxonomy. These verbs were used to classify the questions in the official exams. For validity of this classification, three math experts were consulted. The analysis made was shared with them and a discussion took place about the classification method. The questions were read and the method of solution was discussed. Questions that require breaking down the information and then solving were classified as "Analysis". Questions that require understanding the meaning of facts like the ratio of a direct plane similtude or the conditional probability of an event. If the student is able to comprehend the question, it was referred to as "Understanding". As for "Applying", it refers to all questions that require solving or drawing. The judgement and justification questions were reserved to "Evaluating".

Create	Combining parts to make a new whole Build, combine, formulate, devise, change, adapt, construct, produce
Evaluate	Judging the value of information and ideas Validate, justify, critique, rate, prioritize, select, assess, monitor
Analyze	Breaking down information into basic parts Classify, divide, differentiate, research, discover, simplify, dissect
Apply	Apply the facts, rules, concepts and ideas Practice, implement, solve, develop, generalize, operate, plan
Understand	Understanding what the facts mean Discuss, infer, paraphrase, interpret, outline, review, organize
Remember	Recognizing and recalling facts Define, list, name, recognize, match, choose, show, find

Figure 2. Bloom's Taxonomy Levels and Verbs

Results

The Center for Educational Research and Development (CERD) released Circular No. 28/m/2018, dated May 21, 2018, on the objectives that have been added or suspended from mathematics for grades 10, 11, and 12 (CERD, 2018). Schools were forced to close for extended periods of time during the 2019–2020 school year due mainly to demonstrations that began on October 17 and later the Corona lockdown that began on March 3, 2020. The ministry of education ended the school year early and all the students were promoted to subsequent classes. Grade 12 students were also granted certificates that give them access to the university.

During the year 2020-2021, schools implemented blended learning, and CERD suspended more mathematics objectives. CERD then released Circular No. 13/m/2021 on August 23, 2021, for the academic year 2021–2022, in which the objectives for the academic year were specified. In order to infer secondary students' learning loss, comparison of the mathematics curriculum based on the suspensions was performed from 2018 till 2022. It is worth noting that no circulars were issued in 2019-2020 because of the pandemic, however, because of revolution protests and the Corona lockdown which started in March 3, less than 50 % of the program was covered. Thus, the comparison was done between the three academic years of 2018-2019 before the pandemic and the economic crises and the academic years 2020-2021 and 2021-2022. In 2020-2021 the topics were distributed over 13 weeks to 15 weeks, while in 2021-2022 the topics were distributed over 18 weeks, knowing that in normal school years the program is distributed over 23 or 24 weeks.

The results were also analyzed in terms of assessment; the official national exams were revised based on Bloom's taxonomy. The importance of official exams in Lebanon is the major concern of teachers and principals at schools. According to Jaber (2019), students describe how teachers employ prescriptive pedagogy, telling them to memorize and practice rote learning in order to gain grades and do well on official exams. Learning is irrelevant; what matters is passing the Brevet or Terminale. Thus, the official exams reflect on the way of instruction in the classroom. According to Haydar (2020), after seven years of the curricula implementation in 1997, the system reshifted into old educational practices and this was driven by the assessment system. This shows the influence of the official exams on teachers' practices and school policies.

Content Learning Loss

The content was analyzed based on the three suspensions that were issued by the center of research and development in the years 1999, 2018 and 2020 on the curriculum released in 1997. The curriculum was revised based on content domains specified by CERD. Table 2 shows the cumulative percentage suspensions of topics over the years for grade 10. The suspension of 100% of important topics like Trigonometry, Calculus, 3D Geometry and Statistics in grade 10 have accumulated along the years. In grade 11 Sciences, Geometry was totally deleted (see Table 3). Also, 3D geometry was totally suspended for grade 12 general sciences in 2020.

Table 2. Mathematics Content Suspension in Grade 10 according to over the Years

	Content Suspension over the years		
	1999	2018	2020
Algebra	50	50	70
Calculus	0	100	100
Trigonometry	0	0	100
Geometry 2D	0	0	60
Geometry 3D	0	0	100
Statistics	0	0	100

Algebra was totally suspended in grade 11 except for quadratic equations. Looking at the picture reversely, it is noticed that students were learning 30% of the Algebra and 40% of the geometry requirements for grade 10 only while the other topics were totally deducted in 2020. In grade 11, students were learning 20% Algebra, 70% of Calculus, 40% of Trigonometry, 20% of 3D geometry with 2D geometry being totally suspended. Statistics was totally suspended while probability concepts remained but the random variable concept which is a means for feasibility studies.

It is worth highlighting the idea that Statistics was suspended from the curriculum for all grade levels. This topic is important since it has many uses across a wide range of areas. According to Encyclopedia, statistics is the science of data gathering, analysis, interpretation, presentation, and organization. When it comes to data analysis, probability theory and descriptive statistics are a minimum need. You may use these concepts to help you base business decisions more effectively on data (Groth, 2021).

Table 3. Mathematics Content Suspension in grade 11 Sciences

	Content Suspension over the years		
	1999	2018	2020
Algebra	70	70	80
Calculus	0	0	30
Trigonometry	0	30	60
Geometry 2D	60	60	100
Geometry 3D	50	50	80
Statistics & Probability	0	0	25

It is also worth noting that Lebanese students are deprived of learning algebraic reasoning found in logic and linear programming which were deleted from the program and other algebraic reasoning strands that were not included in the curriculum from the first beginning.

Table 4. Mathematics Content Suspension in grade 12 General Sciences

	Content Suspension over the years		
	1999	2018	2020
Algebra	30	50	80
Calculus	20	20	40
Trigonometry	30	60	60
Geometry 2D	17	33	33
Geometry 3D	20	20	100
Statistics & Probability	0	0	25

Grade 12 general sciences is referred to as the math class. In this class, students were supposed to learn 20% of the algebra objectives, 60% Calculus 40% trigonometry, 67% geometry 2D with 3D geometry being totally suspended. Statistics and probability topics were also reduced to 75% of the total number of topics.

Learning Loss in Official Exams

Comparison of the four grade 12 general science Lebanese official exams for the years 2018, 2019, 2021, and 2022 was based on content split into the five domains: Algebra, Geometry 2D, Geometry 3D, Statistics and Probability and Calculus. The exams were also analyzed according to Bloom’s taxonomy levels. Before the pandemic and the economic crisis, the official exams of grade 12 general sciences in 2018 and 2019 were composed of six exercises covering the five domains required by the Lebanese curriculum: The exam duration was set to 4 hours before the pandemic. However, after the pandemic the exam was set to 3 hours with 5 exercises. Table 5 displays the percentage classification of the exams in terms of the topics Calculus, Geometry 2D and 3D and Statistics and Probability cross-tabulated with Bloom’s taxonomy levels.

It is worth noting that none of the questions was classified as remembering since they all employ verbs that belong to higher levels. The Algebra domain in grade 12 consists of complex numbers and sequences. Numerical sequences were totally suspended after the crisis, so they were not considered in the table. Complex numbers were emphasized after the crisis while they constituted parts of other problems in Geometry in previous sessions, thus it was not included in the comparison. Analytic 3D geometry was also totally suspended after the crisis.

Table 5. Percentage of Topics based on Domains and Bloom’s Taxonomy Levels

Bloom’s Taxonomy	Calculus				Geometry 2D & 3D					Statistics and Probability			
	2018	2019	2021	2022	2018	2018	2019	2021	2022	2018	2019	2021	2022
Understanding	15	7	19	7	10	25	19	20	20	20	10	33	10
Applying	30	22	63	36	20	35	43	60	30	15	30	33	40
Analyzing	24	57	13	36	40	15	25	10	40	20	20	17	25
Evaluating	31	14	5	21	30	15	13	10	20	40	40	17	25

Through a careful reading of Table 5, it is noticed that there is substantial decline in higher level reasoning exercises from the years 2018 and 2019 to 2021 and 2022 and it was least in 2021. On the other hand, the “Applying” Bloom’s level was dominant in the years 2021 and 2022 as compared to 2018 and 2019. This shows a deterioration in exam quality with respect to higher order thinking questions for mathematics official exams from 2018 till 2022. Analysis also shows an increase in “Applying” domains from 22% to 63% in calculus; 43% to 60% in geometry and 33% to 40% in statistics and probability.

Learning Loss based on Teachers’ Practices

Seventy-one teachers responded to the questionnaire about their experiences in teaching before, during and after the crisis. The questionnaire was prepared as google form and sent to the teachers via WhatsApp. Teachers questions were related to their communication with students, ability to cover the required content during online classes and ability of students to follow online classes. The teachers were also asked about their opinion in equity of teaching and learning related to public and private schools as well as governorates disparity. Table 6 displays the teachers’ answers related to teachers’ practices through online teaching. Almost all teachers affirmed

communication with their students, but only 56% of the teachers considered that students have an equal chance in following online classes and 65% were able to complete the requirements.

Table 6. Teachers’ Practices of Online Teaching

Questions	Answers in percentage	
	Yes	No
Were you able to communicate with your students during school closure?	97	3
Did your students have an equal chance to follow online classes?	56	44
Were you able to cover the required content during online classes?	65	35

The variations in percentage content covered was analyzed according to the type of school. Figure 3, Figure 4, and Figure 5 represent the percentage content covered in each of the grades 10, 11 sciences and 12 general science class respectively. It is noticed in the three figures 3, 4 and 5 that public schools showed a decline in accomplishment of the required content as compared to private schools for the three grade levels across the four years. The difference was significant in the years 2018- 2019 and 2020- 2021 for grade 10 ($p < 0.05$).

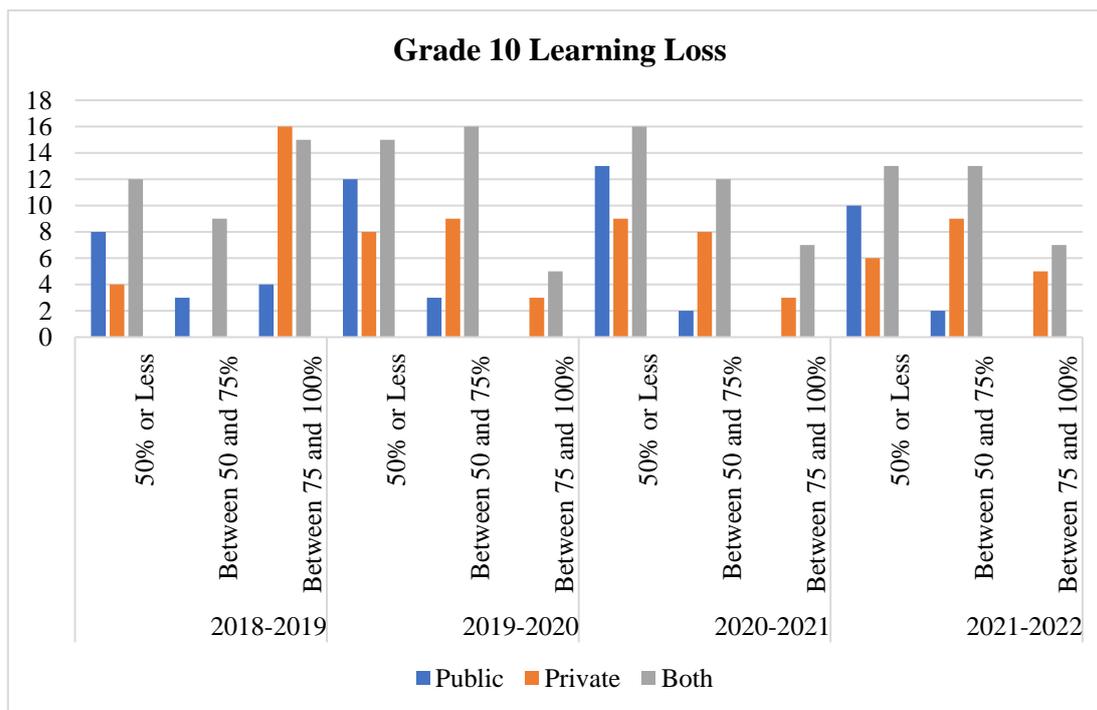


Figure 3. Grade 10 Learning Loss over the years Based on Teachers’ Practices

For grade 11 scientific, the difference was significant in favor of private schools for the same years. As for grade

12, the difference was significant for the years 2020-2021 and 2021-2022. It is important to highlight here the fact that all grade 12 students from private and public schools sit for the same official exam.

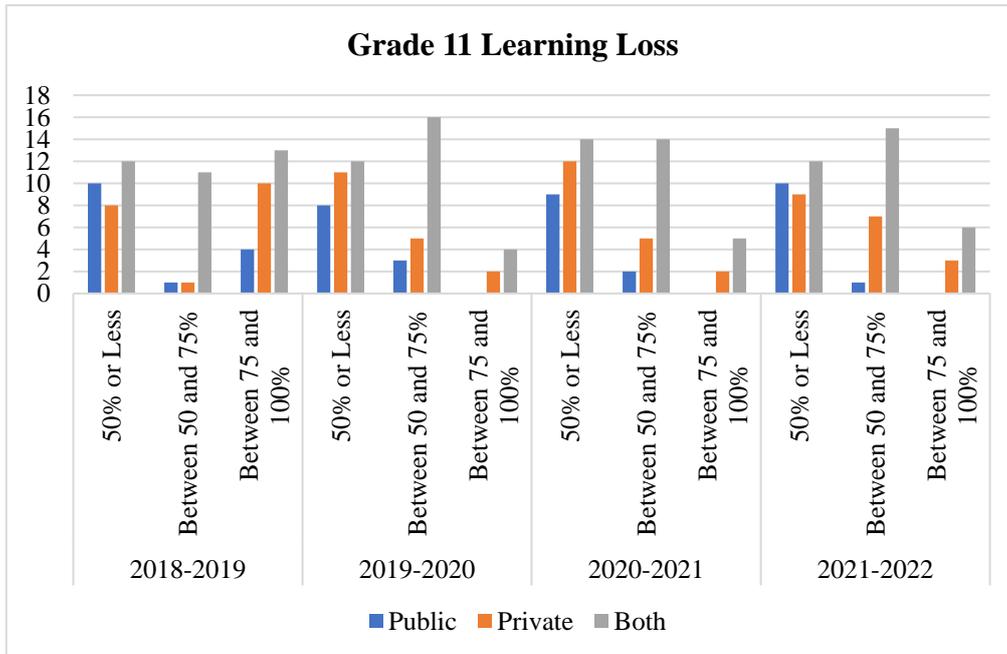


Figure 4. Grade 11 Learning Loss over the years Based on Teachers' Practices

It is noticed that public school teachers were not able to cover 75% of the program for grade 10 while only 4 % grade 11 teachers in public schools covered 75% of the program in 2018-2019 and 2 out of 71 were able to cover 75% in 2019- 2020. None of the grade 11 teachers reached 75% of the program in 2021-2022 with 2 only covering 50% as compared to 9 private school teachers and 13 others who teach in both schools.

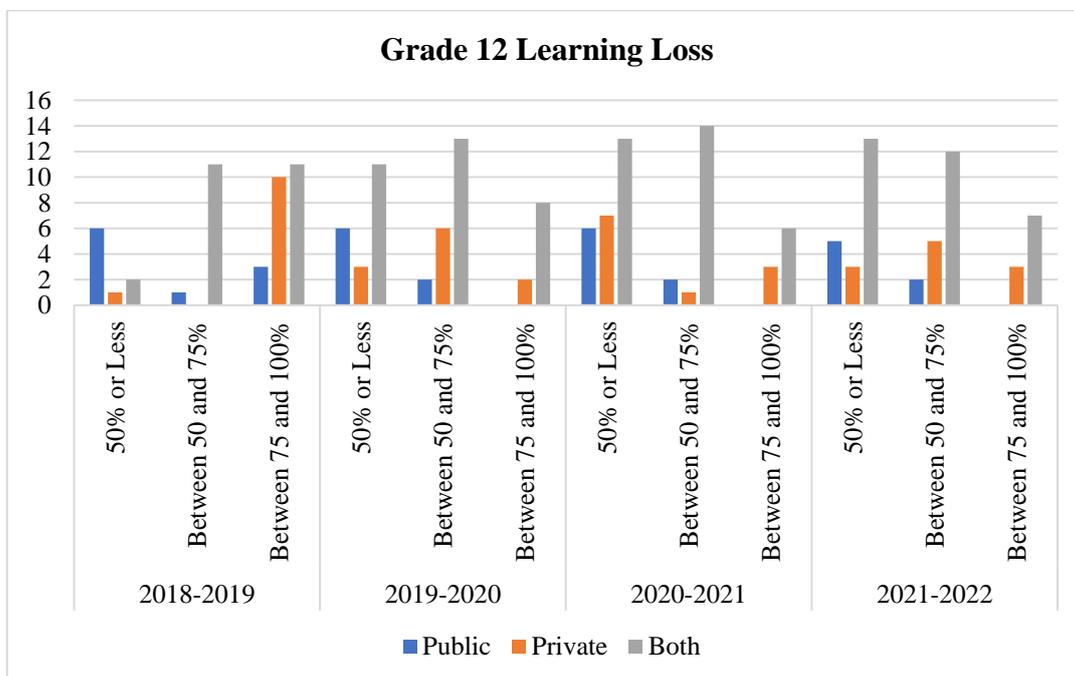


Figure 5. Grade 12 Learning Loss over the years Based on Teachers' Practices

In grade 12, and despite the fact that all students have to sit for the same official exams at the end of the year, there were disparities between the teachers' practices. Some public-school teachers were able to cover 75% and more of the program in 2018-2019 but failed to do so in 2019-2020 and in 2021-2022.

Learning Loss based on Teachers' Opinions

As for the qualitative data in the questionnaire, the teachers were asked to answer three open ended questions. The first one is related to their opinion about the nature of students' learning loss. Twenty-four teachers considered the learning loss of students in their knowledge, thirty-five were worried about learning loss in the cognitive abilities and 15 teachers regarded it in mathematical skills. Excerpts from teachers' answers are: "I think that students lost most of knowledge in mathematics and that is because of the nature of cancellations that took place. Their aim was to reduce the curriculum according to time and not according to what is necessary to know. That is what made students lose competencies and skills". Another teacher's reply for the first open question is: "The students lost everything, but with varying percentages. On top, they lost scientific skills, then knowledge, then cognitive level and some competencies". As for the second question, which refers to the teachers' opinions about equity between public and private schools, 63 out of 71 teachers answered that there is no equity between public and private schools. Public schools learning loss was extremely higher than that in private schools. A teacher stated that the time needed to cover all the required content was different between public and private schools. The third open question aimed at exploring teachers' opinions about equity between the regions. The majority affirmed the disparity between Lebanese regions in learning loss. One of the teachers' answers is: "Every region has its own economic and security issues. The North region for example had more cut-offs than other regions". Other replies stressed the security circumstances in some regions that contributed to learning loss more than other regions. Some teachers claimed that students in some regions don't have access to online learning due to socio-economic issues.

Discussion

This study investigated secondary students' learning loss in mathematics from 2019 till 2022 due to the combined effect of the pandemic and the economic crisis. During this period both public and private schools in Lebanon closed for lengthy periods because of the COVID lockdown, revolution protest, and teachers' strikes. For qualitative analysis, official documents issued by CERD were utilized to highlight the suspended mathematics content before and during this period. For quantitative and qualitative data collection, a questionnaire was designed by the researcher in parallel to another questionnaire in biology for a similar study. The aim of the questionnaire was to investigate equity in students' learning loss in mathematics in private and public schools on one side and in Lebanese regions on the other side based on teachers' experience. In addition, the quality of the three official exams of 2019, 2021 and 2022 was assessed based on specific criteria.

To answer the first question of research about students' learning loss in mathematics in terms of content: the comparison of the official documents issued by CERD concerning the required and suspended mathematics content showed a decline in the required topics in grades 10, 11 scientific and 12 general sciences. More than 50%

of the mathematics curriculum was suspended by CERD for G10, G 11-S, and G 12-LS during the academic years 2020-2021 and 2021-2022. This conforms with Rose (2022) that key learning gaps from past years prevent comprehension of more advanced ideas, thus if grade-level instruction is the main focus, pupils run the real risk of falling further behind.

In grade 10, big ideas are missed in mathematics due to the imposed suspension in 2020. Students, especially in public schools are missing concepts related to numbers such as “Order of Real numbers” and “Intervals”. They have missed “Plane representation of objects in space” a topic which was also deleted from the program for previous grades since 1999. It is well known that 3D geometry is a very important concept. The logical, technical side of the brain is on the left, while the creative, artistic side is on the right. Most people either have a dominant right brain or left brain. Both can be combined with geometry to produce an exact symmetry between the two sides (Vingerhoets, 2021). In grade 11 scientific even more important concepts are suspended such as “Barycenter” suspended in 1999 which relates mathematics to physics and real life. All the other geometry topics were also suspended in 2018 and 2020. Students who have not encountered spatial geometry in the elementary classes and due to the crises and have been deprived of it in the secondary cycle may not be able to function well in their career. Children who acquire a solid understanding of space and spatial language tend to demonstrate higher math achievement than students who do not achieve such mastery (Ginsburg & Oppenzato ,2022). Grade 12 content turned to be missing important topics for general science students who should have emphasis on mathematics. Important topics related to real life like “Conics” which was suspended in 2018 and “Parametric curves” which was suspended in 1999 in addition to “Random Variables” in probability are big ideas that make students able to model real life situations. To sum up, the loss students have missed in mathematics content is huge and will have a great impact on their careers in the future.

To answer the second research question concerning students’ learning loss according to the teachers’ practices, the questionnaire was used to collect quantitative and qualitative data from seventy-one secondary school math teachers in Lebanon. The answers showed a discrepancy between teachers’ practices during the crises. Some of them, mainly teachers in private schools, were able to finish the program and even covered more topic than those specified by CERD. On the other hand, some public school teachers were not even able to cover the required topics in spite of the suspension. These results conform with Haser et al. (2022) and Hammoud and Shuayb (2021) about inequity between private and public schools. Another major concern of the questionnaire was exploring the learning loss in different regions in Lebanon. The majority of the teachers’ answers assured inequity between regions due to security reasons, revolts and teachers’ strikes. This issue was not only in Lebanon since the Mckinsey report claimed that there was a disparity in learning loss between schools from low economic background and others with high economic status (Dorn et. al. 2020).

In response to the third research question of research concerning students’ learning loss in terms of quality of official exams, four grade 12 general science exams of the years 2018, 2019, 2021 and 2022 were analyzed in terms of mathematical domains and Bloom’s taxonomy levels. It is worth noting that the 2020 exams were cancelled and students were promoted automatically. The results showed a decline in the quality of exams in terms of content and reasoning levels. The results showed that the content was reduced; instead of six problems with a

duration of 4 hours to five problems with a duration of 3 hours. The geometry content was reduced to one problem in transformations while geometry domain used to constitute three problems; transformations, 3D analytic geometry and conics. As for the cognitive levels, there is a drop in higher order level questions and an increase in “applying” and “understanding” questions. Research aligns with this result since mathematics is a sensitive subject and needs to be practiced in schools not at home like reading for example (Sawchuk, & Sparks , 2020).

Conclusion

Based on three constructs—curriculum content, teachers' practice, and standardized assessment—the official G12 exams—this study examined the learning loss in mathematics experienced by Lebanese secondary students between 2019 and 2022. The MEHE in partnership with CERD reduced the curriculum and the content necessary for the official examinations as a result of the simultaneous economic and COVID crises that struck Lebanon during this time and resulted in school closures for lengthy periods of time for three consecutive academic years. The study's findings showed that Lebanese secondary pupils lost a lot of mathematics knowledge during the course of the investigation. Due to the pandemic and the economic crisis, Lebanon's public and private schools both had extended closures in 2019; instead, sporadic online sessions were offered. However, only 32 teachers of those who responded to the questionnaire were able to explain more than 75% of the required content in 2018- 2019 as compared to 10 teachers who were able to cover the same percentage in 2020-2021.

Recommendations

Learning Loss should be a major concern for schools at all grade levels. The Lebanese Ministry of Education should take measures in order to alleviate learning loss. Math learning loss should be approached differently due to its spiral nature. Thus, gaps should be addressed properly and comprehensively with no need to target every pre-grade learning gap. A more efficient strategy to help children achieve proficiency is by strategically combining fundamental pre-grade abilities with on- and post-grade skills. Teachers can cover the grade-level curriculum and address pre-grade gaps only with a massive infusion of instructional time or a multi-year approach (Rose, 2022). This needs specific policies to be taken from the ministry of education for teacher training and to truly address math learning loss so students can succeed, schools will need the backing and creativity of senior administrators and policymakers—especially when it comes to testing and accountability policy, as well as the procurement of instructional materials.

Finally, future studies should address learning loss from the perspective of university students in order to measure the learning gaps they have encountered at school. Other studies should also target mathematics learning loss at early stages of students' learning due to the cumulative gap of learning loss in mathematics (Dorn et al., 2020). Action research may pave the way to ideal solutions.

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