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Original Paper

The Content of Meteorology in Greek Geosciences' Textbooks

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Abstract

In the Greek primary and secondary education, weather phenomena and climate change are mainly approached through the courses of Physics, Geology, Geography and Chemistry. The main objective of teaching Science is to acquire knowledge about theories, laws and principles. The expected result is that the student will be able to interpret the physical, chemical, biological and geological phenomena, as well as their interactions. Furthermore, teaching Science aims to develop the personality of the student through the promotion of independent thinking and the ability to reasonably deal with difficult situations. In this context, this research seeks to investigate the adequacy of the knowledge provided in existing school textbooks on weather events with impact on society. This study is based on the content analysis method, adopting the following four key steps: Specification of the objectives, identification of the analysis term, clustering of the data and data analysis. The main focus of the work is the chronological approach of the content of Meteorology in Geosciences and Natural Sciences, and Junior High School textbooks.

Keywords

textbooks, education, Meteorology

1. Introductıon

The predominant position of education researchers is that the integration of elements of the history of science into the teaching can contribute to the understanding of the content of science and the position of a science. Recognizing the importance and hierarchy of science, the student can clarify the concepts that govern it as well as their evolution. "Using history can humanize science, help students improve their critical thinking skills, promote a deeper understanding of scientific concepts, and address common student misconceptions that often resemble those of scientists of old" (Matthews, 1994). In the above theoretical framework, the proposed research is set on the subject of the longitudinal approach to the subject of meteorology and the concept of Climate Change in Geosciences and Natural Sciences textbooks, of Middle School and High School, which were published from 1977 to 2020. The

Greek educational system is based on the dominance of the school textbook, where it "holds a position of authority, as it is the main means of teaching both in terms of the subject matter, but also in terms of the basis of teaching guidance. It is the basic tool of pedagogical and teaching practice and student education" (Kapsalis & Charalambous, 1995, 2002; Stasinakis & Koliopoulos, 2009).

In the present paper, the content analysis method of Greek textbooks was applied. Content analysis is based on the analysis of all kinds of forms of communication, such as textbooks, essays, newspapers, novels, magazine articles, songs, political speeches, advertisements and pictures. This analysis is often used in conjunction with other methodologies, particularly in educational research, where it can be used to code, categorize and quantify data. The content analysis method deciphers the messages contained in the texts. It is a quantitative communication method that analyzes texts for the presence and frequency of specific terms, narratives or concepts. In quantitative analysis, there are three distinct phases: collecting data, coding and analyzing the data, and presenting the analysis.

The present research includes a measurement procedure to calculate the occurrence of meteorological terms in school textbooks of the Greek modern education system. The number of meteorological terms, the number of pages for each topic, the type of descriptive or scientific forms and the number of figures per category will be the variables analyzed in our research (Makri, 2015). After measuring the variables, statistical processing will be performed to produce the final results of the study.

The current study, conducted for the first time μ presents the temporal evolution of the content of meteorology in Greek textbooks during 1977-2020. Internationally, the literature is referred to students' perception on extreme weather phenomena, without, until now, taking into account the Curriculum.

Through this study, the need to strengthen the content of Meteorology at future Curriculum structure emerges, with the aim to develop the skills of students—future citizens regarding extreme weather phenomena.

2. Framework

The main objectives is the perennial approach of the content of Meteorology at Greek textbooks and the factors that influenced it. In addition, the quantitative content of Meteorology in each school textbook and more specifically at Geoscience and Physics as well as the scientific completeness through figures are studied. The textbooks used at Geoscience are the textbooks that were taught and entitled under the terms of Geology or Geography.

The bibliographic research in analysis of the school textbooks demonstrated five dominant methodologies. Each methodology represents a different tendency in education research. From these five dominant methodologies, content analysis has been chosen as the most appropriate since the identification of material relevant to Meteorology is feasible. Furthermore, content analysis leads to a qualitative record, as well as formulates a material that can also be used for quantitative analysis (Stasinakis, 2021).

In content analysis, a dominant aspect is the conceptual framework used to guide the research. There is

a variety of conceptual frameworks for conducting book analysis, each designed to examine printed material from a particular perspective. The analysis of textbooks can be governed by epistemological, pedagogical and sociological issues, depending on the research perspective, genre and content of the textbooks. For example, the study of the textbooks of theoretical courses mainly includes ethnological and ideological criteria, while the study of the textbooks of science courses focus on their content and at their scientific approach and theory. For the implementation of educational research, there are various methodological trends, which this research takes into account in order to design its methodology.

In particular, in the article "The philosophical underpinnings of school textbook research" (Nicholls, 2005), concerning the study of school textbooks, the main philosophical positions (e.g., positivism, critical theory, interpretive) are described in order to assess their effects on the research of school textbooks. It is based on listing the differences, identifying the type of philosophical position and comparing them. However, the critical analysis of the information presented differs according to the philosophical underpinnings of the research undertaken.

According to the trend of positivism, the scientific method is used in the study of textbooks, which is considered neutral and objective. The positivist research evaluates the sample of books, according to scientific validity, examines to what extent the facts provided are real, as the book considered as a reality that represents accuracy. There is no dynamic interaction between subject and object, since the scientific method allows the textbook to be studied as a neutral and autonomous subject. Supporters of critical theory believe that school textbooks express the unequal social and economic relations in the society in which they refer (Apple, 1979, 1986). By adopting a critical theory approach to school textbooks, the researcher promotes enlightenment and change, becoming able to identify ideological contradictions. The basis of critical theory is ethics and consequently, it is governed by the obligation to expose social injustice, wherever it occurs and the school textbook by extension is an object for the struggle for justice. In the **interpretive method**, knowledge is in a circular and continuous relationship, with objectivity and subjectivity and vice versa (Bleicher, 1980). In the present paper, the philosophical approach of textbooks is not appropriate due to the long-time span and the diverse primary material.

Laurinda and Leite (2002), at the article "History of Science in Science Education: Development and Validation of a Checklist" suggest the study of school textbooks with the main question of whether they have been written in the light of the History of Science. The analysis of the content is based on a series of criteria and has been conducted by the use of a classification tool, which has been used and evaluated by a number of researchers. The main used criteria are: "*The type and organization of historical information, the ways used to present the historical information, the information related to the historical information: scientific, technological, political, religious, the location of the historical content (fundamental or optional, the bibliography in the history of science and the short biography of the scientist".* The above criteria are used to construct a checklist and then record the frequency of the elements in each book. Leite's methodology concerns the recording and study of integrated elements in

textbooks, related to the provision of information and knowledge about the History of Science and not to the subject of the book.

Park and Do - Yong (2005) developed a methodology to investigate the differences between a standard curriculum in America (Earth Common) and curricula that follow traditional standards and textbooks. Three textbooks have been compared in terms of the type of inquiry style and the level of laboratory activities they contain, using criteria expressed in proportions and percentages. Specifically, the type of experimental questions, the type of non-experimental questions, the range of laboratory activities and the general characteristics included in all the pages in the three selected books (sections, chapters, topics, concepts) are counted in a sample of three books and compared. For example, the funds rate of 3.7% is calculated as follows: (17/463) x 100 = 3.7%. The comparison concerns three books that were taught in a short period of time (1995-2001) in America and Korea. This method is considered appropriate under two circumstances: the use of a limited number of book for a short period of study. Therefore, the aforementioned method is not suitable for the current research.

Chiappetta and Fillman (2007) studied five Biology textbook published in the period 2002-2004, in order to determine the amount of emphasis placed on four themes or aspects of the nature of science: (a) as an object of knowledge (b) as a mode of investigation, (c) as a way of thinking, and (d) its interactions with technology and society. Furthermore, an attempt is made to ascertain whether these books of Biology have a different distribution and proportion of their subjects, compared to those written in an earlier reformation. They also explore whether the authors responded to the demands of the reformist needs, regarding teaching students a more comprehensive view of science. A unit of analysis is defined as: an entire paragraph, figures, figures and tables with captions, comments and definitions, end-of-chapter questions and each laboratory activity. The above criteria are recorded and counted, their statistical processing is carried out, after the sample has been weighted, creating tables with coverage percentages of the aspects of science (a, b, c, d) per book, compared to each other, as well as with data from previous teachers and curricula. The methodology used by Chiappetta and Fillman (2007) is also widely found in the Greek literature (Bonidis, 1997; Drakopoulou, 2003; Skordoulis, 2005; Stasinakis, 2021).

The above methodologies and framework cannot be applied with the exact same way to the present research, as they do not cover the needs and objectives of the present research. Although, they are a basis for the implementation of a new, proposed methodology.

3. Method

The present research focuses in the analysis of a long time period spanning from 1977 up to 2020 and explores a diverse sample of school textbooks in terms of content including Geology, Geography, Physics, Chemistry, and Biology. Having considered the existing methodologies used in the literature and the particularities of the present research, the content analysis approach has been selected and applied. These textbooks were published, from 1977 to 2020, after their approval by the Curriculum.

The term "Curriculum" is defined as the formulation of the characteristics of a didactic action. The Curriculum is a kind of social program and therefore, constitutes a human invention and creation. The Curriculum defines valid knowledge (Bernstein, 1991) and has as a general goal to achieve a specific and predetermined result, aiming to improve the meeting of teaching needs. During the design of a Curriculum, certain parameters, such as the level of learners (e.g., age, grade, particularities), the nature of the needs to be met (e.g., cultural, financial) and the activities to be implemented (e.g., teaching activities), the persons (teachers and assistants) should be considered.

The implementation of the content analysis methodology at the present research has been implemented as follows:

1) Regarding the area occupied by the book, the number and type of images-figures and their frequency of occurrence. The content concerning the individual sections of Meteorology, Climate, Movements in the Atmosphere, Weather Phenomena, Effects of weather phenomena, protection from Weather Phenomena will be recorded**.**

2) All textbooks will be sorted in chronological order based on the title, the time of publication and the author.

3) In each book, the number of pages and the figures that will be divided into scientific and descriptive are initially calculated. In particular, the following proportions are defined:

- shapes / pages.
- descriptive figures / page.
- scientific figures / page.
- Meteorology scientific content pages per book

The scientific figures are defined as those whose construction requires accuracy, reliability and objectivity, such as a weather map. Shapes are defined as descriptively, where they are depicted as a sketch, without interpretation, such as a sketch of an earthquake disaster. Then the number and pages of sections and topics covered by each book are counted and the values are expressed in percentages.

These values are used as an indication of the cognitive completeness of the books and as a criterion for evaluating the importance and prioritization of the Meteorology content.

For the comparable values (pages, figures), the absolute values will not be used but they will be expressed in ratios and percentages as indicators. Table 1 summarizes the measurable values and the symbolism of each indicator.

Table 1. Measurable Values and Their Notation

Symbol	description
L	shapes per page.
$\mathbf{L}_{\mathbf{P\_m}}$	descriptive figures per page.
$\mathbf{L}_{\mathbf{S\_M}}$	scientific figures per page.

G_M	% pages of scientific Meteorology content per book.

During the formulation and elaboration of the Curriculum, the main questions are: "*what will be taught, to whom, in what way, at what level, for how long and in what way will the acquired knowledge be certified"* (Bernstein, 1991). In order to answer, the following two conditions should be clarified:

- We cannot examine curricula without their social dimensions.
- We cannot only examine these dimensions without analyzing the programs**.**

4. Results & Discussion

In order to draw conclusions, the textbooks were divided into Geosciences, Physics and other books. The grouping was considered necessary, as there was a large discrepancy between the content in the book categories (geosciences - physics - etc.). The results are detailed in the diagrams below.

Figures 1 and 2 show the results of time evolution of the ratio G_M and L_{p_m}, L_{s_m} in geosciences school textbooks.

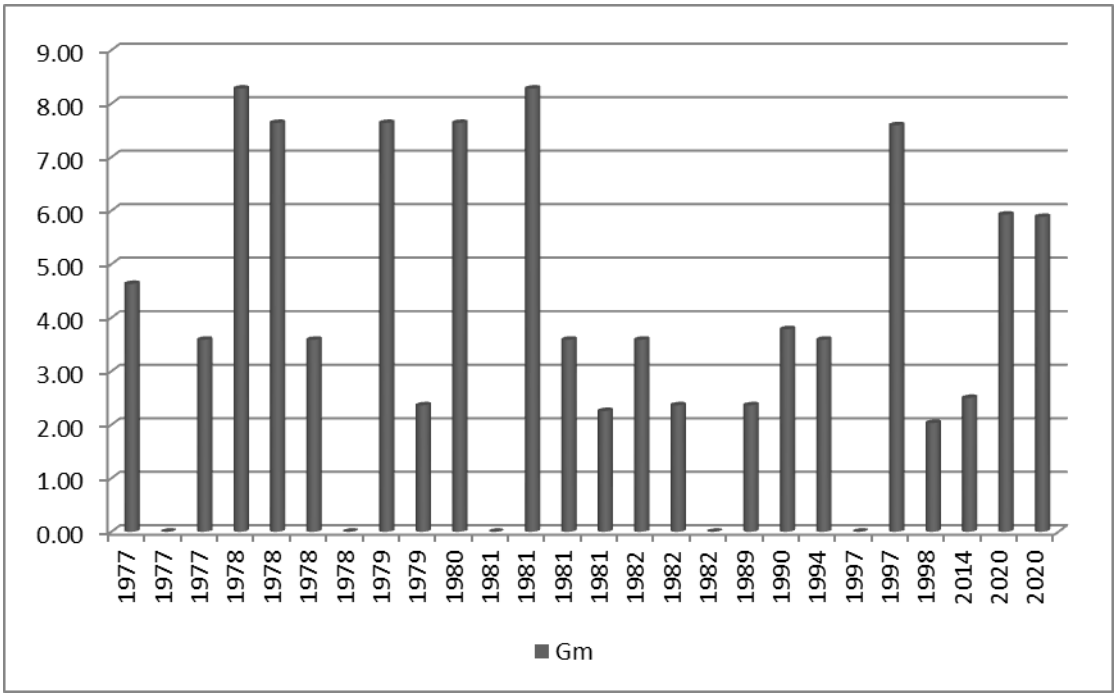

Figure 1. Time Evolution of the Ratio G_M, in Geosciences Textbooks during 1977-2020

G_M's greatest values correspond to the book "Elements of Geology and Mineralogy" (G_M = 7.64), which was taught in the 1st Lyceum until 1982, in the Geography of the 2nd Gymnasium (G_M = 8.28) which was taught until 1982 and in Geography of the 1st High School (G_M = 7.59) taught until 2003 (Fig .1).

In the "Geography" for 1rst Lyceum 1982 (Mazis, 1982) and 2nd Lyceum 1978 (Mazis, 1978), the

meteorological content is completely absent, as well as in the "Geography of Continents" (Gavreseas, 1977). The book by A. Mazis for the Geography of the 1rst Lyceum was succeeded by the one of G. Georgalas with G_M = 7.64. Lower values appear in the Middle School Geography books of E. Mariolakos, from 1982 until 1989 (G_M = 2.36), and in "Geology & Natural Resource Management" (G_M = 2.5), of G. Voutsinos et al. of 2014 (Figure 1).

It is noteworthy that the higher values of G_M appear in different High- School grades, during these three (3) consecutive decades. Furthermore, it is observed that books with a high G_M (G_M = 7.59, Geography 1997, Karabatsa et al.) have no continuity and are replaced by books with a lower ratio such "Geology-Geography", G_M = 5.88 (Aslanidis et al., 2020).

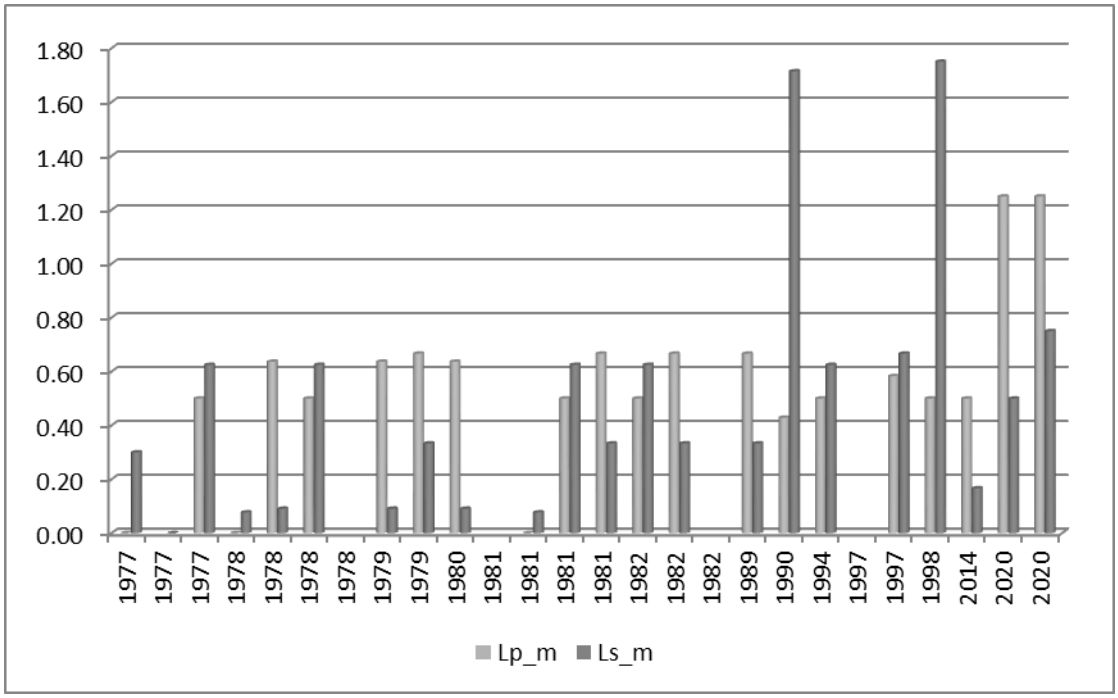

Figure 2. Time Evolution of the Shapes' Ratio L_{p_m} and L_{s_m} in Geosciences Textbooks during 1977-2020

Regarding the representation of figures in Geosciences books, the descriptors show a constant low value ($L_{p\_m} \approx 0.67$) with a significant increase from 2003 to 2020 (L_{p_m} = 1.25). This increase concerns the books taught in the current period at the High School. Scientific depiction lags throughout the study period, with a strong positive difference in the 1990 "Geography of the Continents" for 3rd class of Junior High School (Zamani et al., 1982) and in the 1998 "Geography" for 2nd class of Junior High School (Karabatsa et al., 1998).

The results of time evolution of the ratio G_M and L_{p_m}, L_{s_m} in geosciences schools' textbooks per class, in Junior High School, are presented in Figures 3-5. The G_M value in the 1rst class of Junior High School is stable until 1997, where it rises significantly from 3.59 to 7.59 (Figure 3). The status is different in 2nd class

of Junior High School, where G_M decreases after 1981 (Figure 4). Correspondingly in 3rd class of Junior High School (Figure 5), G_M shows low values in the Geography course, with a small increase in 1990, before its removal from the curricula.

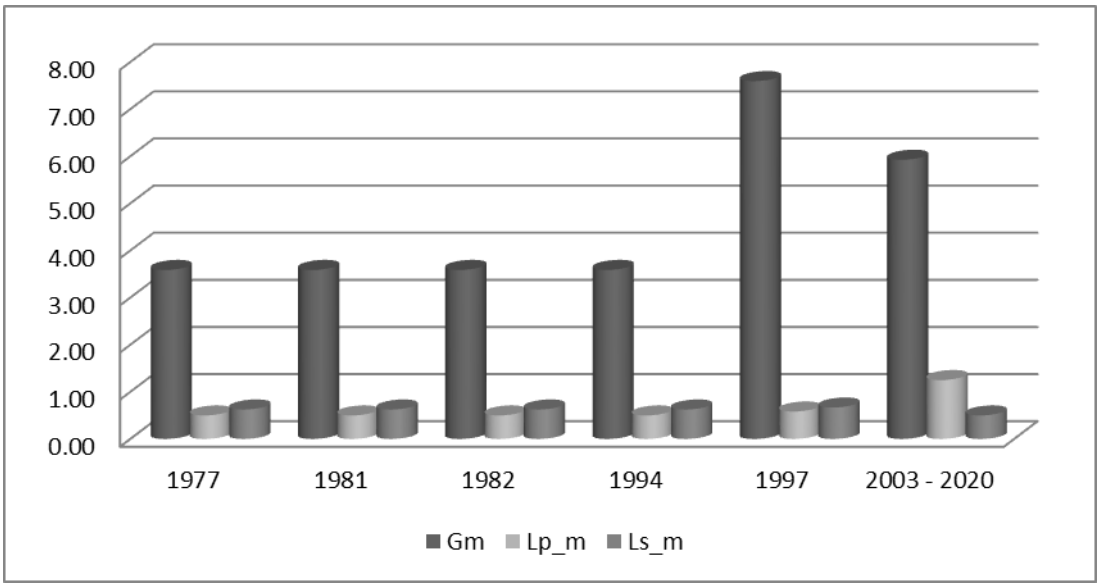

Figure 3. Time Evolution of the Ratio G_M, L_{p_m} and L_{s_m} in Geosciences Textbooks during 1977 - 2020, in the 1rst Class of Junior High School

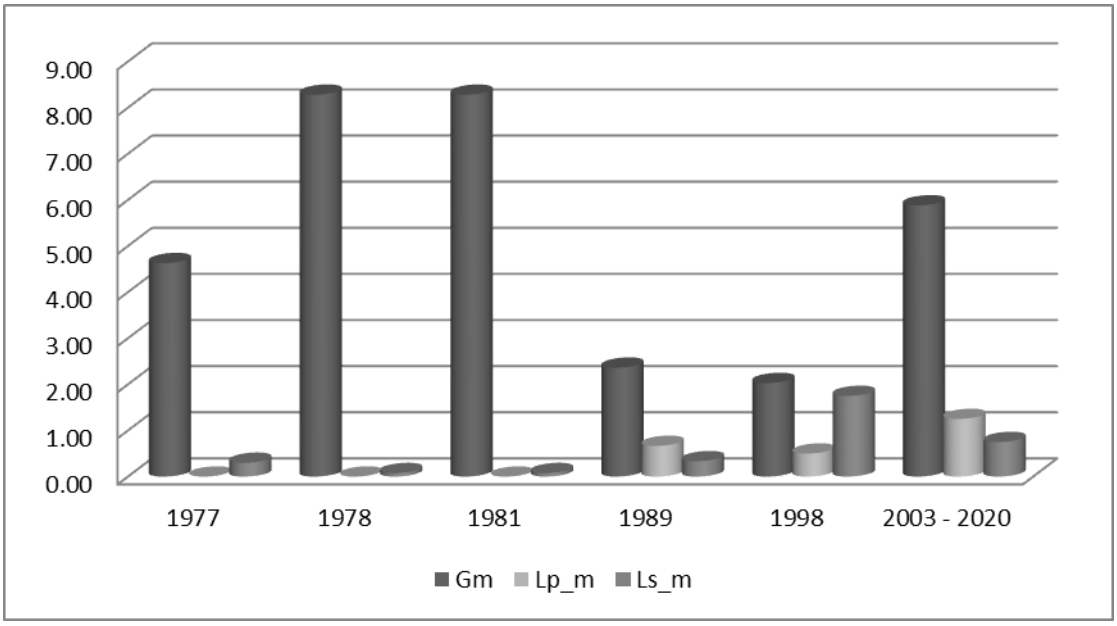

Figure 4. Time Evolution of the Ratio G M, L p_m, L s_m, in Geosciences Textbooks, 1977 - 2020, in 2nd Class of Junior High School

It should be noted that an important educational reform took place in Greece in 1981. New books were written for students and teachers and new curricula were created (Fragoudaki, 1992). Bouzakis (1991) commented that the educational reform of the 1981 "*attempts to open the school to life, connect education with social and economic life and modernize curricula and textbooks*". However, the educational reform of 1981 is not positively correlated with the ratio G_M, in the 2nd class and the 3rd class of Junior High School (Figures 4-5). The contradiction between the goals of the 1981 reform and the content of meteorology can be interpreted from the status of Environmental Education at the same period. During 1977-1990, Environmental Education in Greece is considered as a preparatory period. Its substantial entry into the Greek educational system takes place in 1990, as part of the curricula of Secondary Education (Skanavis & Sakellari, 2001). The same interpretation can be given for the slight strengthening of the ratio G_M, after the 1990 reform in the 1rst class Junior High School (Figure 3). Also, this view is documented by Liarakou et al. (2011), where it is reported that students who attended educational environmental programs, had increased their perception and ideas about severe weather phenomena.

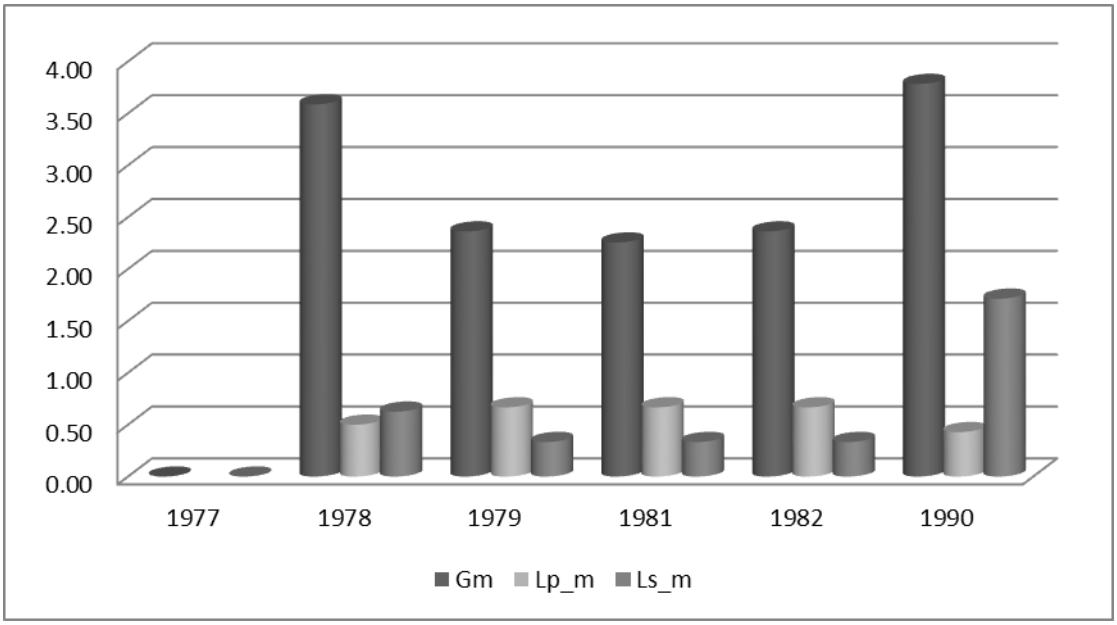

Figure 5. Time Evolution of the Ratio G_M, L_{p_m} and L_{s_m} in Geosciences Textbooks during 1977 - 2020, in the 3rd Class of Junior High School

The time evolution of the ratio **G_M, Lp_m,** and **Ls_m** in Physics school textbooks is presented in Figures 6-7. The G_M index has a wide range (0 - 8.93), greater than the one in Geosciences textbooks (Figure 1). However, G_M index is significantly lower in Physics school textbooks compared to the one in Geosciences textbooks. The maximum price of **G_M** concerns the textbook "Physics with Experiments" (Kalkanis et al., 2020), which contains the largest meteorological content in Physics.

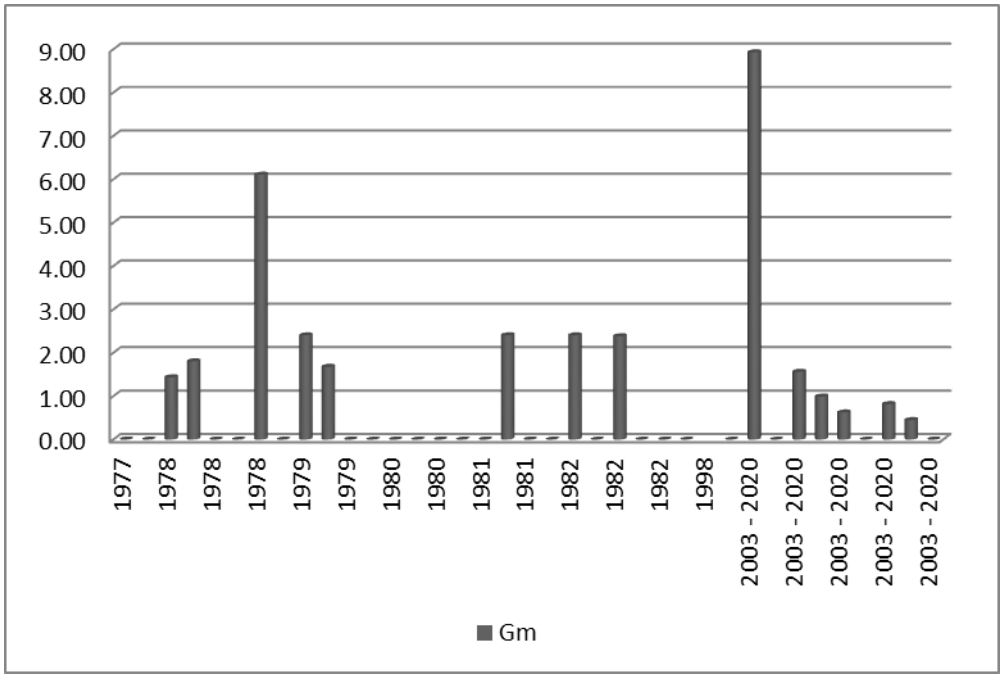

Figure 6. Time Evolution of the Ratio G_M in Physics Textbooks during 1977-2020

Although Meteorology is a scientific field of Atmospheric Physics, its content in Physics textbooks lags behind the equivalent of Geosciences textbooks. One possible interpretation of this differentiation is that Physics was mainly concerned with Mechanics and Electromagnetism in the Secondary Education Curricula since 1977. The teaching of Physics, in particular, focuses on laws and exercises and less on the interpretation of natural phenomena. On the contrary, in Geosciences, the interpretive approach of natural phenomena is followed, including those related with the Atmosphere (Makri et al., 2021).

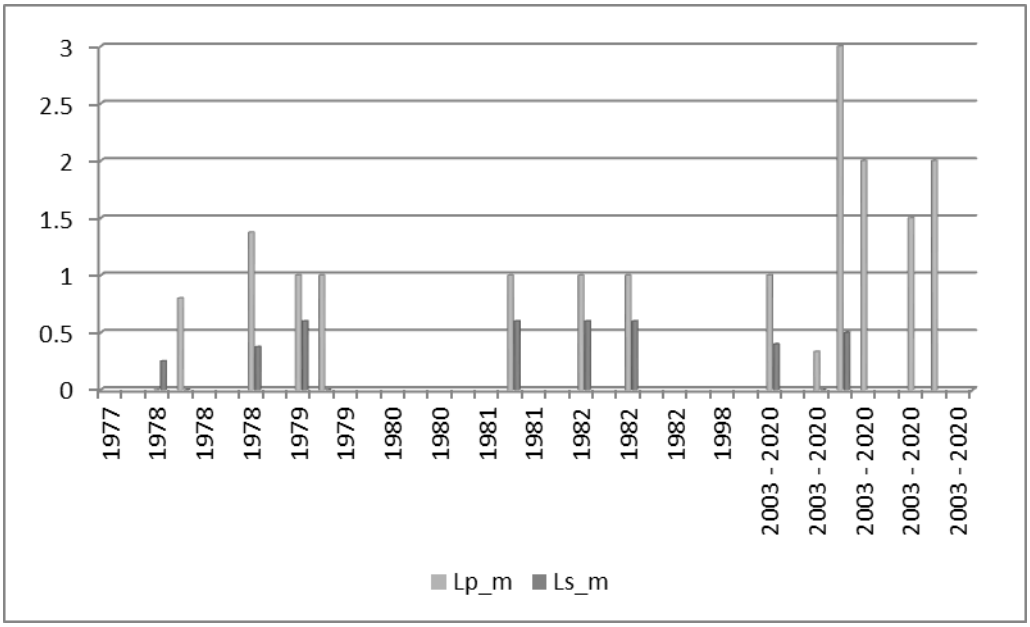

Figure 1Time Evolution of the Ratio L_{p_m} and L_{s_m} in Physics Textbooks during 1977-2020

5. Conclusions

In the frame of this work the Greek school textbooks in the period 1977-2020 are analyzed in terms of their content related to Weather and Climate. It was found that the education about weather phenomena and the climate is clearly included as a subject in Geosciences school textbooks and is barely approached in Physics textbooks. The ratio G_M, representing the percentage of pages of scientific Meteorology content per book, presents its largest values from 1977 to 1981, which then decline until 1997. By the end of the 1990s, changes in education did not cause any significant changes in overall content concerning weather phenomena and climate topics. The variation of the book of Geography, for 1rst class of Junior High School, in 1997, (Karabatsa et al., 1997) had no continuity and duration. Since 2003, meteorology content is characterized as poor, with accompanying scientific figures.

According to modern pedagogical approaches, Science should not only impart fundamental scientific knowledge of students, but should also prepare citizens to be able to make informed decisions within society (Mansour, 2009). At the same time, modern society requires its citizens to develop appropriate action mechanisms against dangerous weather phenomena, as the ability to adapt to the risk, depending on the degree of preparation for the potential risk and the spontaneous or pre-planned reactions that take place after the event (Dalziell & McManus, 2004).

In this context, it is deemed necessary to strengthen the subject of meteorology and climate topics, so that the process of building and enriching knowledge should be supported, as well as the development of skills and attitudes on the part of students. It could be considered as the main educational goal of the 21st century and is aligned to the Sustainable Development Goals for Education (Goal 4) and Climate Change (Goal 13).

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