

Social semiotics comparison between old and new Palestinian mathematics curriculum for the ninth grade

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ABSTRACT

This research aimed to analyze Algebra unit in both the old and new Palestinian curriculum for the ninth grade by using deductive content analysis based on the social semiotic approach. The results of this study showed that, in both books, the mental, behavioral, and verbal processes were more frequent than the relational, existential, and material processes. Moreover, the most frequent object used in both curriculums were the initial description, the rule, and the official definition. The most frequent representation of the mathematical object in both curriculums, was the algebraic representation, then the verbal, the numerical and the graphic representations. The research findings also indicate that in both books, the use of the pronoun "I" was the most frequent, then the pronoun "we" and then other pronouns. The imperative was frequent in the Algebra unit in the old curriculum, but less frequent in the new curriculum. The research findings, regarding the textual function in both books, indicated that the text orientation 'previous knowledge to new knowledge' was the most frequent in Algebra. This demonstrates that the author in both books cared about applying the new knowledge and assessing it, what means that the text progresses horizontally in both curriculums.

INTRODUCTION

Influencing the lives of individuals and the culture of their societies is one of the goals of learning and teaching mathematics (Nur et al., 2020; Umbara et al., 2021). Therefore, one way to identify the effects of mathematics on the life of the individual and society is to identify the characteristics of learning and teaching mathematics, and one of the most important sources of learning and teaching is the mathematics textbook (Alkhateeb, 2019). It is considered a link between individuals and society. Therefore, the analysis of the mathematics textbook helps in identifying how to bring about changes in the individual and society (Rezat et al., 2021).

Researchers in mathematics education have been interested in analyzing the mathematical curricula, so that they can improve the practices of learning and teaching that occur in the classroom (Said, 2014). Increasingly, the production of mathematical knowledge is viewed as a multi-faceted activity that includes synchronic and diachronic interactions of semiotic systems (Sabena et al., 2014).

One of the modern educational and social theories receiving attention by researchers in mathematics education is the semiotic theory that supports the analysis of student learning as well as the mathematical curricula and textbook (Ernest, 2008). This theory is broad, including a variety of approaches as the formal orientation (Noth, 2010), the social approach (Morgan, 2006), and cultural historical approach (Radford, 2009).

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Social semiotic analysis has been pointed at by researchers as a linguistic methodology that could illustrate the meanings in the textbook, especially three functions of the textbook: the Ideational function, the interpersonal function, and the textual function (Morgan, 2006), based on Halliday (1985). These functions shed light on three central issues in mathematics education: The mathematical notions, the social environment of the textbook and the advancement of the text. Despite its treatment of the three main educational issues, still, relatively few studies have used this methodology for analyzing textbooks, but it is in the center of textbook analysis. Lately, Bergvall and Dyrvold (2021) used the social semiotic framework to electronic mathematics textbooks, what points at the main functions that it addresses. This makes it most relevant for mathematics textbook analysis.

O'Sullivan (2017) says that understanding the mathematical tasks that students and teachers face every day can be gained through textbook analysis, where this analysis supports the understanding of what is being taught and learned in the classrooms. In this research, we are interested in the linguistic methodology for analyzing mathematics curricula. We utilize it in order to compare between the curricular meanings (ideational, interpersonal and textual) in the old and new Palestinian ninth grade mathematics textbooks. This comparison would provide tools for mathematics books authors for taking into consideration critical issues that serve the present research when coming to write a new mathematics textbook. This consideration would probably enrich the textbook, compared with the old one, in terms of the three critical issues. Particularly for the Palestinian context, little research has utilized the social semiotic framework for comparing new and old mathematics textbooks. In addition, comparing old and new versions of a book helps understand the development of the curricula, as well as the rationale behind it. This would help develop the specific curriculum, in addition to curriculum all over the worlds.

Curriculum analysis

The curriculum is one of the components of the educational process, which consists of the teacher, the student, and the learning environment (Laurillard et al., 2013). The curriculum plays a major role in this process, as it is the basis on which the teacher relies to share experiences with students (Langhout & Mitchell, 2008). The book also represents one of the means of achieving and implementing the curriculum, whose impact on the learner's behavior is expected to appear. The textbook plays a major role in the learning and teaching processes. The book defines what the student studies in terms of knowledge and skill. Importantly, the book is the main means that translates the curriculum into tangible reality (Al-Zoubi & Obeidat, 2014). Thus, it has a significant impact on the teaching and learning. The process of analyzing and evaluating textbooks is considered both a diagnostic process and a remedial one. Thus, it leads to the development of the curriculum and the improvement of the textbooks (Murdaningsih & Murtiyasa, 2016; Setyawan et al., 2020). Specifically, this process enables appropriate modifications to the textbook. The analysis process is useful in understanding the content of the book and clarifying its means and activities, which increases the effectiveness of its use in the teaching process (Abu Zina, 2010).

Social semiotics

Social semiotics involves the study of social relations in the classroom and the textbook depending on linguistic means. It started as 'Functional Grammar' (Halliday, 1985), was used by Margan (1996,1998) to analyze students' mathematical texts. This theoretical framework includes three functions: the ideational function, the interpersonal function and the textual function.

Ideational function

In the mathematical text, it relates to the nature and of the human presence in the text, and the role of the human in the mathematical acts. It is related to the type of learning processes found in the mathematical text. When you analyze the ideational function in the mathematical text, you look at the following types of processes: the mental, the material, the behavioral, the verbal, the existential, and the relational (Halliday, 1985, Morgan, 1998). Mental processes are processes of feeling and are of three types: sensory perception (hear, see, etc.), emotional (like, hate, etc.) and mental perception (think, know, understand, etc.). Mental processes have two things in common: the person who feels and the phenomenon. Material processes are processes belonging to the real world and they have two things in common: the subject and the target. Behavioral processes are

processes that fall between material processes and mental processes. Therefore, sometimes it is difficult to differentiate between behavioral processes and both material processes and mental processes. The behavioral verb is a non-transitive verb. Verbal processes have three components: the sender, the message and the receiver. Existential processes are processes that represent something that exists or something that happens. Relational processes are processes that is involved in a relation.

Interpersonal function

It is concerned with the relevant relationships between the participants, the identity of the speaker and the addressee. This means that this function describes the relationship between the author and the reader and could be made clear through the use of the pronouns (we, I, you, they, he, she, etc.). The interpersonal function could also be made clear from the type of verb used, for example whether the verb is an imperative. The use of an imperative verb indicates a formal relationship between the author and the reader. Some of the questions that we answer when we evaluate the interpersonal function between the author and the reader are: Who is the reader of the text? To what degree is he seen as an expert? Does the author speak with authority? Does the author consider himself/herself part of a learning community? Does the author sympathize with the reader?

Textual function

It relates to the role that the language itself plays in the text, i.e., it relates to how the words of the text are used, for example in terms of description, command or explanation. It is also related to how the text progresses, does the text progress from the given to the result? from the known to the new? Is it presented as a logical and causal text? it is also related to the types of text and their function and the relationship between them, such as verbal text, mathematical symbols and mathematical drawings. Some of the questions we answer when evaluating this function are: What role does the text play for the reader? Does it tell a story? Is it related to content description? Is it involved with calculation or solving methods? Is it related to proof? (Daher & Abu Thabet, 2020).

Studies in the field of analyzing mathematical texts directed towards the linguistic methodology for analyzing mathematics curricula, and specifically social semiotics, where this analysis depended, as described above, on Halliday's functional grammar (Halliday, 1985). Morgan (1998) led in the application of functional grammar in mathematical education. This motivated the use of 'functional grammar – based' social semiotics in analyzing mathematical texts. Daher (2009a, 2009b) suggested a framework for analyzing electronic mathematical texts based on social semiotics. Al-Shuwaikh and Morgan (2013) analyzed the 'triangles' congruency' unit in the Palestinian mathematics book according to social semiotics, and they compared this unit with the similar mathematical text in the British curriculum. Their research results indicated that there is a difference between the two texts, where the focus the British text was on transformations.

O'Keeffe and O'donoghue (2011) depended on social semiotics to analyze the mathematics textbook in the Irish curriculum and examine its role in encouraging understanding and motivation among mathematics students. The study found that the most objects of language that affect students' motivation and focus on studying mathematics is the use of pronouns, passive tense, informal sentences, special words, verb forms and symbols. In addition, O'Keeffe (2013) relied on the framework of social semiotic analysis as one of three theoretical frameworks in order to build a suitable theoretical framework for analyzing the mathematics textbook.

Daher and Abu Thabet (2020) analyzed the geometry unit in the Palestinian old mathematics textbook for the seventh grade. This study concluded that the mathematics represented in the text indicates a pre-existing object that can be discovered by learners. At the same time, the geometry unit includes relationships that can be considered by the learner.

The research objectives and rationale

One of the recent trends in the analysis of mathematics curricula is the use of social semiotics that uses linguistic means (Daher 2009a, b; Morgan, 2006). The present research utilizes the social semiotics approach to analyze the Algebra unit in the old and new Palestinian mathematics textbooks for the ninth grade and compare them regarding the ideational, the interpersonal and textual functions. This analysis will help assist the effort of the Curriculum Development Centers in

their attempts to develop a more functional mathematics textbook. In addition, this analysis helps the mathematics teacher in planning how to deal functionally with students and the textbook, and this is evident in view of the comparison that will be made between the old and modern curricula.

Little research has attempted to compare the two books; the old and the new, which the present research attempts to do so. This will give deeper insight into the social semiotics meanings the embed the mathematics textbooks.

Research Questions

1. How is the ideational function of the mathematical text manifested in the Algebra textbooks in the old and new Palestinian curriculum for the ninth grade?
2. How is the interpersonal function of the mathematical text manifested in the Algebra textbooks in the old and new Palestinian curriculum for the ninth grade?
3. How is the textual function of the mathematical text manifested in the Algebra textbooks in The old and new Palestinian curriculum for the ninth grade?

METHODS

This study relied on the method of deductive content analysis, considering the features dealt with by Morgan (1996), Al-Shuwaikh (2013), and O'Keeffe and O'Donoghue (2011). Deductive content analysis is a priori design, where the categories and themes are taken from a theoretical framework and the researchers finds the values of these categories in the specific data (McKibben et al., 2020).

The data collection method

We analysed the Algebra unit in the Palestinian textbook for the ninth grade. The algebra unit was chosen from the second part of the mathematics book for the ninth grade, on pages 76-103 in the old curriculum (2004), and on pages 46-71 in the new curriculum (2018). The unit includes the following titles: Polynomial functions, operations on polynomials, rationale functions, operations on rationale function.

In 2004, the ministry of education stresses, in the introduction of the old version of the mathematics book for the ninth grade, that it considers the student an active learner who builds the mathematical concepts by himself or herself. Furthermore, in 2018, the ministry of education stresses that mathematics should be given to the students through appropriate contexts that is based on solving life problems. The ministry of education further stresses that these contexts should be based on tasks that encourage thinking and simulates the Palestinian environment, in addition to technology-based tasks.

Analysis method

The above-mentioned unit from the ninth-grade textbook in the old and modern Palestinean textbooks were analyzed according to social semiotics. In search of a features specific to each function, the unit of analysis was an introduction to a lesson, an example, a question, and an activity, if existed. Doing that, we searched for the values of the semiotic function in the unit. After that, frequencies were computed for each value in each function. It can be said that the method of analysis is mainly a method of deductive content analysis, taking into account the categories and features that were dealt with by the resources that depended on in our analysis (Alshwaikh, 2013; Morgan, 1996; O'Keeffe & O'Donoghue, 2011). More specifically, to analyze the ideational function resulting from the text in the Algebra unit in the old and new Palestinian mathematics textbooks for the ninth grade, we looked for the learning processes: material, mental, relational, verbal, behavioral, and existential.

With regard to humans, we looked whether the human is involved with the general or the specific. The 'general' is achieved when we speak in general, for example we say an algebraic term contains one or more variables. Here the person can be the author or the reader, where the mental process is a general mental process because it speaks in general, so it generalizes. The 'special' is achieved when we talk about special cases. When this happens, the human performs a special process, for example when talking about special cases with limits. With respect to mathematical objects, we also look at the representation of this object (table, algebraic, graph, word, etc.). On the other hand. It may express a mathematical relationship or mathematical definition with a particular

representation. The mathematical object or the mathematical relationship can also be a cardinal or a derivative. For example, a mathematical relationship when it is an axiom is basic, while the theorems resulting from the axiom are derived from it.

To analyze the interpersonal function, we examined the pronouns used in the mathematical text (for example, the pronoun 'we' indicates the author's attempt to include the reader in the audience on mathematicians). We also examined the types of verbs, especially the presence of imperative verbs (the imperative indicates a distant relationship between the author and the reader). Here we will draw on Halliday (1985) and Morgan (2006). To analyze the textual function, we will examine the progress of the text, relying on O'Keefe and O'Donov (2011) and Al-Shuwaikh and Morgan (2013). More specifically, relying on Al-Shuwaikh and Morgan, we will examine whether the text advances in a horizontal direction (a new given), in a vertical direction (a real example), or from the center (central marginal). We will rely on O'Keefe and O'Donov to examine whether the text progresses as simultaneous thinking and reasoning, as logical simultaneous reasoning and thinking (therefore, a basis for), or as compulsive reasoning and compulsion (next, then).

FINDINGS

Below we describe the values of the three social semiotics functions found in the Algebra unit of the ninth grade old and new mathematics books.

The ideational function

Here, we will describe three issues related to the ideational function. First, the percentages of the process according to its type. Second, the percentages of mathematical objects according to their type, and third, the percentages of the mathematical objects according to their representation. Table 1 shows the percentages of the process according to its type. Talking about percentages in total, Table 1 shows that the percentage of the relational processes and the verbal processes were more in the new curriculum, while the percentages of the material and behavioral processes were higher in the old curriculum. Table 2 shows the percentages of mathematical objects according to their type. Talking about percentages in total, Table 2 shows that the percentage of the derived initial description, as well as the percentage of the derived axiom, were higher in the old curriculum. The percentage of derived rule identity was higher in the new curriculum. Table 3 shows the percentages of representations according to their type. Talking about percentages in total, Table 3 shows that the percentage of the graphic representation was higher in the new representation, while the percentage of the numerical representation was higher in the old representation.

The interpersonal function

Here, we will describe two issues related to the interpersonal function: the pronouns and the imperatives. Table 4 shows the percentages related to the previous two issues. Talking about percentages in total, Table 4 shows that the percentage of the pronoun 'we' was higher in the old curriculum while the use of the pronoun 'I' was higher in the new curriculum. The percentage of the 'Imperative verb' was higher in the old curriculum.

The textual function

Here we will describe one issue related to the textual function, which is the advancement of the text. Table 5 shows the percentages of the types of this advancement. Table 5 shows that the advancement 'new knowledge to application knowledge' was higher in the new curriculum, while the advancement 'application knowledge to assessing knowledge' was higher in the old curriculum.

Table 1
Percentages of process according to their type

Math text		Process: author/reader					
Algebra unit in old and new curriculum		Material process	Mental process	Relational process	Verbal process	Behavioral process	Existential process
Polynomial functions	old	%3.13	%28.13	%18.75	%18.75	%21.87	%9.37
	new	%0	%26.92	%19.24	%38.46	%15.38	%0
Operations on polynomials	old	%0	%34.73	%8.42	%23.15	%33.68	%0
	new	%0	%20	%23.64	%34.54	%21.82	%0
Rationale functions	old	%7.63	%42.3	%7.69	%9.61	%32.69	%0
	new	%0	%50	%7.15	%28.57	%14.28	%0
Operations on Rationale functions	old	%10.63	%42.55	%8.51	%17.02	%21.27	%0
	new	%0	%28.57	%19.04	%28.57	%23.82	%0
Total	old	%4.42	%37.17	%9.74	%18.14	%29.20	%1.33
	new	%0	%26.72	%19.83	%33.62	%19.83	%0

Table 2
Percentages of mathematical objects according to their type

Math text		mathematical objects							
Algebra unit in old and new curriculum		Initial description		Formal definition		axiom		Rule and identity	
		Basic	Derived	Basic	Derived	Basic	Derived	Basic	Derived
Polynomial functions	old	%0	%16.67	%100	%0	%0	%33.33	%0	%50
	new	%50	%0	%50	%0	%0	%0	%0	%100
Operations on polynomials	old	%100	%66.67	%0	%0	%0	%0	%0	%33.33
	new	%50	%25	%50	%25	%0	%0	%0	%50
Rationale functions	Old	%50	%75	%50	%0	%0	%0	%0	%25
	New	%50	%0	%50	%0	%0	%0	%0	%100
Operations on Rationale functions	Old	%0	%16.67	%0	%50	%0	%0	%0	%33.33
	New	%100	%0	%0	%0	%0	%0	%0	%100
Total	Old	%50	%40.9	%50	%13.63	%0	%9.09	%0	%36.36
	New	%57.14	%10	42.86	%10	%0	%0	%0	%80

Table 3
Percentages of representations according to their type

Math text		Representation of mathematical objects			
Algebra unit in old and new curriculum		Algebraic	Graphic	Verbal	Numerical
Polynomial functions	old	%30	%0	%50	%20
	new	%37.5	%12.55	%50	%0
Operations on polynomials	old	%76	%0	%20	%4
	new	%50	%5.55	%38.90	%5.55
Rationale functions	old	%50	%0	%50	%0
	new	%66.67	%0	%33.33	%0
Operations on Rationale functions	old	%38.46	%30.76	%23.07	%7.69
	new	%45.45	%18.19	%36.36	%0
Total representations	old	%51.42	%5.71	%34.28	%8.57
	new	%47.5	%10	%40	%2.5

Table 4

Percentages of interpersonal function between the character between the author and the reader

Algebra unit in old and new curriculum		Pronoun we	Pronoun I	Other pronouns	imperatives	Other verbs
Polynomial functions	Old	%0	%81.81	%18.18	%71.42	%28.63
	New	%14.28	%85.72	%0	%0	%100
Operations on polynomials	Old	%26.31	%57.89	%15.75	%77.27	%22.72
	New	%16	%64	%20	%19.24	%80.76
Rationale functions	Old	%29.41	%64.70	%5.88	%25	%75
	New	%16.67	%83.33	%0	%0	%100
Operations on Rationale functions	Old	%21.05	%57.89	%21.05	%26.67	%73.33
	New	%0	%100	%0	%0	%100
Total	Old	%22.35	%62.35	%15.29	%53.96	%46.03
	New	%13.20	%77.36	%9.43	%9.61	%90.03

Table 5

Percentages of the types of the text's advancement

Algebra unit in old and new curriculum		previous- new - application		
		previous knowledge- new knowledge	new knowledge- application	application- assessing knowledge
Polynomial functions	Old	%18.18	%18.18	%63.63
	New	%25	%50	%25
Operations on polynomials	Old	%42.1	%31.57	%26.31
	New	%42.86	%42.86	%14.28
Rationale functions	Old	%57.14	%14.28	%28.57
	New	%50	%50	%0
Operations on Rationale functions	Old	%75	%25	%0
	New	%60	%20	%20
Total	Old	%41.46	%24.39	%34.14
	New	%44.44	%38.89	%16.67

DISCUSSION

The present research intended to analyze, based on the social semiotics framework, the Algebra unit in the Palestinian mathematics book of the ninth grade. Below, we discuss the results regarding each of the social semiotics' functions.

The ideational function

The research results showed that the percentage of the relational processes and the verbal processes were more in the new curriculum, while the percentages of the material and behavioral processes were higher in the old curriculum. The previous results indicate the new curriculum is concerned with the students' exploration of mathematical relations. This is in line with another finding of the present research, specifically that the percentage of the derived rules was higher in the new curriculum. The two results indicate the emphasis in the new curriculum on algebraic relations and identities. Mental and behavioral processes in the new curriculum were higher than any other processes. Thus, the authors look at mathematics as "a system of relationships between objects or between objects and their properties" (Morgan, 1996, p. 4). Daher and Abu Thabet (2020) found that the relational and mental processes were the most used in the geometry unit in the old fifth grade mathematics textbook. The difference could be due to the topic, where Daher and Abu Thabet (2020) addressed the geometry unit, while here the algebra unit is addressed.

The above results indicate that probably the new curriculum should have taken into consideration the material process more than it did, for example by using physical manipulatives. This would need effort to do so, as physical manipulatives in Algebra are less frequent than those in geometry for example. Larbi and Mavis (2016) describes physical manipulatives: "These physical media appeal to the senses of the learners which bring things that are far beyond their environment

near". The previous description shows the importance of trying to enrich the mathematics curriculum, including the algebra unit with manipulatives, whether they were physical or virtual (Lange, 2021; Roberts et al., 2020).

The percentage of the graphic representation was higher in the new textbook, while the percentage of the numerical representation was higher in the old textbook. This indicates the awareness of the Palestinian ministry of education for the role of the graphic representation in enriching the meanings of the mathematical phenomenon. These graphic representations were static, and dynamic graphic representations are needed to enrich the mathematical concepts of the students (Daher & Swidan, 2021; Swidan & Daher, 2019).

The interpersonal function

The percentage of the pronoun 'we' was higher in the old curriculum while the use of the pronoun 'I' was higher in the new curriculum. This result indicates the emphasis put by the Palestinian ministry of education on the individual student. It also implies a relatively formal relationship between the author and the reader, by not using the 'we' pronoun (Morgan, 1996). This formal relationship could not indicate a distant relationship, as the results indicated that the percentage of the 'Imperative verb' was higher in the old curriculum, and lower in the new curriculum. Thus, here we distinguish between the formal and the distant relationship. The author considers himself as part of the educational community but speaks formally. In addition to the above, it could be claimed that the use of the singular pronoun 'I' to refer to the establishment of the reader as an expert, which could fit the cognitivism approach to learning. Furthermore, Daher and Abu Thabet (2020) found that the authors of the geometry unit in the old eighth grade mathematics book used the plural first person pronoun to talk about issues related to reasoning. The authors of the old eighth grade mathematics book also extended the use of the plural first person pronoun to other learning processes as the behavioral processes.

In addition to the above, Li and Yang (2021) found that teacher-student interaction had positive impact on students' self-efficacy and their preference for the mode of learning. The previous findings stress the importance of looking at the interpersonal function and its characteristics. We found that, in the new mathematics version, the author-reader relationship was formal but not distant, which could influence the relationship teacher-student.

The textual function:

The advancement 'new knowledge to application knowledge' was higher in the new curriculum, while the advancement 'application knowledge to assessing knowledge' was higher in the old curriculum. This implies that the author in of the new mathematics curriculum, in comparing with the old curriculum, was more concerned with the application knowledge. This is in line with researchers who stressed the importance of applying knowledge by the student to substantiate her or his new knowledge (ex., Piñeiro et al., 2021; University of South Australia, 2022).

The present research studied three specific functions of the texts using the social semiotics theory. Future curriculum research, addressing mathematics textbooks especially in the high school, is needed to analyze these textbooks regarding other criteria or categories. Some of these categories could be: values in general (Daher, 2021), democratic values in particular (Daher, 2020) and life skills (Wahbeh et al., 2021).

CONCLUSIONS

The present study used the three meta-functions of language in the frame of systemic functional linguistics to analyze and compare the algebra unit in the old and new ninth grade mathematics textbooks. The research results indicated that the authors of the algebra unit in the new Palestinian mathematics book for the ninth grade were mostly concerned with the mental and verbal processes. This concern would probably indicate their concern with the students' activity according to the cognitivism framework. This influenced the interpersonal function, as they used the singular pronoun 'I' to address the reader, and thus they showed their consideration of the reader as capable learner.

The present research results indicated that the new mathematics textbook addressed the 'new knowledge to application knowledge' more than they did for the 'application knowledge to

assessing knowledge'. New mathematics curriculum needs to address the advancement 'new knowledge to high order thinking'. This recommendation applies to assessment as well as creative and critical thinking.

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