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Readability of Texts in Secondary School Mathematics Course Books

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Abstract

This study aimed to investigate the readability of the fifth-, sixth, seventh and eighth-grade mathematics course books prepared in deference to the 2017 curriculum and distributed to schools by MEB. This study utilized the descriptive document analysis which is a qualitative research method. Readability of the mathematics course books were subjected to a quantitative analysis by Çetinkaya-Uzun Readability Formula. Addressing the readability levels of the texts in secondary mathematics course books, this study performed analyses of average word and average sentence lengths of the texts in secondary school course books. These analyses showed that there is no linear correlation between grade level and word and sentence length averages. Readability scores and levels of the text in the analyzed secondary school mathematics course books are not in parallel with the grade level. Accordingly, readability scores of information and solution texts in the fifth-grade course book were lower than the scores in other grades' course books whereas readability scores of question texts were lower than the scores in all grades' course books but the eighth-grade course book. Readability levels of the text in the analyzed secondary school mathematics course book were found to be on frustration level and educational level. Course books should also include independent texts with readability scores and levels.

Keywords: Readability, Comprehensibility, Mathematics course books.

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1. Introduction

As one of the biggest helpers of teachers, course book is a material which significantly determines what (subject, concept, properties,...) and how (activity, method,...) to be thought in the classroom. Course books need to be prepared in parallel with the curricula accepted by the Ministry of National Education (MEB). In other words, course books, as mirrors reflecting the curriculum, should be able to reflect the curriculum in the exact sense so that they can achieve the desired goals (Arslan and Ozpınar, 2009). The matter in question has brought the assessment of course books into the agenda. Therefore, course books have been featured as a special matter in the educational studies in recent years. Accordingly, there have been assessments and scales created in several domains such as mathematics, physics and chemistry in our country (Cepni *et al.*, 1999; Cepni *et al.*, 2001; Keles, 2001; Dane *et al.*, 2004; Gökdere and Keles, 2004; Semperci and Semerci, 2004). For instance, certain research studies have been conducted to examine the current and desired status of course books used in the mathematics education (Dane *et al.*, 2004; Semperci and Semerci, 2004; Dede and Yaman, 2005). Studies on the relationship between reading and Turkish, science, social, and mathematical achievement are observed in the literature (e.g. (Bloom, 1998; Sertsöz, 2003; Akay, 2004; Sallabaş, 2008; Obalı, 2009; Paige, 2011; Yılmaz, 2011; Yilmaz, 2012)).

A prominent factor that strengthens the positive relationship between academic achievement and reading is the role of printed/written words in the learning environment. Reading tools (story books, course books, notebooks, summarized notes, etc.) play an important role in learning current information on world (Pretorius, 2000). Much of the information on world is available in written, printed or increasingly electronic format. Reading is the most effective power used in accessing this information available in today's world. Moreover, it has a key role in acquiring preliminary knowledge, improving and transforming the acquired information. A successful learning requires being competent in integrating new information with knowledge, transforming and transferring it to other domains. Reading comprehension is the act of making sense of the information given in text by integrating it with the information structures in mind. Academic achievement requires learning, and learning requires reading. Students can satiate their linguistic skills, vocabularies and general knowledge levels by reading. This contributes to students' academic achievement and how they achieve academic information positively. Even though there are studies in Turkey on the readability of Science, Turkish and Geography course books (Cepni *et al.*, 2001; Geçit, 2010; Ozcan, 2011) no study was observed on the readability of course books which are of importance in mathematics learning environment.

Significant part of how reader can maintain word processing and interpretation competently is linguistic properties that form the text (Cetinkaya, 2010). Acceptability of all linguistic properties more or less by the reader is defined as readability (Klare, 1963). Readability levels of texts are important factors in how reader interprets a text. Hence, text's readability level should be in parallel with reader's level. There are readability formulas developed specifically to every language to determine readability level of texts.

The fact that no study has been performed on readability levels of mathematics course books prepared in consideration of the curricula and distributed to schools by MEB is an important deficiency. However, two of the most important factors that will determine success of current curricula are teachers and course books. Thus, even if curricula are well-prepared, their implementation will be negatively affected and their effectiveness will be hindered if course books are not compatible with curriculum's general approach or neglect the criteria that should be possessed by a course book. Accordingly, this study aimed to investigate the readability of the fifth-, sixth, seventh and eighth-grade mathematics course books prepared in deference to the 2017 curriculum and distributed to schools by MEB. Answers were sought to the following research questions to that end:

1. How do the numbers of information, question and solution texts appear in secondary school mathematics course books?
2. How do average word lengths and average sentence lengths of texts appear in secondary school mathematics course books?
3. How do the readability levels of texts appear in secondary school mathematics course books?

2. Method

2.1. Study Design

This study utilized the descriptive document analysis. Readability of the mathematics course books were subjected to a quantitative analysis by running the formula developed by Cetinkaya and Uzun (2011).

2.2. Sample

MEB-approved fifth-, sixth-, seventh- and eighth-grade course books used in the academic year of 2017-2018 were included in the study.

2.3. Collection and Analysis of the Data

First, texts of information, question and solution were identified in the mathematics course books. Next, average word, average sentence and readability scores of the text were calculated through the directive in Cetinkaya (2010).

1. Count the words

Numbers, graphemes (letters), symbols and groups of grapheme separated with space are accepted as words. Words separated with hyphen and acronyms are accepted as words. For example;

- *Gel-git* (Tide)
- ASL

2. Count the sentences.

Each unit deemed to be independent from other sentence or object grammatically are accepted as a sentence. A unit ended with full stop (.), colon (:) and two brackets ( ) is accepted as a sentence.

3. Count the syllables.

Count the syllables as you pronounce them. For example;

"*Gel*" (Come) has 1 syllable
"*Gelsin*" (Let him/her come) has 2 syllables (Gel-sin)
"*Gidelim*" (Let us go) has 3 syllables (Gi-de-lim)
Symbols and shapes are counted as they are pronounced. For example;
Cm has 4 syllables (San-ti-met-re)
1918 has 7 syllables (Bin-do-kuz-yüz-on-se-kiz)

4. Find the average sentence length.

Divide total number of words by number of sentences to find the average sentence length.

$$ASL = \frac{\text{Total number of words}}{\text{Total number of sentences}}$$

5. Find the average word length.

Divide total number of syllables by total number of word to find the average word length.

$$AWL = \frac{\text{Total number of syllables}}{\text{Total number of words}}$$

6. Run the formula.

Place the average sentence length and average word length values calculated by the abovementioned operational steps in the readability formula below. Here is the formula that gives the readability level of texts:

$$RS = 118.823 - 25.987 \times AWL - 0.971 \times ASL$$

RS= Readability Score
ASL= Average sentence length
AWL= Average word length

The following is an exemplary analysis of an information text available in the eighth-grade mathematics course book. The analyses were performed using the "Turkish text frequency analyzer"[1].

Exemplary Text: Çiftçi Mehmet Bey yetiştirdiği altmış kilogram cevizi torbalara eşit miktarlarda koyarak satmak istiyor. Torbaların kaçar kilogram olabileceğini bulalım. Doğal sayısının çarpanlarını belirleyerek torbaların kaçar kg olabileceğini buluruz. Çarpan ağacını kullanalım: Altmış doğal sayısının çarpanları bir, iki, üç, dört, beş, altı, on, on iki, on beş, yirmi, otuz, altmıştır. Siz de altmış doğal sayısının asal çarpanlarını bulunuz.

Bir doğal sayıyı kalansız olarak bölebilen sayılara o doğal sayının çarpanları denir. Bir ve kendisinden başka böleni olmayan sayılara asal sayılar denir

"*Mr. Mehmet the Farmer wants to sell sixty kilograms of his walnuts he grew putting them in bags in equal amounts. Let us find how many kilograms each bag can be. We find how many kilograms the bags can be by determining factors of the natural number. Let us use the factor tree: Factors of the natural number sixty are one, two, three, four, five, six, ten, twelve, fifteen, twenty, thirty, and sixty. Now you too find the prime factors of the natural number sixty.*

Numbers that can divide a natural number without remainder are called factors of that natural number. Numbers that do not have any other divisors than one and itself are called prime factors" (p.12).

Table-1. Sentence frequency of the exemplary text by number of words

Order	Number of Words	Frequency	%	Sentence (Frequency) Distribution
1	8	1	12.50	siz de altmış doğal sayısının asal çarpanlarını bulunuz (1) "now you too find the prime factors of the natural number sixty"
2	12	1	12.50	bir doğal sayıyı kalansız olarak bölebilen sayılara o doğal sayının çarpanları denir(1) "numbers that can divide a natural number without remainder are called factors of that natural number"
3	10	1	12.50	bir ve kendisinden başka böleni olmayan sayılara asal sayılar denir(1) "numbers that do not have any other divisors than one and itself are called prime factors"
4	18	1	12.50	altmış doğal sayısının çarpanları bir iki üç dört beş altı on on iki on beş yirmi otuz altmıştır(1) "factors of the natural number sixty are one, two, three, four, five, six, ten, twelve, fifteen, twenty, thirty, and sixty"
5	3	1	12.50	çarpan ağacını kullanalım(1) "let us use the factor tree"
6	5	1	12.50	torbaların kaçar kilogram olabileceğini bulalım(1) "let us find how many kilograms each bag can be"
7	9	1	12.50	doğal sayısının çarpanlarını belirleyerek torbaların kaçar kg olabileceğini buluruz(1) "we find how many kilograms the bags can be by determining factors of the natural number"
8	13	1	12.50	çiftçi mehmet bey yetiştirdiği altmış kilogram cevizi torbalara eşit miktarlarda koyarak satmak istiyor(1) "Mr. Mehmet the Farmer wants to sell sixty kilograms of his walnuts he grew putting them in bags in equal amounts"
Total		8	100	

[1] http://ihaleka.com/metinanaliz/

According to the analysis above, there are 78 words and 8 sentence in the exemplary text in total. In the light of these data, we can do the operation in the fourth step of the directive.

$$ASL = \frac{78}{8} \qquad ASL = 9.75$$

The average sentence length was calculated to be 9.75 by dividing the total number of words by the total number of sentences.

Table 2 below presents the analysis performed to find the average word length of the exemplary text.

Table-2. Word frequency of the exemplary text by number of syllables

Order	Number of Syllables	Frequency	%	Frequency Distribution
1	2	26	33.33	doğal (natural)(5) altmış (sixty)(3) kaçar (each)(2) denir (called)(2) iki (two)(2) asal (prime)(2) satmak (sell)(1) yirmi (twenty)(1) çarpan (factor)(1) otuz (thirty)(1) çiftçi (farmer)(1) mehmet(1) eşit (equal)(1) altı (six)(1) kg(1) başka (other)(1)
2	3	16	20.51	kilogram(2) olarak (as)(1) koyarak (putting)(1) olmayan (do not have)(1) sayılar (numbers)(1) sayıyı (number)(1) sayının (of number) (1) kalansız (without remainder)(1) bulunuz (find)(1) bulalım (let us find)(1) buluruz (we find)(1) böleni (divisior)(1) istiyor (wants)(1) cevizi (walnut)(1) altmıştır (sixty)(1)
3	1	15	19.23	on (ten)(3) bir (one)(3) beş (five)(2) siz (you)(1) üç (three)(1) ve (and)(1) dört(four) (1) de (too)(1) bey (Mr.)(1) o (that)(1)
4	4	15	19.23	sayısının (number)(3) sayılara (numbers)(2) torbaların (bags)(2) çarpanları (factors) (2) torbalara (bags)(1) miktarlarda (amounts)(1) bölebilen (that can divide)(1) kendisinden (than itself)(1) kullanalım (let us use)(1) ağacını (tree)(1)
5	5	4	5.13	çarpanlarını (factors)(2) yetiştirdiği (he grew)(1) belirleyerek (by determining)(1)
6	7	2	2.56	olabileceğini (can be)(2)
Total		78	100	

The table above gives the number of syllables and the number of words which have the specific syllable.

$$AWL = \frac{209}{78} \qquad AWL = 2.68$$

The average word length was calculated to be 2.68 by dividing the total number of syllables by the total number of words.

Readability score can be calculated by placing the average sentence length and average word length values found as a result of the abovementioned operational steps.

AWL= 2.72
ASL= 13.08
RS= 118.823 – 25.987 x 2.68 – 0.971 x 9.75
25.987 x 2.68= 69.65
0.971 x 9.75 = 9.47
118.823 – 69.65= 49.17
49.17 – 9.47= 39.7
RS= 39.7

Readability score of each text was calculated with the operations above, and then average readability scores of the text in course books of every grade level were calculated.

There are readability formulas developed specifically to every language to determine readability level of texts. The only readability formula which meets the requirements of a scientific approach in determining the readability levels of Turkish tasks is Çetinkaya-Uzun Readability Formula. It seems that the formula is based on informative texts. In this sense, the fact that mathematical question, information and solution texts are of the same characteristics increases the validity of the analyses.

Texts with a readability score of 51 and above are defined as *independent*;
Texts with a readability score of 35-50 are defined as *educational*;
Texts with a readability score of 0-34 are defined as *frustration*.

While readers can process texts by themselves easily, they can interpret educational texts in the guidance of teacher. These levels refer to the structural difficulty level of a text. If the student has a high linguistic, contextual and formal background, they can even interpret frustration level text independently. That is, structural difficulty of texts may differ by individual's background. Values achieved with the readability formula provides us with information on text's structure and allows us to grade it by its structural difficulty. We can know what level text we need to provide them with once we determine our students backgrounds.

The variables taken as basis in the formula to determine the readability level are average sentence length and average word length. It is observed that several formulas developed for foreign languages (McLaughlin, 1969; Duffy, 1985; Chall and Dale, 1995) take these variables as basis. Average sentence length corresponds to the syntactic complex level of the structure. Study results show that word problems with long sentences, that is, a complex syntactic structure cannot be interpreted by students with lower achievement levels (Shaftel *et al.*, 2006). Test-developer experts often utilize syntax and resort to abbreviate the syntactic structure to facilitate interpretation and relieve the mental load (Oakland and Lane, 2004).

Texts in the course books were categorized as Information Text (IT), Question Text (QT) and Solution Text (ST) to examine their readability levels separately. Texts with extra textual reference were not included in the analysis.

3. Findings

3.1. Numbers of Texts in Secondary School Mathematics Course Books

Table-3. Numbers of texts in secondary school mathematics course books

Grade Level	Information text	Question text	Solution text
Fifth grade	106	319	100
Sixth grade	165	330	119
Seventh grade	105	452	115
Eighth grade	131	419	94

According to Table 3, there were 106 information texts in the fifth grade, 165 in the sixth grade, 105 in the seventh grade and 131 in the eighth grade. It was found that there were 319 question texts in the fifth grade, 330 in the sixth grade, 452 in the seventh grade and 419 in the eighth grade. Number of the solution texts were found to be 100 in the fifth grade, 119 in the sixth grade, 115 in the seventh grade and 94 in the eighth grade.

Average word and average sentence lengths of the texts in secondary school course books

Table-4. Average word and sentence lengths of the texts

Grade Level	Information text		Question text		Solution text	
	AWL	ASL	AWL	ASL	AWL	ASL
Fifth grade	2.82	11.84	2.86	11.40	2.84	10.25
Sixth grade	2.75	12.01	2.71	11.47	2.56	9.41
Seventh grade	2.67	12.26	2.77	11.02	2.66	10.31
Eighth grade	2.73	12.41	2.88	10.81	2.64	9.85

According to Table 4 which presents the average word and average sentence lengths of the texts in secondary school course books, average word lengths of information texts were 2.82 in the fifth grade, 2.75 in the sixth grade, 2.67 in the seventh grade and 2.73 in the eighth grade while the average sentence lengths were 11.84 in the fifth grade, 12.01 in the sixth grade, 12.26 in the seventh grade and 12.41 in the eighth grade. Average word lengths of the question texts were found to be 2.86 in the fifth grade, 2.71 in the sixth grade, 2.77 in the seventh grade and 2.88 in the eighth grade whereas average sentence lengths were 11.40 in the fifth grade, 11.47 in the sixth grade, 11.02 in the seventh grade and 10.81 in the eighth grade. Average word lengths of the solution texts were found to be 2.84 in the fifth grade, 2.56 in the sixth grade, 2.66 in the seventh grade and 2.64in the eighth grade whereas average sentence lengths were 10.25 in the fifth grade, 9.41 in the sixth grade, 10.31 in the seventh grade and 9.85 in the eighth grade.

Readability levels of texts in secondary school mathematics course books

Table-5. Readability levels of texts

Grade Level	Information text		Question text		Solution text	
	Readability score	Readability level	Readability score	Readability level	Readability score	Readability level
5	34.20	Frustration	33.41	Frustration	34.94	Frustration
6	35.23	Educational	36.71	Educational	42.19	Educational
7	37.03	Educational	35.49	Educational	39.25	Educational
8	35.40	Educational	32.94	Frustration	40.09	Educational

Table 5 presents the average readability levels of the text in secondary school course books. Readability levels of the information texts were 34.20 in the fifth grade, 35.23 in the sixth grade, 37.03 in the seventh grade and 35.40 in the eighth grade. It can be understood that the information texts are on educational level in the sixth, seventh and eighth grades while they are on frustration level in the fifth grade. Readability levels of the question texts were 33.41 in the fifth grade, 36.71 in the sixth grade, 35.49 in the seventh grade and 32.94 in the eighth grade. It seems that the question texts are on educational level in the sixth and seventh grades whereas they are on frustration level in the fifth and eighth grades. Readability levels of the solution texts were 34.94 in the fifth grade, 42.19 in the sixth grade, 39.25 in the seventh grade and 40.09 in the eighth grade. It can be understood that the solution texts are on educational level in the sixth, seventh and eighth grades while they are on frustration level in the fifth grade.

4. Discussion and Conclusion

The first step of the problem-solving process in Mathematics course is reading and comprehension. When reading and comprehension is not achieved on the sufficient level, either problem-solving process never starts or other steps of the process are hindered. An unproductive problem-solving process is a significant obstacle before the conceptualization of mathematics. Therefore, designing the texts (description, question, etc.) in course books so that students can comprehend them will provide important steps in their cognitive processes. Reading-comprehension is of great importance in transitions of students' convergent learning.

Readability and intelligibility level of any kind of texts to be presented to students have direct impact on their interpretation of textual content. Qualities such as word length and sentence length are also the main variables in determining the readability and intelligibility levels of texts.

Aiming to determine the average word lengths, average sentence lengths and readability levels of the texts in secondary mathematics course books, this study investigated the information, question and solution texts in the fifth-, sixth-, seventh- and eighth-grade course books. The analysis found the numbers of information texts to be 106 in the fifth grade, 165 in the sixth grade, 105 in the seventh grade and 131 in the eighth grade. This indicates that information texts do not increase gradually as the grade level increases. The lowest-level information texts were in the seventh-grade course book while the sixth-grade course book had the highest-level information texts. Yet, it is anticipated that progressivity in every aspect is in question among grade levels when content of course books is designed.

Number of question texts in secondary school mathematics course books were found to be 319 in the fifth grade, 330 in the sixth grade, 452 in the seventh grade and 419 the eighth grade. There were 33 less questions in the eighth-grade course book than in the seventh-grade course book. There is an imbalance in the eighth grade in terms of progressivity. While there was an increase from the fifth to seventh grade in question texts, a decrease was observed in the eighth grade.

Number of solution texts in secondary school mathematics course books were found to be 100 in the fifth grade, 119 in the sixth grade, 115 in the seventh grade and 94 the eighth grade. Accordingly, number of solution texts increased progressively in the fifth and sixth grades, there was no such increase in the seventh and eighth grades; number of solution texts in the eighth-grade course book even remained below the number in the fifth-grade course book.

The highest number of information texts was found to be in the sixth-grade course book, the highest number of question texts was found to be in the seventh-grade course book, and the highest number of solution texts was found to be in the sixth-grade course book. It is understood that principles of progressivity such as from easy to difficult, simple to complex, literal to inferential comprehension, etc. suggested by deciding and pioneering scientists in the educational domain such as Bloom and Barrett were not considered in the distribution of information, question and solution texts in secondary school mathematics course books.

Addressing the readability levels of the texts in secondary mathematics course books, this study performed analyses of average word and average sentence lengths of the texts in secondary school course books. These analyses showed that there is no linear correlation between grade level and word and sentence length averages. However, schemas of students expand as grade level increases, therefore it becomes easier for them to make sense of more complex sentences. Hence, it is anticipated that texts in course books becomes harder as the grade level increases. Text should be not under but above the grade level to a degree so that students can improve their reading comprehension and problem-solving skills. Yet, it was found in the study that average word lengths of information texts in the fifth-grade course book were more than the lengths in other grades' course books, average word lengths of question texts were more than the lengths in the sixth- and seventh-grade course books; average sentence lengths of question texts were more than the lengths in the seventh-grade course book, average word lengths of solution texts were more than the lengths in other grades' course books, and average sentence lengths were more than the lengths in all grades' course books but the seventh-grade course book. As can be understood from these findings, word and sentence lengths were not organized according to grade levels.

Readability scores and levels of the text in the analyzed secondary school mathematics course books are not in parallel with the grade level. Accordingly, readability scores of information and solution texts in the fifth-grade course book were lower than the scores in other grades' course books whereas readability scores of question texts were lower than the scores in all grades' course books but the eighth-grade course book. Information text given before the text and solution text that comes after the question need to be constructed competently and sufficiently in the linguistic sense. These texts which need to be organized in an intensity that can be understood by students will help question understood and solved more easily. Furthermore, lower readability scores, that is, frustration level of question texts in the fifth-grade course book should be considered a problem. Lower readability scores of question texts indicated that students may find it hard to comprehend these texts. Lower readability scores of information, question and solution texts prepared for the fifth-grade students should remind that such scores may reduce the intelligibility level of these texts for students.

The eighth-grade question texts scored lower in readability and marked as frustration level texts in terms of readability. Accordingly, while information and solution texts in the eighth-grade course books were constructed as educational texts, these texts which measure students' level of comprehending the subject or information were not described with sufficient words and sentences. In this sense, it can be argued that question texts in secondary school eighth-grade mathematics course book were prepared in a way that they may affect students' comprehension level negatively.

Texts are classified as independent, educational and frustration in terms of readability level. The fact that none of the texts in the analyzed course books were on the independent level should be discussed. One should give some thought about the question "Should a course book be used only in the guidance of teacher or should it be regarded as an instrument that can be used by student alone?" Besides the educational texts which requires teacher guidance for comprehension, course books also need to include independent texts which students can deal with only by their own knowledge and experience inside and outside the classroom. By this means, it can be ensured that students in the learning phase have stronger confidence.

Readability refers to texts' level of structural difficulty and complexity. The higher readability level gets, the easier students find it to process and comprehend the text. Students of higher grade levels with more knowledge and experience process and interpret more complex and difficult texts than students of lower grade levels. When considered from this point of view, it can be argued that texts in the course books were created regardless of grade level. The following recommendations can be made in the light of the study results:

- Texts in the course books should be prepared in consideration of grade levels and the levels of intelligibility and readability.

- Teachers need to be trained to determine the readability levels of mathematical texts (question, description, solution, etc.) that will write or select to use for courses. Otherwise, teachers may unavoidably come to a wrong or incomplete conclusion whether a text is easy or difficult for students.
- Intelligibility is directly related to readability. If readability levels of mathematical texts are low, their intelligibility levels are reduced. In this context, it would be useful to ask students for opinion on whether they comprehend a mathematical text because this is an important variable for the achievement in a course.
- Readability levels of the text in the analyzed secondary school mathematics course book were found to be on frustration level and educational level. Course books should also include independent texts with readability scores and levels.

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