FLESCH READING EASE SCORE AS AN INDICATOR FOR SELECTING TEXTBOOKS IN PHYSICS

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Abstract: At Latvian secondary schools it is not uncommon to hear students complaining about Physics textbooks being too complicated. Students' ability to perceive and comprehend what is written in the textbooks depends on their reading competence as well as on the readability of the texts. The aim of this study is to determine whether the readability of a Form 11 textbook in Physics corresponds to the readability of students' written language in Form 11. The study identifies readability assessment techniques and examines their suitability for texts written in Latvian. It establishes that out of several text readability indicators, Flesch Reading Ease Score (FRES) is the most appropriate for the present study in order to characterize the readability level of texts written in Latvian. Application of the indicator allowed arriving to a conclusion that the readability of written language of the students under the study substantially differed from the readability of the Physics textbook used in the study process. This discrepancy indicates one of the possible reasons why perception of the content of Physics textbooks causes difficulties.

Keywords: readability, Flesch Reading Ease Score, reading competence, Physics textbook.

Introduction

It is essential that textbooks chosen for the study process correspond to the students' ability of perception. During a period of seven years long unstructured observation process by the author (M.L.) she has come to a conclusion that too often students claim that texts in Physics textbooks are too difficult for them to understand. The existence of this problem actuated the study whose aim is to determine whether the readability level of texts in Form 11 Physics textbook corresponds to the readability level of Form 11 students' written language.

The words said by Irving Lorge about text perception and readability in the middle of the twentieth century have not lost their relevance today: „What a person understands of the material he reads depends upon his general reading ability and the readability of the text he is reading. His reading ability, moreover, depends upon his intelligence, education, environment, and upon his interest and purpose in reading. The readability of a text depends upon the kind and number of ideas it expresses, the vocabulary and its style, and upon format and typography." (DuBay, 2006, 46).

The term readability has several definitions, one of which can be found in The Literacy Dictionary, where Readability is defined as "the ease of comprehension because of style of writing" (Fry, 2006, 1).

Characteristics of readability. How easy or difficult it is for a reader to perceive the text can be identified by several groups of factors. The reader's background and preparedness, his or her motivation as well as the organization of the cognitive process are of utmost importance. Secondly, an important role is played by the visual features – font size, font type and pictures. Thirdly, readability is greatly affected by the linguistic properties of the text – vocabulary, length of the sentences, text structure, etc.

The end of the 19th century, when William Lucius Adelno Sherman (1847 – 1933) started his research into English prose works applying methods of mathematical statistics, marks the beginning of extensive studies on the impact of linguistic properties of texts on their readability. In educational theory, the main area where text readability identification can be applied is language learning. Throughout the world there have been developed numerous language learning resource databases from which teachers can choose language learning tools appropriate for their students, since, as it has been rightly observed by Glenn Fulcher „At the most basic level, teachers recognise that giving students reading material that is "too difficult" is damaging to the learning process, and demotivating to the student" (Fulcher, 1997, 2).

However, using readability tests in the assessment of learning tools does not necessarily guarantee obtaining unequivocal results. „Readability, or "text difficulty", has been, and remains, an area of concern for all those who need to establish the appropriateness of a given text for a pedagogic purpose. And these concerns have historically been more practically than theoretically oriented" (Fulcher, 1997, 2).

Today, a variety of text readability indices can be measured by anyone interested on special websites where by copying and pasting text, readability scores are determined automatically. As an example can be mentioned *Online-Utility.org* (2012). A readability determination tool is also available in Word. Unfortunately, such tool cannot be activated in the Latvian version of Word.

These measurement techniques are useful for translators, publishers of advertising and informative materials, etc. Variety of techniques have been developed for testing readability level, some of them being quite elaborated, for example, methods of Lexil or Coh-Metrix, where text readability can be determined based on a number of criteria which are quite difficult to measure. However, for the greater part, such techniques are not too complicated. Further on, several examples of less complex formulae of measuring readability of English texts have been given. By inserting the appropriate values in the equation can be obtained a figure which characterizes the readability of the text – the index.

The Gunning's Fog Index (1952) $$GradeLevel = 0.4 \times ASL + PHW \quad (1)$$

The New Dale-Chall Readability (1948) $$RawScore = 0.1579 \times PDW + 0.0496 \times ASL \quad (2)$$

The SPACHE Readability (1953) $$SR = 0.141 \times ASL + 0.086 \times PDW + 0.839 \quad (3)$$

Flesch Reading Ease Score (DuBay, 2004) $$FRES = 206.835 - 1.015 \times ASL - 84.6 \times ASW \quad (4)$$

where *ASL* - Average Sentence Length;
PHW - Percentage of Hard Words;
PDW - Percentage of Difficult Words;
ASW - Average number of Syllables per Word.

As can be seen, the readability formulae are different; however, several similar features can be found:

- All of the four formulae include the value "Average Sentence Length" (*ASL*),
- In Formulae 2 and 3 one of the parameters is "Percentage of Difficult Words" (*PDW*), but the parameter "Percentage of Hard Words" *(PHW*) included in Formula 1 is essentially similar to value *PDW*,
- Equation 4 differs from the others with the parameter *ASW* – "Average number of Syllables per Word".

The main advantage of Flesch Reading Ease Score (Formula 4) in comparison with other equations mentioned before is that both values, *ASL* and *ASW*, can be easily measured and cannot be interpreted subjectively, whereas when measuring parameters *PDW* or *PHW* required for Formulae 1, 2 and 3, it is highly likely to have very different interpretations. Possibly, because of this reason, Flesch formula is one of the most popular and is most commonly applied. Unfortunately, the original Flesch formula (Formula 4) is suitable only for evaluating English texts. When analysing texts in other languages but English, it will not produce a result which could be compatible with the relevant scale. Some world languages have specially adapted Flesch formulae (Formulae 4-7). Included in these formulae are factors of *ASL* and *ASW*, whose values depend on the usage frequency of the so called number of zero value words in the relevant language, as well as on other peculiarities of the language.

Flesch Reading Ease Score Formulae for English (DuBay, 2004, 22):
$$FRES = 206.835 - 1.015 \times ASL - 84.6 \times ASW \quad (4)$$

Flesch Reading Ease Score Formulae for Spanish (Barrio Cantalejo, 2007, 154)
$$FRES = 206.835 - 1.0 \times ASL - 62.3 \times ASW \quad (5)$$

Flesch Reading Ease Score Formulae for Russian (Денисенко, 2008, 201)
$$FRES = 206.835 - 1.3 \times ASL - 60.1 \times ASW \quad (6)$$

Flesch Reading Ease Score Formulae for French (Barrio Cantalejo, 2007, 154)
$$FRES = 206.835 - 0.692 \times ASL - 74.2 \times ASW \quad (7)$$

where ASL= Average Sentence Length;
ASW = Average number of Syllables per Word.

When using Flesch's reading ease score formula appropriate for the relevant language, readability of any language could be compared with the Flesch scale (Table 1).

Table 1

Flesch's readability scale (DuBay, 2004, 22)

Style	**Flesch Reading Ease Score**	**Estimated School Grade Completed**
Very Easy	90 to 100	4th grade
Easy	80 to 90	5th grade
Fairly Easy	70 to 80	6th grade
Standard	60 to 70	7th or 8th grades
Fairly Difficult	50 to 60	Some high school
Difficult	30 to 50	High school or some college
Very Difficult	0 to 30	College

As it can be seen from Table 1, the higher Flesch Readability Ease Score, the easier is the text. In addition, Flesch's studies reveal which level of formal education the text is appropriate for.

Appropriateness of the text for the reader can be detected with a number of various measurements, including evaluation of a text written by the reader herself. William H. DuBay (2006) in his work "The Classic Readability Studies" refers to the words by William Lucius Adelno Sherman (1847 – 1933), the founder of the statistical analyses of literary works, "No man should talk worse than he writes, no man writes better than he should talk." (DuBay, 2006, 11) When choosing linguistic study material, appropriate for the student, it is assumed that the reader can perceive texts whose readability level is close to the readability level of texts written by the reader herself.

Estimated School Grade Completed shown in Table 1 is an indicator which indirectly points to the *reading competence* characteristic for the given level of education or age. Wide international studies of reading competence are being carried out within the framework of OECD (Organisation for Economic Cooperation and Development Programme for International Student Assessment). Reading competence can be defined as "understanding, use and evaluation of a written text by an individual in order to achieve one's goals, develop one's knowledge and potential, and participate in public life " "Reading competence embraces a wide range of cognitive skills – from recognition of a written text, knowledge about words, grammar, language and text structure to the general knowledge about the world. It also includes metacognitive skills – application of different strategies while working with the text." (Geske, Grīnfelds, 2010, 19)

Within the framework of our study reading competence was researched as students' ability to perceive and understand texts of a certain readability level.

While searching for information on studies in the field of readability by Latvian scientists, only indirect references could be found on the existence of such research in this country. For example, in correspondence exchange of 2010 between the Ministry of Education and the Consumer Rights Protection Centre a reference can be found about the fact that researchers of the Institute of the Physical Research and Biomechanics are working on a readability formula for Latvian texts. A few references to application of Fog Readability Test can be found in the research paper of 2004-2005 February published by the National Centre for Education "Textbook Readability – Relevance of the Content Expression Form to the Developmental and Perceptual Specifics of the Student Age Group, their Interests, Experience and Needs" (Mācību grāmatu ..., 2005).

On Tilde website can be found a statement, that "IT Competence Centre" informs the public that in the period from November 2011 till February 2013 it would be conducting a research project "Research into reading Latvian texts of different levels of complexity for primary school children and development of a readability formula for this age group" (Projekts "Dažādas ..., 2012). However, neither scientific

publications on Latvian written text readability assessment nor a readability formula adapted to the Latvian language could be found.

Translations into Latvian of foreign authors' works in this field have not been found, either.

Research objectives:

- becoming aware of text readability assessment options and choosing appropriate techniques to determine readability of texts in Latvian;
- determining FRES of students' written language and comparing results with Flesch's scale;
- determining FRES of the language used in Physics textbooks;
- comparing readability of Physics textbooks and students' written works.

Research period and participants: 2012, Tukums Rainis Gymnasium. In the studies of students' written language readability were involved 52 Form 11 students. For research was chosen "Physics textbook for Form 11" by E. Šilters, V. Reguts, A. Cābelis (2006).

Methodology

In order to identify the possibilities to assess readability of texts in Latvian with the existing Rudolph Flesch formulae, a pilot project was carried out with the aim to evaluate texts written in three languages.

Table 2

Usage of Formula 4 and 6 for evaluation of texts in English, Russian and Latvian

Text in English		**Text in Latvian**		**Text in Russian**	
Hotel Jurmala Spa is a place, where to regain harmony of soul and body!	14 W* 21 S*	Hotel Jūrmala Spa ir vieta, kur atgūt dvēseles un ķermeņa harmoniju!	11 W 23 S	Hotel Jurmala Spa это место для восстановления гармонии души и тела!	11 W 26 S
Get away from your everyday routine and for a moment forget the world around, come for peaceful relaxation to our Spa & Wellness Centre.	24 W 37 S	Izraujieties no ikdienas steigas un uz brīdi aizmirstiet apkārtējo pasauli, ļaujoties mierpilnai atpūtai, mūsu Spa un veselības centrā.	18 W 43 S	Вырветесь из ежедневной суеты и на мгновение забудьте внешний мир, придаваясь умиротвори-тельной релаксации в нашем спа-центре и оздоро-вительном комплексе.	19 W 54 S
For your pleasure and health Hotel Jurmala Spa in Latvia offers - relaxing massages, various water treatments, beauty treatments for face and body.	22 W 40 S	Jūsu labsajūtai mēs piedāvājam - relaksējošas masāžas, dažādas ūdens procedūras, skaistumkopšanas kūres sejai un ķermenim.	15W 41 S	Для Вашего отдыха мы предлагаем - релаксирующие массажи, различные водные процедуры, косметические процедуры для лица и тела	17 W 49 S
Supply of more than 100 different treatments allows you to choose the most suitable for improving health and well-being.	19 W 31 S	Vairāk kā 100 dažādu procedūru plašais piedāvājums ļaus Jums izvēlēties sev piemērotāko veselības un pašsajūtas uzlabošanai.	16 W 43 S	Широкий выбор из более чем 100 различных процедур позволит Вам выбрать наиболее подхо-дящую для улучшения здоровья и самочувствия.	18 W 48 S
Together: 4 sentences, 79 words, 129 syllables		**Together:** 4 sentences, 60 words,150 syllables		**Together:** 4 sentences, 65 words, 177 syllables	
*ASL= **19,75** ASW= **1,63***		*ASL= **15,00** ASW= **2,50***		*ASL= **16,25** ASW= **2,72***	
Calculation of FRES using Formula 4					
FRES = 48.9		**FRES = −19.9****		**FRES= −39.8****	
Calculation of FRES using Formula 6					
FRES= 83.2**		**FRES=37.1**		**FRES= 22.2**	

* W – words; S – syllables ** Data acquired should not be regarded as valid

Texts written in three languages (altogether 6 texts) and two interpretations of Flesch formulae were chosen: Formula 4 (for evaluation of texts in English) and Formula 6 (for evaluating texts in Russian).

FRES was calculated for all of the six texts with the help of both formulae. The example of the study of the three texts shown in Table 2 is a part of the pilot project on the usage of Flesch's formulae.

Summary of results acquired in the research process of all six texts can be seen in Figure 1.

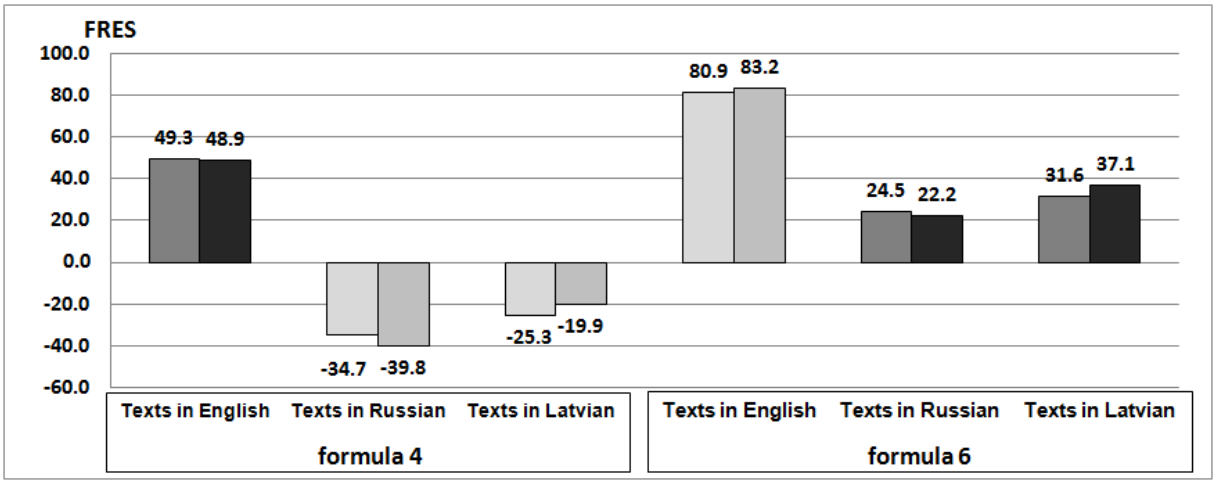

Figure1. FRES values in English, Russian and Latvian texts acquired by means of Formula 4 and Formula 6.

- The text readability index FRES, acquired when evaluating texts in English, equals 48.9 (FRES=48.9), which on Flesch's scale (Table 1) corresponds *Fairly Difficult*. When evaluating the same texts by Formula 6, the result acquired is distinctively different: FRES= 80.9 and 83.2, which on Flesch's scale corresponds *Easy*. When applying Formula 6 to texts in English, the result acquired is not valid.
- When evaluating texts in Latvian and Russian by Formula 4, the indices acquired are negative figures, which does not correspond to Flesch's scale; consequently, these data are not valid.
- When evaluating texts in Latvian and Russian by Formula 6, research of Latvian texts results in $FRES_1$= 31.6 and $FRES_2$= 37.1, but for Russian texts the corresponding figures are: $FRES_1$= 24.5 and $FRES_2$= 22.2. The acquired FRES index characterizes Russian texts as *Very Difficult*, but Latvian texts as *Difficult*. It is evident that the Russian texts have a higher degree of complexity than the variants of the same texts in Latvian and English, which can be explained by the usage of extremely long compound words in Russian texts.

The results of the pilot research on the usage of Flesch's formulae allows to arrive at a conclusion that Rudolph Flesch's equation (Formula 6) can be used in order to compare texts written in Latvian.

Results and Discussion

FRES of students' written language was determined by analysing three different written assignments for students of Form 11:

- content summary of the novel "The Adventures of Tom Sawyer" by M. Twain;
- creative writing task „My Morning";
- description "The Present and the Past of the School".

The results of the analyses of the written language of students from Form 11 are given in Table 3 and in Figures 2 and 3. The total number of analysed written works is 143. They were written by 52 students. Some of the students did not write all tasks.

As can be seen from Figure 2 and Table 3 students demonstrate very different language readability results in the three types of written assignments. Written language FRES substantially differs depending on the contents of the task.

- In the creative writing task „My Morning"; the greatest part of FRES (32 items) are spread in the interval from 60.0 to 79.9 – in this type of work students create a text which is easier to read compared to the written presentation of thoughts in the other two assignments.

- In the description "The Present and the Past of the School" the greatest part of FRES (33 items) are spread in the interval from 40.0 to 59.9 – in this type of work students create a text which is more difficult to read compared to the written presentation of thoughts in the other two assignments.

Table 3

Form 11 students' written language FRES

Type of written assignment	FRES interval						
	20.0 - 29.9	30.0 - 39.9	40.0 - 49.9	50.0 - 59.9	60.0 - 69.9	70.0 - 79.9	80.0 - 90.0
	Number of works						
Content summary of the novel "The Adventures of Tom Sawyer" by M. Twain	0	2	5	14	24	7	0
Creative writing task „My Morning";	0	0	0	7	15	17	4
Description "The Present and the Past of the School"	1	2	14	19	9	3	0
Together	**1**	**4**	**19**	**40**	**48**	**27**	**4**

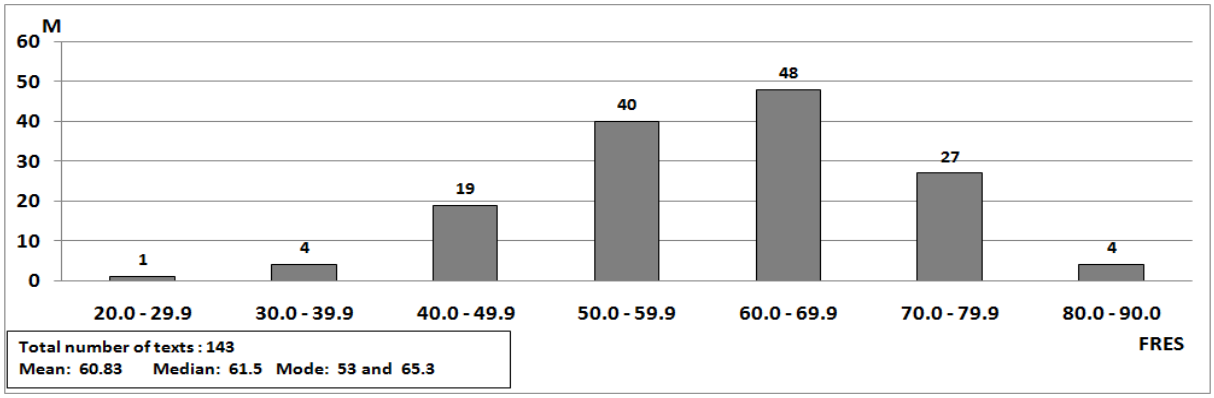

Figure 2. FRES values in the three types of written assignments performed by Form 11 students (M- number of works).

Data procession performed by on-line programme *Mean, Median, Mode Calculator* (2012). 46 of the participants of the research project wrote all three written tasks. When calculating the mean FRES value of each participant, the acquired data spread in a narrower interval (Figure 3).

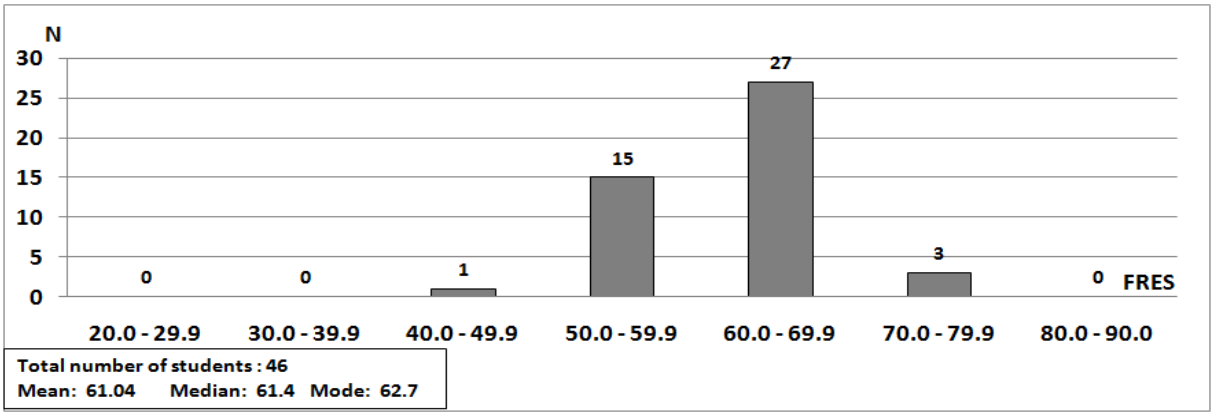

Figure 3. FRES mean values in Form 11 students' written works (N – number of students).

- As can be seen from Figure 3, for 42 out of 46 students' written works the mean FRES value is in the interval from 50.0 to 69.9.

- The FRES value interval acquired corresponds to Flesch's scale groups: *7th or 8th grades* and *Some high school*. In Latvian system of education Secondary School Form 11 (17 years) corresponds in terms of age to "high school" in the US system of education (15 – 18 years) while 7th or 8th grades in Latvian system of education correspond to Forms 7 and 8, which belong in the primary stage of education (13 – 14 years).
- The data acquired are close to the data given in Flesch's scale (Table 1). It is therefore appropriate to continue research on the usage of FRES to specify factors used in Formula 6 in relation to texts written in Latvian.

In order to research the language difficulty level of Form 11 textbooks in "Physics for Form 11" **(**Šilters, Reguts, 2006) 10 paragraphs were selected. Taking into account the fact that the presence of mathematical expressions increases the complexity of the text, "easier texts" were selected, which did not abound in mathematical figures and formulae. In the chosen texts, mathematical symbols and formulae were not included into the total word and syllable count. The results of the analyses of the text difficulty level in Form 11 Physics textbook can be seen in Figure 4.

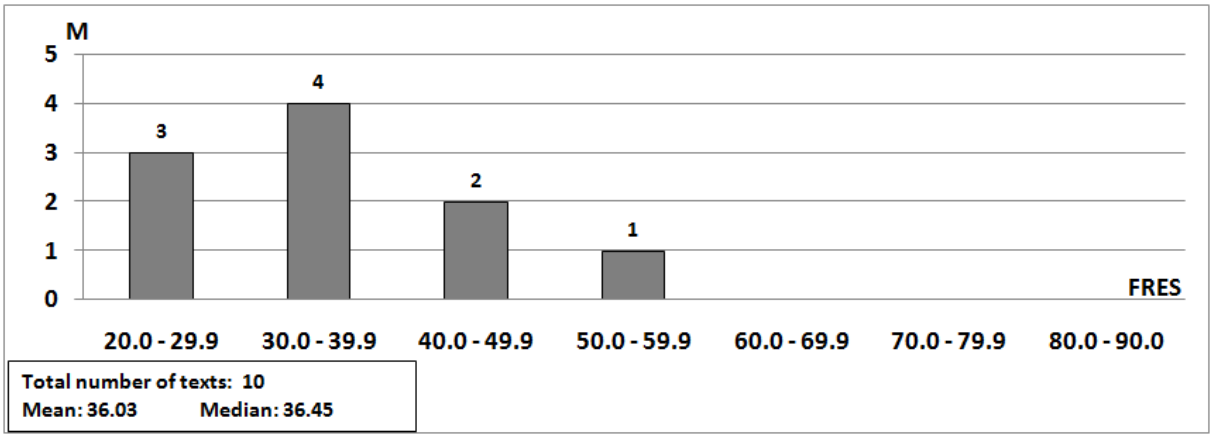

Figure 4. FRES values in the texts of Form 11 Physics textbook. (M – the number of texts evaluated).

As it can be seen from Figure 4, in "Physics for Form 11" by Edvīns Šilters seven texts out of ten are in the interval from 20.0 to 39.9, which on Flesch's scale corresponds to *Difficult* and *Very Difficult*.

Analyses of secondary school Physics textbooks leads to conclusion that opportunities to lower the difficulty of text readability are limited since many of specific terms used in physics quite often are long compound words; moreover, it is not feasible to explain a theme in physics without using mathematical symbols, which considerably influences the readability of the text.

Comparison of FRES values of Physics textbooks and students' written language makes it evident that:

- The intervals of students' written language FRES mean values (Figure 3) and the intervals of the textbook FRES values (Figure 4) overlap in a narrow area;
- Students' written language FRES mean value is 61.04, the median is 61.4, but the mean value of the textbook FRES is 36.03, and the median is 36.45. The significance of the differences is evident – the readability of Physics textbooks is considerably more complicated than the readability of texts produced by students themselves.

Future research is required in order to establish the preferable FRES difference required both to perceive and fully comprehend the text in the Physics textbook and to improve students' reading competence.

Conclusions

- Each of the identified text readability formulae has its specific traits and application characteristics. When doing research on text readability comparison, formulae relevant for the particular language must be chosen. In the pilot project researching the readability of text fragments in English, Russian and Latvian it was established that from the formulae discussed *Flesch Reading Ease Score* formula for the Russian language (Formula 6) is also the most appropriate for evaluating texts in Latvian. Using this formula it was proved that readability level of

Form 11 students' written texts considerably differed from the readability level of Physics textbooks, and for majority of students the language in the Physics textbooks was too difficult.

- Possibilities to lower the readability level in secondary school Physics textbooks are limited since special physics terms and mathematical symbols are indispensable part of such texts, which substantially affects text readability.
- It is considered useful to do further research on the usage specifically of *Flesch Reading Ease Score* to specify the compliance of its calculation formulae for Latvian texts.

It is necessary to continue research also to clarify what is a rational *Flesch Reading Ease Score* difference between the language in the textbook and the text produced by students themselves in order to promote the development of student's reading competence, as well as to facilitate Physics textbook comprehension.

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