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Text Difficulty in Czech Natural Science Textbooks for the Fourth Grade

Abstract

The paper focuses on the assessment of text difficulty in six contemporary Czech science textbooks for fourth graders. Text analysis followed the authors' own methodology. The results obtained reveal varying text difficulty between individual textbooks. Only textbooks by the Alter and SPN publishing companies comply with the difficulty scale for fourth-year textbooks and may be recommended for teaching.

Keywords: natural science textbooks for the fourth grade, text difficulty, syntactic factor, semantic factor

Introduction

Without a doubt, language represents the most important medium in primary school instruction. Education at the primary school level cannot be imagined without vocabulary-based printed information (Selander 1990; Shepardson, Pizzini 1991). Along with teacher presentations, textbooks act as one of the primary sources of information which channel school education at primary schools (Poláková 1992, Sikorová 1998). The quality of school education is therefore to a great extent conditioned by the qualities of textbooks as learning mediums. If textbooks are created without the prior objective assessment of the suitability of their language structure and text content for the respective level of pupils' linguistic competence, textbooks of inferior didactic quality may be produced (Olechowski 1995, Zujev 1995).

With respect to didactic tools, it is obvious that textbooks represent but one of a wide range of didactic means, dated as they may appear when compared with the latest interactive didactic tools or in the context of the boom of e-learning. Yet, textbooks will not disappear from schools. On the contrary, their utilization as basic didactic tools for both pupils and teachers is irreplaceable in the contemporary European education system.

Textbooks fall into the category of didactic tools which significantly enhance meeting the educational goals of primary and secondary schools (Maňák et al. 1994). Průcha (1989) defined three key textbook functions, which encompass (1) curriculum presentation function, (2) learning and teaching management function and (3) organizational function. A typical textbook includes an explanatory text and a number of colourful visuals, whose quality is vital for comprehending the book's text (Bielková 1995, Lienhard 1992). The categorization of a textbook's visual sources of information drawing on measurements of their area representation in complex didactic texts was proposed in a study by Wahla (1983). Didactic practice acknowledges that apart from visual information, the degree of text difficulty in textbooks is of key importance to the educational quality of textbooks (Pluskal 1996). Textbook texts should be attractive to pupils, factually correct and adequate to the age and mental abilities of the target pupil age group. Textbook texts frequently contain a relatively high amount of special terminology (Hrehovčík 1989, Marenčík 1993), which is, at times, not sufficiently illustrated or is not explained at all. This well-established fact has prompted some authors to conduct an empirical evaluation of textbook text difficulty based on the frequency of terminology occurrence in individual thematic units of the given textbook (Moody 1996). With respect to this issue and following her didactic practice, Mazáčová (2000) recommends that terminology used in textbooks by individual publishing houses be analogous for given fields and pupil ages (as terminology causes problems for pupils, e.g., when transferring to new schools). Different textbooks are analyzed from a number of perspectives, including text difficulty, question types, sources of non-verbal information, etc. The following authors have focused on the said analyses in our country: Hrabí (2005, 2008, 2009, 2010), Maňák, Knecht (2007), Pluskal (1996), Průcha (1984, 1997), Sikorová (2004), and Vránová (2008). Foreign authors dealing with this issue include Mikk (2000), Schmidt (1991), Stiner (1992), Olechowski (1995), Ottich, Kowalczyk (1992), Shepardson; Pizzini (1991).

In recent times, the issue of evaluating text difficulty has tended to be neglected. Our intention was therefore to provide information on the quality of didactic texts of contemporary science textbooks in the Czech Republic.

Methods of text difficulty assessment

The methods of assessing the difficulty of didactic texts may be divided into two groups: quantitative methods in linguistics, which evaluate text difficulty using measurable units (e.g. terminology, sentence structures, etc.) and psychological methods (predominantly quantitative), which determine the difficulty levels of didactic texts through analyses of textbook users' or a given field experts' opinions (Anderson, Boticelli 1990). Following extensive research on citation databases, Swanepoel (2010) found that quantitative analyses significantly outnumber studies which apply qualitative analysis methods in the available published assessments of textbook difficulty levels, with the latter focusing predominantly on textbook visuals.

Qualitative psychological research methods designed to study textbook difficulty levels tend to apply various types of questionnaires (Gavora 2000). Qualitative research on textbook difficulty levels has been conducted, e.g., by Poláková (1992) and Šimeková (1992). Based on the evaluated respondents' (teachers) responses, the authors divided the evaluated textbooks into three groups according to the volume of content requiring changes (up to 30% – textbooks which may be used without any changes required, 30 to 40% – textbooks requiring re-edition, 40 to 50% and more – textbooks requiring complete rewriting). A survey of textbook quality carried out with teacher respondents was conducted by Martínková et al. (1993/94) and Lachmannová (2000), Sikorová (1998). A survey conducted among pupil and student respondents was applied, e.g., by Olechowski (1995) and Hrouda (1996). Results obtained through qualitative research on textbook difficulty levels in pupils' parent respondents were published, e.g., by Bianchi (1994) and Ottich, Kowalczyk (1992).

As a rule, quantitative methods assessing the difficulty levels of didactic texts tend to be applied through formulas calculating the text difficulty levels. Björnson (in Průcha, 1997) applied a formula constituted by the sum of average sentence length and average word length. Průcha (1997) considers this formula based on mere two parameters to be too simple, regardless of the fact that in principle it has proved useful in the assessment of Polish textbooks. Pluskal (1996) applied the formula to Czech geography textbooks, but it proved to be unsuitable. A similar conclusion was made when applying the formula in the evaluation of Czech science textbooks (Hrabí, 2005). A formula developed by Mistrík (in: Průcha 1989) encompasses three parameters, which include average sentence length, average length of the hundredth noun and the word repetition index. The downside of the formula is that it does not allow for measuring the qualitative aspect of lexis and

text syntax. The published applications of this formula (Petřková, 1985, Průcha, 1989) revealed that the text difficulty of some primary school textbooks is similar to that of university didactic texts. Konůpka (1993) applied the Mistrík formula in an analysis of some secondary school textbooks. Science textbooks for lower secondary schools subjected to the analysis showed that the general text difficulty of the compared textbooks was relatively even (ranging from 26.7–27.7 points), which was in stark contrast to the results obtained through the application of other assessment methods (Hrabí, 2002). The Czech didactic practice saw a relatively frequent application of the so-called Průcha method (Průcha, 1984). This method drew on three term categories (P_1 – common terms, P_2 – expert terms and P_3 – factographic and numerical data). With respect to this method, Mareš (1987) pointed out its insufficient recognition of the difficulty inherent in scientific terms when compared with fact-collecting terms. Pachman, Banýr (1987) complemented the Průcha method with category P_4 – scientific terms. Although this category draws on analyses of a limited number of samples, we believe that thus modified Průcha method has a number of advantages, as it enables researchers to define the syntactic structure of the assessed text as well as semantic categories of terms. In addition to this, the method allows us to determine sources of the assessed text difficulty, which has a considerable practical importance. The validity of the method was confirmed by the high correlation of its results with an independent assessment of textbooks by experienced pedagogues (Průcha, 1984). The method was later modified by Pluskal (1997) by introducing two new term categories which are reflected in the formula for calculating the semantic factor (numerical data, repeated terms).

An extensive and analytical application of all the existing methods of assessing the difficulty of didactic texts in contemporary science textbooks for primary schools has detected a need to innovate the applied methods mentioned above (Hrabí, 2005). Decreasing the weight of common terms in the formula for calculating term difficulty is in accordance with the low occurrence of these terms in science textbooks. Similarly, the occurrence of factographic and numerical data in these textbooks is very low, which calls for decreasing the weight of these factors as well. The introduction of the repeated term coefficient allows for a more detailed text analysis with respect to text difficulty. Assessment of the evaluation range of the syntactic and semantic factors by using the coefficient of variation (Chráska, 1997) showed high reliability of the innovated method in evaluating science textbooks. For these reasons, the newly proposed method (Hrabí, 2008) was applied in the presented paper.

Research Methodology

The text difficulty of six Czech textbooks for the fourth grade of primary school was studied. Books by the following publishing houses were analyzed using our own methodology: Alter (1995, 1999), Fortuna (2001), Nová škola (2007), Prodos (1996), Scientia (1996) and SPN (2003). Precise citations are listed in the Bibliography. A total of 16 characteristics of text difficulty were evaluated. Text samples of minimum 100 words (ΣN) were randomly selected from each textbook. A total of 10 samples from each book were analyzed. Individual characteristics, their symbols, definitions and methods of calculations are listed below:

T – text difficulty; $T = T_s + T_p$ (points),

T_s – syntactic factor; $T_s = 0,1 \times \bar{V} \times \bar{U}$ (points)

\bar{V} – average sentence length (word number),

\bar{U} – syntactic complexity of a sentence (word number),

T_p – semantic factor (points),

$$T_p = 100 \times \frac{\sum P}{\sum N} \times \frac{\frac{\sum P_1}{2} + 2\sum P_2 + \sum P_3 + \sum P_4}{\sum N}$$

$$\bar{V} = \frac{\sum N}{\sum V}$$

$$\bar{U} = \frac{\sum N}{\sum U}$$

ΣN – number of words

ΣV – number of sentences

ΣU – number of regular verbs

ΣP – number of substantive terms

ΣP_1 – number of common terms

ΣP_2 – number of scientific terms

ΣP_3 – number of factographic terms

ΣP_4 – number of repeated terms

$i = 100 \times \frac{\sum P_2 + \sum P_3}{\sum N}$ – coefficient of scientific and fact-collecting information density (%)

This coefficient expresses the ratio of biological terms and factographic terms within all the words in the text sample.

$$h = 100 \times \frac{\sum P_2 + \sum P_3}{\sum P} - \text{coefficient of scientific and factographic information density (\%)}$$

Unlike the previous coefficient, this one expresses the ratio of biological and factographic terms in the sum of all terms in the text. It shows higher values than the previous coefficient. If its values are too high, it may indicate excessive content of expert and factographic terms in the given text.

$$o = \frac{\sum P_4}{\sum P} \times 100 - \text{coefficient of repeated information density (\%)}$$

The existing text difficulty (T) analyses of science and biology textbooks make it possible to compare texts in individual textbooks with the recommended difficulty level (Hrabí, 2005).

Fourth grade $T = 27-30$ points

Fifth grade $T = 29-32$ points

Sixth grade $T = 31-34$ points

Seventh grade $T = 33-36$ points

Eighth grade $T = 35-38$ points

Ninth grade $T = 37-40$ points

Research Results and Discussion

The key data on text difficulty characteristics of individual textbooks are shown in Table 1.

Table 1. Key characteristics of didactic text difficulty in fourth grade science textbooks

Characteristic	Publishing companies					
	Alter	Fortuna	Nová škola	Prodos	Scientia	SPN
ΣN	1063	1033	1045	1034	1030	1034
ΣV	103	99	105	97	93	115
ΣU	151	151	155	154	141	145
\bar{V}	10.32	10.43	9.95	10.66	11.07	8.99
\bar{U}	7.04	6.84	6.74	6.71	7.30	7.13

Characteristic	Publishing companies					
	Alter	Fortuna	Nová škola	Prodos	Scientia	SPN
ΣP_1	62	66	95	108	82	53
ΣP_2	262	224	275	211	196	282
ΣP_3	20	21	14	19	1	12
ΣP_4	41	47	53	39	31	35
ΣP	385	358	437	377	310	382
T_s	7.26	7.13	6.71	7.15	8.08	6.41
T_p	20.99	18.42	26.59	18.83	13.59	22.78
T	28.25	25.55	33.3	25.98	21.67	29.19
i	26.53	23.72	27.66	22.24	19.13	28.43
h	73.25	68.44	66.13	61.0	63.55	76.96
o	10.65	13.13	12.13	10.34	10.0	9.16

The total number of the analyzed words in the science textbooks studied ranges from 1030 to 1063, constituting 93–115 sentences. This fact indicates a relatively even number of words in the selected textbooks by the individual publishing companies, as well as similar sentence length. A higher number was found in the SPN textbook. The average sentence length is 9 to 11 words. The syntactic complexity of a sentence is made up by approximately 7 words. The sum of common terms differs significantly in the analyzed books, ranging from 53 to 108 words. The lowest count was found in the SPN textbook, while the highest count was found in the Prodos textbook. The following category reflects a similar distribution, with the sum of scientific terms ranging from 196 to 282 words. The number of factographic terms ranges from 1 to 21 words. This can be attributed to the different spectrum of the textbook sample selection. The sum of repeated terms ranges from 31 to 53 words. The values of the syntactic factor, which range from 6.41 to 8.08 points, represent a highly important characteristic of text difficulty. In this respect, there is no major fluctuation among textbooks by individual publishing companies. It means that the average sentence length and syntactic complexity of sentences do not differ significantly in the textbooks by individual publishing companies. The values of the semantic factor span a relatively wide interval – from 13.59 to 26.59 points. The Scientia textbook registered the lowest reading, while the Nová škola textbook registered the highest. The values obtained show that the terminology load of the textbooks by individual publishers varies greatly. The total text difficulty covers a wide range from 21.67 to 33.3 points. It thus may be assessed that the Nová škola textbook has the most difficult text with the highest semantic factor. The lowest value characterizes the Scientia textbook. Following

a comparison of total text difficulty values with the difficulty scale for science and biology textbooks, it may be concluded that only two analyzed textbooks, namely those by the Alter and SPN publishing houses, are suitable for the fourth year of schooling. The Scientia, Fortuna and Prodos textbooks are characterized by low text difficulty, while the Nová škola textbook contains a very difficult text. These textbooks are therefore not suitable for use in the fourth grade of primary schools. The coefficients of scientific and factographic information density reflect different loads by individual term categories. The coefficient of repeated information density ranges from 9 to 13%, which indicates a varying representation of repeated terms in individual textbooks.

In this paper, the author team present an assessment of text difficulty in Czech science textbooks for the fourth grade of primary school using their own methodology, which applies to the assessment of both the syntactic and semantic aspects of the evaluated texts (Hrabí, 2005). This method stresses the importance of respecting the variability of difficulty of individual evaluated textbooks, as it is primarily science and biology textbooks which are characteristic of a high frequency of special (biological and environmental) terminology (Matyášek, Rychnovský, 1994). The reliability of the difficulty scale of didactic texts, as applied in this paper, was evaluated using a comparative analysis of science textbooks for lower secondary schools with other widely used methods, e.g., the interview and questionnaire method (Mareš, 1983). A non-standardized interview was conducted with experts in textbook assessment. The questionnaires were administered to science teachers.

Based on the levels of text difficulty in science and biology textbooks determined with the use of our own research, a difficulty scale was created. The difficulty bands for every grade (4th to 9th) are relatively narrow, as the span of text difficulty levels in individual science and biology textbooks is not very broad either.

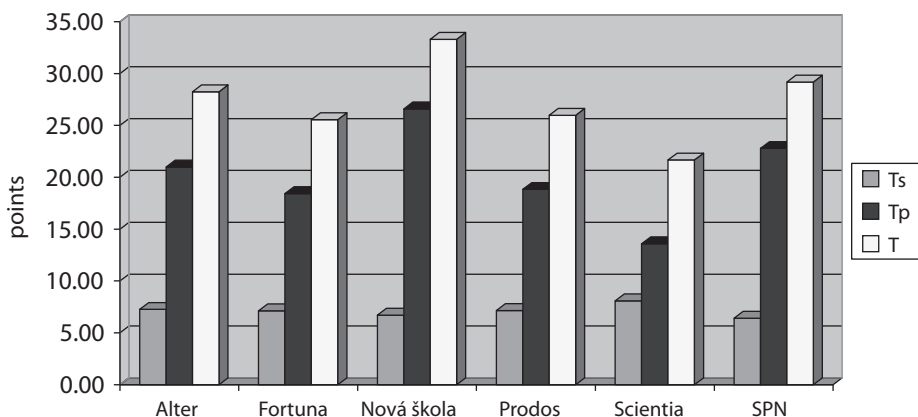
The Průcha method (Průcha, 1989) requires doubling of the quantitative sample for the purposes of assessing text difficulty at the expense of text source length, while respecting the same qualitative indicators. However, it is a comparative method which does not determine a scale of text difficulty. The method according to Pluskal (Pluskal, 1996) is of a similar character, extending the geography textbook evaluation by the possibility to detect factographic and repeated terms in the studied texts and stressing the importance of calculating the coefficient of numeric data density.

As a general rule, however, numeric data rarely occurs in natural science and biology textbooks, whose focus tends to be factographic. Owing to this, the method

of textbook assessment focusing primarily on numeric data contained in the text is not applied widely in the didactics of biological subjects (Vránová, 2008).

The key components of text difficulty are shown in Graph 1.

Figure 1. Key components of text difficulty in the analyzed textbooks



The obtained syntactic factor (T_s) values in individual textbooks indicate similar sentence complexity. However, the values of the semantic factor (T_p) differ, which means that the textbooks in question contain different amounts of common terms, as well as scientific, factographic and repeated terms. The graph shows fluctuating values of total difficulty, which reflects the uneven values of the semantic factor in the textbooks studied.

Conclusions

The presented paper sums up findings obtained in the course of assessing text difficulty in six current science textbooks for the fourth grade of primary school used in the Czech Republic upon applying the authors' own methodology (Hrabí, 2005). The results obtained reveal that text difficulty varies in the individual textbooks analyzed. The textbooks by the publishing companies Alter and SPN fall into the band of science text difficulty acceptable for the fourth grade (28–29 points), while the text difficulty of the Nová škola textbook is very high (33 points) and in the Scientia textbook it is very low (22 points). These findings may be of assistance

to teachers when selecting science textbooks which would meet the requirements of textual content and visuals as well as appropriate text difficulty.

The creation of new textbooks with respect to their quality and difficulty levels should accommodate the latest theoretical didactic findings in the field of textbook assessment. The aim of this evaluation was to enable textbooks to continue to play their vital educational role as basic study support for primary school pupils of corresponding mental and age levels.

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