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TARTU ÜLIKOOLI

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УЧЕНЫЕ ЗАПИСКИ ТАРТУСКОГО УНИВЕРСИТЕТА

ACTA ET COMMENTATIONES UNIVERSITATIS TARTUENSIS

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Papers on education

II

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C O N T E N T

PREFACE

Schooling and teaching materials have a long history in Estonia. The first catechism in Estonian, which was most probably widely used as a primer and textbook, was published in 1517. Tartu University was founded in 1632. The first Estonian primer came out in 1685. In the first decades of the 19th century it was followed by an Estonian school reader, a textbook of arithmetic and a textbook of geography. Since then original Estonian textbooks started appearing systematically.

After the Second World War, Estonian schools had to teach mostly with the help of unified textbooks, which were invariably to be used all over the Soviet Union. So the textbooks were translations into Estonian. The teacher was obliged to use the approved textbook only. There could be no competition for better textbooks and there was very little experimental testing of the approved textbooks. All this contributed to the lowering quality of textbooks. In the 1960s the catchword in education was scientific approach. This led to a new set of books for general public schools. The books, mostly written by leading scientists in the corresponding field, proved to be too sophisticated and complicated for pupils to acquire the material contained in them, or it could be done by making the school day in senior forms up to ten hours long. Too strenuous study harmfully affected the pupils' health. Educators, proud of the highly scientific textbooks, ignored the fact that the effectiveness of education is judged not by the degree of scientific approach in the textbooks but rather by the level of pupils' knowledge.

Now we witness a period when new original school textbooks are being written for all the subjects in the general public school. It should be remembered that small Estonia cannot afford to produce and test several parallel school textbooks. So all results of education research and world experience in creating new school

textbooks should be considered as extensively as possible. One of the primary tasks would be relinquishing the tradition of supersophisticated textbooks, a practice that has become firmly established in the minds of Soviet textbook authors over the past decades.

This collection of scientific papers of the Department of Education is mostly devoted to questions of textbook readability. This being the first collection to be published in English, it will be started with a survey by A.Elango and I.Unt on the past and present of pedagogy at Tartu University.

The following three papers deal with general problems in compiling and assessing textbooks and materials. So I.Unt analyses study material from the point of view of individualizing the learning process. Individual approach in learning was the subject of I.Unt's thesis for the Doctor of Education degree. Urve Läänemets comes forward with a very interesting and promising fundamental theory concerning choice and gradation of material in foreign language textbooks. In her other article Urve Läänemets propounds a systemic approach for the assessment of textbooks of foreign languages. The approach is most probably applicable in the assessment of textbooks of many subjects, not only textbooks of foreign languages. The articles are based on the research summarized in U.Läänemets dissertation for the Candidate of Education academic degree.

The series of papers on readability is introduced by an article of J.Mikk. The article is about derivation of readability formulae, rules of clear writing and criteria for the optimal level of text complexity in graded textbooks. This is in short J.Mikk's thesis for the Doctor of Education degree. H.Kukemelk and J.Mikk in their joint paper present a derivation model for a text complexity formula to assess physics textbooks written in Russian and resultant formulae for prognosticating text readability, subject attractiveness and textbook effectiveness. Contrary to the well-established belief, a too frequent repetition of terms in junior textbooks tends to reduce the effectiveness of the textbook, as it considerably diminishes interest in the textbook. H.Kukemelk has thoroughly studied a rather neglected factor in learning effectiveness - the time spent in acquiring the information in a study text. The time spent on this can be easily prognosticated on the basis of the text characteristics, so the teacher can foretell what is the amount of independent work the pupils can cope with within given time limits.

M.Lepik's research has yielded new formulae for prognosticating the correctness of answer and the time needed in doing different problems presented in the collections of physics and mathematics problems for Estonian schools. It has been shown that the logical structuring and the graph characteristics of the problem are of great help. These two papers sum up the author's dissertation for the Candidate of Education degree.

Computers should be used in textbook analysis. That would make it possible to make corrections and suggestions in the process of compiling school textbooks.

Automated computer analysis presupposes that the computer should be able to reduce any word form to it original form. The Estonian language is difficult to cope with as its declinable words have fourteen cases and its verbs a number of conjugational forms. E.Mikk presents a computer program for morphological analysis of text in Estonian. The last paper in the collection is also devoted to computerized text readability analysis. J.Mikk, E.Mikk and J.Tirmaste present the results of readability analysis of English textbooks in Estonia.

Over recent decades education theory in Estonia has developed under a strong influence of Soviet pedagogy. It has been isolated from contemporary development in education theory in Europe and America. That is why our argument may seem unusual or been savage to the reader. We do hope, however, that the material will hold some ideas and facts that may offer interest to the English-speaking scholar.

Editor.

THEORY OF EDUCATION IN TARTU UNIVERSITY

Aleksander Elango, Inge Unt

The Estonian national theory of education began to develop in about 1870 - 1880 together with the general awakening of self-consciousness of Estonians as a nation. Among those who made the biggest contribution to the theory were the most prominent representatives of the national awakening movement - Fr.R.Kreutzwald (1802-1882), J.Hurt (1839-1906) and C.R.Jakobson (1841-1882). Their program centered around the following points: giving everybody education (in the mother tongue), freeing school from under the influence of clergymen, paying greater attention to the subjects that would develop creative thinking (at the same time cutting the number of classes for religious instruction), providing better conditions for educating teachers etc. The chief initiator of those ideas was the Society of Estonian Literati (1872-1893) in whose work the teachers of national schools played the leading role.

The policy of Russification which started at the end of the 1880s put an end to those aspirations. The attempts of the tsarist government to teach all children only in Russian left no room for the development of national ideas of education.

After the Estonian Republic was established (1918) education at all levels was given in the mother tongue. The national schooling system called for a national theory of education.

In the universities of Tsarist Russia education (pedagogy) as a science was not taught. The students of the teacher training courses at Tartu University were given a very short and elementary course of the theory of education by N.Grunski (1872-1951) a Slavic philologist, who compiled a relatively good textbook on the theory of education in 1909.

The young republic did not have many Estonians working on the theory of education. Mention could be made of Konstantin Ramul (1878-1975) who majored in psychology at St. Petersburg University, and the August Kuks (1882-1965) who attended refresher courses on the theory of education at the Moscow Shelaputin Private University. K.Ramul was elected Assistant Professor and in 1928 Professor of Tartu University. A.Kuks was employed as a school inspector, the object of his research being the ideals of the Estonian schoolchildren.

Systematic instruction and research in education theory began when chair of Education was opened at national Tartu University in 1920. Peeter Põld (1878-1930), an experienced secondary school headmaster who had been to Western Europe to improve his knowledge in the theory of education, was invited to work at the University. More and more Estonians graduated as educationists.They were mostly employed by teacher training establishments (seminaries and the university). J.Käis (1885-1950) became a leading expert on students' individual work. J.Käis had closed contacts with Finnish teachers and some of his works have been published in Finland.

P.Põld studied the history of Estonian schooling. His monograph "The History of Estonian Schooling" (1933) was published posthumously. He directed his students to studies of history of education. K.Ramul excelled in his research into experimental psychology, including educational psychology. His students produced research papers on the maturity of Estonian children, the application of the Binet'-Simon test, teaching psychology in high school, etc. A.Elango (born in 1902) studied the problems of psychology and education of young people. J.Tork (1889-1980), director of a seminary, was the first to defend a thesis for the Doctor's degree. The theme of his work was "The Level of Intelligence of Children in Estonia" (published in 1940).

P.Põld died in 1930, J.Käis in 1950. In 1944 J.Tork, J.Estam and some others emigrated to the West. When the Marxist approach came to dominate in education the choice of themes and methods of study, changed. Many fields of achievement had to be given up. Only Prof. K.Ramul and Associate Prof. A.Elango of the researches of the Republic of Estonia continued work at the University. Gradually a few young researches joined the department (E.Koemets, H.Kurm, H.Liimets, I.Unt, etc.). Tartu University, Tallinn Teacher Training

College and Tallinn Institute of Scientific Study of Education (1959–1991) became the chief centres of research.

The chief aspects of research during the post-war decades were educating problem children (H.Liimets) in the theory of education; the check-up and evaluation of the students' knowledge (A.Elango, K.Saks) in the theory of instruction and the history of schooling in Estonia (A.Elango, H.Kurm).

The following survey attempts to throw some light on the results of Estonian theory of education that have been achieved mainly during the last decade. If necessary deviations into near history will be made.

First of all, some data about Tartu University will be presented. As it is the department of education at the University where the research in the field of the theory of education is centered. The problems of teaching methods are being dealt with in special departments of methods (the latter are concerned with the teaching methods of mathematics, Russian and foreign languages). The methods of teaching other subjects are being investigated in the speciality departments.

During the whole post-war period the department of the theory of education has organized post-graduate courses in the field of the history and theory of education. There has also existed (with the exception of a short period of time) a scientific board at the university for the defense of candidate thesis. The post-graduates have come from all pedagogical research institutions in Estonia. The themes of their theses have been of interest either to the various departments at the university or to the institutions where the post-graduates came from.

In the last few decades the theory of instruction has became the leading line of research in the department of education. The research in the 60s and 70s aimed at ways of activating students and developing their learning skills, continued with the focus on the individualization and differentiation of instruction. In other words the traditional trend in the Estonian theory of instruction founded by J.Käis was being developed further. I.Unt defended her thesis for a Doctor's degree on the topic "Individualization of Tasks and its Effectiveness". The research is based on the conception of individualization as a means of developing the student's intellectual capacities. The work is based on an experiment on approximately 2000 students. A typology of individualized tasks has been

worked out. The effect has proved to manifest itself both in the growth of subject-centered knowledge and skills as well as in the growth of general intellectual abilities. As far as the above-mentioned criteria are concerned there were big differences between individual students. It also became clear that there were high correlations between these criteria. J.Ots carried out an analogical experiment in Grades 5-7 to study methods of teaching Russian as a foreign language and H.Sikka in Grade 3 to study the teaching of mathematics. Both scholars obtained similar results. Besides there was a positive shift in the attractiveness of mathematics as a subject. Positive results were also obtained by T.Pedastsaar who made an experiment on the ways of developing map-reading skills. A system of learning skills that must be developed in primary school has been worked out by K.Indre. I.Unt has concentrated her attention on problems of differentiation.* At the moment she is working at a model of optimum differentiation that could be applied in the course of the school reform under way in Estonia. Comparative data from other countries have proved helpful in this work. Motivation problems connected with differentiation and the possibilities of using the elements of the open teaching at school are also being investigated. I.Kraav has studied the peculiarities of students of various subject-biased classes as compared to students of ordinary classes; she has discovered several social characteristics in which students of biased-classes excel their peers in ordinary classes.

The research carried out by L.Vassiltchenko upon students' preference of sources of information is closely connected with the above-said. L. Vassiltchenko's object of study was students of the junior and senior secondary school levels. Quite a few factors have been discovered that contribute to the rise of the students' interest in various sources of information (communication vehicles, especially textbook characteristics; sex of students; students' attitude towards the subject, etc.).

In the 80s the most promising line of research at the Department of Education was studies of textbook readability under the supervision of J.Mikk. The ultimate goal of the program was to discover the character-

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* Since 1990 Prof. I.Unt has been working at the Estonian Education Centre in Tallinn.

istics of the text on which the students' knowledge is dependent. For this purpose the characteristics of well and poorly acquired texts were compared. The experimental work resulted in a formula used to predict the average academic progress depending on the average length of the sentence and the degree of noun abstractness in the textbook. Suggestions for better textbooks have been worked out, which, when put to use, might raise the academic progress approximately 20–30 per cent. The optimum degree of complexity of the text suitable for different age groups has also been investigated in experimental work. J.Mikk summed up the work in his thesis for a Doctor's degree under the title of "The Theory of Measuring the Complexity of Study Material and Choosing the Optimum Degree for it" (1982). Formulas have been inferred for textbooks of physics in Russian that use text characteristics to predict the level of students' knowledge, the gain of new knowledge and the students' evaluation of the content values of the text. The degree to which texts in a physics textbook present interest to students depends on the repetition of words, on the length of sentences, on the number of symbols in the text, etc. The analysis of the textbooks in current use shows that the books are too complicated and uninteresting.

To evaluate textbook degree of appropriateness computerized systems for textbook analysis are being worked out. With the help of the reading machine, the texts of a number of textbooks of English for Estonian schools have been entered into the computer for the degree of readability to be determined and frequency vocabularies to be compiled. A system of morphological analysis of Russian texts is in use. The average frequency of occurrence of text vocabulary in spoken language is calculated. Computer programs to estimate the degree of difficulty of Estonian texts are being compiled. M.Lepik has studied how the solving of physics and mathematics problems depend on the text of the assignment. He and H.Kukemelk experimentally proved the significance of correlation between the graphs of text structure and time spent on learning the text and the amount of information acquired. Text readability has also been studied in the department of methods for teaching mathematics at Tartu University (E.Mitt) and in the department of German (J.Tuldava, H.Tõevere).

In the last few years the study of teaching objectives has became an essential line of research in the

Department of Education. This work is based on the concepts of B.S.Bloom. P.Kreitzberg has been investigating ways and means of making teaching objectives more concrete. At the moment P.Kreitzberg is engaged in studying self-image as a basic in educational planning and aim setting. E.Krull, taking B.S.Bloom's concepts of mastery learning as the starting point, carried out an experiment in teaching physics in Grade 8. The strategy of total learning in the experimental classes resulted in twice as good academic progress as in the control classes.

Two thesis for a Doctor's degree have been written on teaching methods. A.Töldsepp in his thesis "Methodological Essentials for Presenting Systematic Knowledge of Chemistry in High School" based on extensive experimental material worked out a system of presentation for chemical terms in which the governing principles were integrity and succession.

G.Karu in his thesis "Methodological Essentials for Creative Teaching of Physics in High School" has put forward a concept of creative teaching of physics and presented a corresponding teaching model. A complex of teaching methods has been put forward, their advantages having been experimentally proved on extensive empirical material.

The Department of Methods for Teaching Mathematics (the leader of the research group being J.Reimand) has been working on the modeling of the system of mathematical problems in school textbooks and establishing the optimum degree of their complexity. A corresponding system for mathematical problems has been worked out and sets of study material have been compiled for senior grades. The effective use of personal computers in Grade 8 has been experimentally investigated and recommendable teaching methods have been presented. The history of teaching mathematics (O. Prinits) and the history of chemistry teaching (H. Muoni) have also been studied.

In the department of methods teaching Russian as a foreign language a communicative approach of teaching Russian has been worked out (the leader of the research team being A.Metsa). This approach was necessitated by a careful study of the students' learning motivation and their communicative needs.

In the department of special education (teaching exceptional children) attention has been concentrated on three main areas. First, under K.Karlep's supervision different methods of teaching reading and writing

to handicapped children have been dealt with. Grammatical structures as problem for handicapped children have also been an object of research. Secondly, the possibilities in special schools in modeling the intellectual activity of mentally handicapped children have been defined (J.Kõrgessaar). The results have been put in practical use in teaching geography and natural history in Grades 5...8 of special school (A.Reinmaa). A third field of study has been the investigation of social relations between students. The peculiarities of interpersonal perception in special schools as compared to those in ordinary schools have been studied (T.Aunapuu). E.Viitar has been dealing with the study of self-evaluation of students suffering from hearing troubles and T.Puik has investigated the development of social relations between deaf students.

Last but not least there are studies on the theory of education. In past decades these questions, especially interpersonal relations were more actively dealt with under the supervision of H.Liimets. When he resigned from the university in 1975 this trend was of less importance but in the last few years it has gained momentum again. In the Department of Education studies of this kind are dealt with by L.Ounapuu who has studied the development of self-consciousness in 10...15-year-old students. Taking D.Krathwohl's affective taxonomy as a starting point a complex of factors to measure children's self-consciousness has been worked out. Three phases of development were singled out in the given age group: attending to "I", responding to "I" and valuing "I".

R.Valgma has studied the role of personality characteristics of schoolgirls in classes of physical training. She discovered factors which determine girls attitude towards the development of their physical abilities. R.Valgma suggests a self-perceptional-communicative approach in physical education.

Another sphere of research in the theory of education is the study of family problems and questions connected with education in the family. H.Kurm has studied students' knowledge of family life. She has worked out a course of a new subject in Estonian schools which may be called "Family life foundation". I.Kraav and V. Raudik together with the scholars of Kuopio University are investigating problems of education in the family. The lab of family studies of Tartu University (the scientific supervisor is E.-M. Tiit and its head is A.Tavit) has been mainly concerned with

the sociological aspects of education in the family. Questions of education have also been investigated in the laboratory of educational sociology (the head of the lab is J.Saarniit) and in the laboratory of occupational counseling (the head of the lab is A. Sukamägi). The scientific supervisor of both the laboratories is Doctor of Philosophy P.Kenkmann whose thesis for a Doctor's degree was about the social characteristics, values and attitudes of young people, students in particular.

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SCHOOL TEXTBOOKS AND INDIVIDUALIZED INSTRUCTION

Inge Unt

Different styles of teaching different types of students is a topic of urgency and importance in present Estonian school reform. One of the most imperative reforms is the transition from a uniform and rigidly delineated education to a more flexible, diversified, and child-centered approach. To implement this system, new textbooks will be needed. The purpose of this paper is to examine some theories which pertain to the compilation of these textbooks.

First, we must define what is meant by individualized and differentiated teaching. In pedagogical articles written by experts from various countries, these two ideas have acquired different meanings and interpretations. Sometimes the terms are considered to be synonymous, with individualization denoting that style of teaching which takes into account individual characteristics of students. Differentiation here refers to various types of individualization. But in most German pedagogical literature, the interpretation is just the reverse. For our purposes, we will define the terms as follows:

Individualization is the broader concept. It refers to teaching methods which consider the characteristics of individual students as much as possible.

Differentiation is a form of individualization. It may refer to a class or study group of common characteristic. Thus, differentiation is subordinate to individualization.

This paper will introduce the following issues:

1) requirements to textbooks suitable to individualized teaching;
2) individualized textbook tasks;
3) individualized assignments in textbooks as a whole, as well as in other teaching materials;
4) empirical data about the effectiveness of textbooks

which have been compiled for individualized teaching.

1. Requirements for textbooks suitable to individualized teaching

We recognize two principal objectives of individualized teaching. The first is the consideration of individual characteristics to improve instruction as a whole. These characteristics include the level of knowledge of a certain subject, special skills, study techniques, general and specific aptitudes, and creativity. The differences among students in these areas are considerable. The second objective is the preservation and development of the uniqueness of each student. Here variables such as interests, motivation, emotional attributes and volition, are to be studied and each student should be viewed as a complex individual. School textbooks can meet the requirements of individualized teaching and facilitate its implementation. Different forms of individualization presuppose textbooks of different structure. The following is a brief synopsis.

Currently we are in the process of transition to specialization in Forms 10-12 according to the following model by which the curriculum is divided into four parts:

1) basic compulsory education;
2) specialized education in one of the disciplines such as the humanities, sciences, etc.;
3) a compulsory number of lessons in optional subjects;
4) optional subjects which may or may not be chosen.

In addition to a more flexible curriculum, several alternate schools will be opened. All of these programs and types of school will have to be supplied with textbooks.

One fact relevant to the situation should be mentioned here. As a rule, up to the present time, in Soviet schools there has been only one textbook available which all students of that subject must use. Now there is a widespread demand for alternative textbooks. The availability of a selection of textbooks would, of course, increase the possibility of individualized teaching.

The best way to allow for the diversity of individual students is to include individualized tasks in the school textbooks. This method is universally applicable, because these tasks can be incorporated

into all types of textbook and offer an endless variety of possibilities.

2. Types of individualized tasks for school textbooks

Individualized tasks differ from the ordinary ones in their formulations which take the diversity of students into consideration. We have already referred to individual characteristics which render students different which should be considered in individualization process.

Accordingly, we may differentiate tasks as follows:

1) Tasks which take into consideration differing degrees of knowledge, aptitude, and proficiency. These are designed to remedy deficiencies according to school program requirements and also to account for the student's existing knowledge. Our research and that of others indicate that much of the students' knowledge has been acquired through extra-curricular sources, especially mass media. As expected, individual differences among students may be considerable. School textbooks cannot possibly contain all the relevant data, because the amount of potential information is too big, but they can lead students to integrate their existing knowledge with new information, (e.g. through tasks which ask what the student has heard, seen or read about a specific matter). In this way, the knowledge students possess can be integrated with the information required by the school program.

2) Tasks which call for a variety of study skills (e.g. the independent use of learning materials and reference literature).

3) Tasks which take into account differences in students' aptitude and creativity, as well as special abilities. These include tasks of differing degrees of difficulty and complexity. To account for different levels of creativity, students are presented with problems of varying complexity. So-called open-ended problems may be solved in different ways and on different levels according to the student's degree of creativity. The tasks with due consideration of the students' interests might take various forms, such as reading, experiment and observation, gathering material for reports on well chosen topics, special tasks exhibition and museum visits, the use of reference literature, creative projects, etc.

When compiling school textbooks and tasks, it is

advisable to offer four levels of attainment:
1) tasks selected by the teacher;
2) optional tasks selected by the students, of equal or varying degrees of complexity;
3) elective tasks for program enrichment directed to those especially interested in the particular area of study;
4) tasks designed and selected by the students themselves.

In addition to formulating tasks, there is also the matter of their proper placement in textbooks, and the selection of the types of textbooks and workbooks best suited to particular assignments. These issues will be discussed in the following section.

3. Individualized assignments in sets of study material

Individualized assignments and other elements of individualization in school literature depends on the availability of the material on a particular subject for each form.

In Estonia there are school literature "kits". It is generally agreed that those kits should contain:

1) a textbook
2) a workbook
3) test papers and examination papers
4) additional materials or readings
5) a handbook summarizing the fundamentals of the subject

Other materials may be added to that kit.

Up to now, workbooks have proven themselves the best vehicle for the individualized presentation of material. Workbooks designed to develop facility for independent work have long been ubiquitous to Estonian schools, as indeed they are all over the world. Between 1920–1930 Johannes K&is compiled various workbooks for all primary school subjects. The use of workbooks was reintroduced in Estonia in the 1960's. Estonia is the only republic of the Soviet Union wherein workbooks are used for nearly all school subjects in all forms. A thorough examination of the principles by which they are devised and utilized has been given in a monograph by O. Nilson on the development of students' ability to work independently (Nilson O., 1976).

Workbooks generally contain assignments for all students. In order to adapt a workbook for indi-

vidualized instruction, the type of task described at the last section can be incorporated.

A function of the workbook is to direct and organize the pupil's study. Workbooks in particular individualized assignement offer especially fruitful opportunities for individualized teaching. In our work we have used the following types of assignements:

Type I.
1. Common tasks for all students
2. Additional tasks for more gifted students

Type II.
1. Common tasks for all students
2. Graded tasks

Type III.
1. Graded tasks

Type IV.
1. Graded tasks
2. Common tasks for all students

In these types graded tasks include easier average and more difficult tasks.

According to practical experience, the first type of assignments proved useful in presenting new information with ample learning material for all students. The more capable students may attempt to work at additional or more advanced material.

The second type has been found to be effective where it is not productive to offer the same material to all students, as it is too simple for some and too difficult for others.

The third type is useful where students' knowledge and abilities vary so much that no unified way to develop their skills can be devised and uniform assignments prove impractical. Such situations may occur during practice and revision, and also where the levels of knowledge are vastly different.

The fourth type is recommended where existing knowledge of students varies significantly.

It is also possible to use combinations of the various types. These kinds of individualized assignments can be incorporated into textbooks, especially where workbooks are not available.

Sample test papers and examination papers can be used for individualized checking of knowledge and skills.

It should be obvious that all the components of school literature kits can incorporate individualized teaching materials. The teacher can use the materials according to his or her own style and method of

organizing lessons. Such materials will neither hamper the teacher's creativity nor prevent him or her from doing things in his or her own way. Rather, the materials are a methodological resource and time-savers for the teacher.

4. Empirical data on the effectiveness of school literature written for individualized instruction

We have conducted several studies of school literature, especially of workbooks which include individualized assignments for independent work. In most cases we noted an improvement in teaching and learning effectiveness, students' progress and mental development.

A doctoral dissertation was based on a study of the effectiveness of individualized independent work. The findings have been published in a monograph (Unt I., 1990).The study examined varying levels of mental development and the diverse interests of fifth form students in general comprehensive schools. Approximately one thousand students from seven schools were involved in the study, which encompassed nearly all school subjects.

One of the hypotheses of the study was that the inclusion of materials for individualized work in general comprehensive school literature would also increase teaching effectiveness. The following materials were prepared for the study:

1) a workbook for independent study which included assignments of various levels of complexity and also enrichment material for gifted students and those particularly interested in the subject
2) groups of assignments on three levels of complexity in language and mathematics
3) sample test papers and examinations.

All of the materials were adapted to the existing textbooks and their methodological systems. The materials were unaccompanied by methodological instructions, and their use was left to the teachers' discretion. In this way, it was possible to determine the potential increase in teaching effectiveness by modifying existing school literature. The main findings were as follows. Average results were higher in classes using the experimental materials. There was a significant improvement in learning, development of mental abilities, reading skills and facility

for independent work as compared to the control groups, measured by tests. The difference between the experimental group and the control group was statistically significant in all ability groups of students. However, the experimental as compared to control classes were not all more successful. This indicates that school literature in itself does not guarantee learning effectiveness, although it does create better conditions for teaching and learning. It is the teacher who is most important in quaranteering academic progress.

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HOW TO FIND MATERIAL FOR FOREIGN LANGUAGE TEXTBOOKS

Urve Läänemets

For a very long time, the question "Why learn foreign languages?" has remained without a convincing answer. But since the recent opening of our doors to contacts with other peoples and nations, the demand for foreign language instruction has boomed. The most basic function of language - enabling people to communicate with each other - has acquired a new meaning for Estonia and Estonians.

Recent advances in teaching technology have made available a large variety of learning and teaching aids, from cassette recordings to video materials. Still, we must most often rely on the ubiquitous textbook, particularly under the prevailing conditions in Estonia.

The purpose of this paper is to summarize briefly some theoretical work done in Estonia concerning the acquisition and teaching of foreign languages, from the point of view of textbook compilation. The use of research results to produce more appropriate and effective foreign language textbooks is also discussed.

The first step in ascertaining the most effective organization of foreign language instruction according to the needs of various students is the application of sociological research methods. Next, those needs must be translated into aims or goals of language learning programs in various types of schools or study groups. Third, suitable content must be found and presented in language textbooks and related materials.

The functional aspect of language must be considered in compiling suitable content. Every student learns a foreign language with a specific application in mind. The result of attention to the functional aspect of language learning would be the ability of students to communicate as effectively as they deem necessary in foreign languages.

At this moment there is a pressing need in Estonian education to develop standards, so that the graduate of a particular type of school can be expected to have attained a specified level of knowledge and ability. Schools must guarantee the optimal organization of work to achieve this aim, and teachers must be responsible for their subjects.

In order to ascertain some general aims of teaching foreign languages in Estonian general comprehensive schools, we conducted some sociological research with the objective of determining the functional language needs in Estonia.

The first research (Baykova L., 1980) in this particular field is found in questions on the 1973 census. The population was asked how often they read fiction, popular-scientific books, public press issues (newspapers, etc.), or (special) professional literature in the Russian language. The same question was asked concerning television and radio broadcasting. The percentage of positive answers was rather small. The results are summarized in Table 1 (Baykova L., 1980, p.103).

Table 1

Use of Russian in Estonia

	% read often	% read seldom	% read never	% not responding
fiction	6,1	16,4	74,6	2,8
popular-scientific literature	5,9	14,9	76,4	3,7
professional literature	18,1	17,6	61,2	3,2
public press	13,9	22,2	60,7	3,2
radio broadcasts	18,5	29,0	48,9	3,6
television broadcasts	36,2	37,0	25,4	1,4

Similar research, but more detailed, was conducted in Lithuania by Prof. Siarnas (Siarnas V., 1976).

For the study in 1986-1987 (Lääneмets U., 1988) we compiled an open questionnaire, in which people were asked to indicate their practical requirements for local (Estonian, Russian) and foreign (English, German) languages in their daily lives. Their expected language competence was given in six principal functional styles according to the classification of N. Kondrashow (Kondrashow N., 1985, p. 14). Accordingly, the respond-

ents had to ascertain their particular language needs for:
1) Carrying out everyday conversation (conversational style);
2) Completing official documents (official style);
3) Reading public press issues (journalistic style);
4) Reading fiction (literary style);
5) Reading instructions and technical literature (technical style);
6) Reading scientific literature (scientific style).
The research program was designed in three stages:

I. Pilot research. A questionnaire was published in the newspaper "Noorte Hääl", which readers were asked to complete, if they were interested in helping to ascertain the possibilities to develop and improve the teaching of foreign languages in Estonia.
The anticipated result was to determine the suitability of the questionnaire and to obtain preliminary data about functional language requirements in Estonia at present.

II. Research on different social groups, mainly students at various types of schools (general comprehensive secondary schools, vocational schools and universities). Language usage of teachers was also studied. The anticipated result was to discern the needs of various groups of students, which could help to establish the learning and teaching objectives in different types of schools.

III. Research based on the demographic model of Estonia taking into account age groups, gender, occupation, etc. of the Estonian-speaking population. Unfortunately, corresponding research could not be undertaken on the Russian-speaking population of Estonia, because of the official consent was not received.

The results of the first stage of research demonstrated that the greatest functional requirement is, predictably, for the native language in all spheres of life. The functional requirement of Russian in Estonia in 1986 was in the second place and foreign languages (English, German) were the least utilized, although the percentage of social demand for them was comparatively high.

The research according to the demographic model of the Estonian-speaking population concentrated only on foreign languages; people were asked to estimate their requirements for Russian, English and German. The results illustrate the requirements for various functional styles in these different languages. Research

subjects were students at vocational and general comprehensive schools and universities.

The results of the research reveal that competence in communication in various languages is absolutely essential in these times, especially for a small nation such as Estonians. Accordingly, programs for foreign language learning should be based on actual and practical needs. School programs as well should correspond to the needs of their particular type of student. Research of this type can be useful in choosing more appropriate material for our school textbooks in foreign languages.

In order to obtain a complete picture, the program for Russian, English and German languages in general comprehensive schools were studied and their corresponding textbooks were analyzed. The proportions of various functional language materials at the level of the textbook were determined. The total for each text was calculated from the total number of printed characters with an approximate error +- 5 - 10 characters per page.

Conclusion: Our research has shown that there is great demand for wider knowledge of various languages from diverse social groups in Estonia. Unfortunately, the selection of foreign language textbooks is limited and the textbooks and programs used in general comprehensive schools for teaching and learning are inadequate, especially concerning the Russian language. At the level of the general comprehensive school, the education standard of language competence should guarantee preliminary knowledge of all existing functional styles and current syntax to meet students' conversational language requirements. It is impossible to fix the exact proportions of functional material, but general practical social language requirements should be considered, and all styles presented in the textbooks with some examples, at least in the textbooks for general comprehensive schools.

In future, new possibilities for finding more appropriate material for foreign language textbooks will arise as learning objectives become more specialized, and textbooks written on certain fields of life (for example, Business English, or English for Bank Clerks) as these have been widely available in many countries for some time.

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HOW TO EVALUATE THE QUALITY OF LANGUAGE TEXTBOOKS AND ASCERTAIN THEIR SUITABILITY FOR PRACTICAL LEARNING

Urve Lää̈nemets

Various school textbooks and programs used at our schools have been heavily criticized because of their primitive or factually incorrect contents, or their poor functional design or technical composition, etc. etc., but there are very few constructive proposals for compiling better books or other teaching and learning aids. The criticism towards schoolbooks is usually expressed in quite indefinite terms or, at best, certain incorrect facts or insufficient information is referred to, although every critic or teacher should make an effort to find some evidence to illustrate one's statement.

The problem is, how to compile an objective evaluation of a textbook or other teaching aid in order to ascertain whether the object of analysis could be used for practical learning under certain conditions. Until now, there has been no system of criteria and methods of evaluation to ascertain the quality of a school textbook before it has been published and put into use.

This problem is made more serious by the fact that there is usually one state-specified textbook which must be used in all schools for teaching and learning a particular subject or discipline. Therefore, if a textbook is a failure, all the pupils of that cohort will have problems with this subject.

A special branch of pedagogical research has been dedicated to the analysis and evaluation of school textbooks. There are two quite helpful monographs written on this particular subject and which are available in this country, namely "A School Textbook" by D. Zujev (1983, 240 p.) and "Arsenal of Education" by V.Beilinson (1986, 288 p.).

This brief report represents an attempt to devise

criteria and to propose methods of evaluation to ascertain the quality of language textbooks, and to decide whether they would be suitable for the practical learning of languages under certain conditions.

The problem lies in what to evaluate and how. An effective system of evaluation should contain:

a) certain criteria by which textbooks (and other teaching aids) may be judged as comprehensively as possible.

b) methods of evaluation which show how the quality of a textbook according to a particular criterion could be ascertained.

The scientific examination of textbooks used in general comprehensive schools in Estonia has largely been conducted at the Institute for Pedagogical Research of the ESSR in 1960-ies.

In the Soviet Union, the evaluation of school textbooks has been carried out on a so-called "general" basis. The scientists of the Pedagogical Academy of the USSR have selected certain criteria (35 in total) by which to evaluate all school textbooks and teaching aids. These criteria have been used for compiling so-called "expert evaluations" of textbooks' manuscripts submitted in competitions for new school textbooks.

However, these "expert evaluations" are based on subjective criteria: the personal opinions of various specialists, whereas an objective evaluation should be based on data generated by specific analysis or measurement.

Another problem arises from the above-mentioned "general" criteria. It is practically impossible to evaluate, for instance, a textbook of chemistry or physics and a textbook for the learning of language according to the same standard. Therefore, we have come to the conclusion that criteria for the evaluation of school textbooks should be divided into two main groups:

1) General pedagogical criteria which pertain to all textbooks, and

2) Special subject-based criteria which are specific to textbooks of a certain type, e.g. languages.

In addition, all criteria could be divided into 3 groups, as follows:

1) Basis for the choice of educational content;

2) Feasibility of educational content;

3) Presentation of educational content.

On the basis of various studies carried out in the field of school textbooks (some listed in bibliography)

we ascertained among the many criteria used by different specialists the following which belong to the first group, and could be termed general pedagogical criteria:

1) Adequacy of a textbook to the subject program. If the program requires certain knowledge and the textbook does not provide the student with the necessary material, the textbook should not be used.

2) Personal motivational qualities to the student of the material selected for study. If the content of the textbook is irrelevant to a student's needs, expectations and future application, it will not be assimilated by the student.

3) Cultural context. The content should be relevant to the lifestyle and cultural milieu of the student.

4) Educational trends of study content. Human values, ethical norms and tolerance should be comprehensible to students of different ages, sexes and nationalities.

5) Feasibility of educational content. This could be determined by the level of complexity and technicality of a text (assisted by statistical data) and also by its suitability to the student, taking into account his age, previous knowledge, and general development.

The average amount of study material in each lesson is also an aspect which should be considered.

Material which is neither too simple nor too complicated is optimal for study purposes. The level of average complexity is preferable, in which brighter students can assimilate the material more quickly, but in which the less bright can still manage within the study time allotted.

6) Development of the student's ability to work independently. Students can benefit from being taught to learn "how to learn": discovering personal and general learning strategies, such as silent rehearsal, etc.

7) Methodological presentation of study material. Every subject or discipline has its own particular methods of instruction, but in general, study materials must be presented in a way which makes them accessible to the student.

8) Functional design of the textbook. Unfortunately, this area has been badly neglected in Estonia, due to the technical standards in our publishing houses, and a lack of knowledge in authors and illustrators of school textbooks. A text should be divided into logical units. Size of type, use of tables, colour schemes,

illustrations, and even blank spaces on the pages of a textbook could be of help or hindrance to the learner.

The most important subject-specific criteria which should be considered in comparing and evaluating language textbooks are:

1) Adequacy of the language material of a textbook to the contemporary language norm. (Unfortunately, there are some out-dated or completely incorrect expressions in our school textbooks!)

2) Functional qualities of the selected language material in a textbook, i.e. the degree to which the content of a textbook meets the requirements and expectations of the student, such as specialized textbooks in conversation, completing official documents, or a reader in English literature, for instance.

Of course, the criteria of development of a student's abilities for independent work, and methodological presentation of the material from the perspective of language instruction are also important and subject-specific.

We consider the following three methods of determining the quality of a textbook to be universally applicable:

1) The most prevalent is the use of evaluation by experts, who usually express their opinions in the form of written reviews, generally in free form. According to a specialist's level of competence, the evaluations range from well-founded to unfounded.

2) Appraisal of the text could be performed on the level of linguistic or statistical analysis. Both are reasonably reliable, as they present objective data in terms of facts or numbers.

3) Trial in schools is the method least frequently employed because it requires a large amount of time to test a new textbook in actual learning situations for a specified period. The evaluation will be performed by comparing the effectiveness of at least two variants (usually the old and the new) of a textbook.

A synopsis of methods and criteria which could be used and has in fact been used in toto for the evaluation of the German language textbooks for Estonian general comprehensive schools, is given in Table 1. English and Russian language textbooks have also been evaluated according to some of these methods and criteria.

Table 1

The Basic Methods and Criteria
for the Evaluation of School Textbooks

Basic Criteria	Trial in Schools	Evaluation by Experts	Analysis of Text
I. Basis for the Choice of Educational Content			
1. Adequacy of a textbook to the program	+	+++	++
2. Adequacy of language material of a textbook to the contemporary language norm	−	+++	++
3. Functional qualities of selected language material in a textbook	+	++	+++
4. Personal motivational qualities of selected study material	++	+++	+
5. Cultural context	+	+++	++
6. Educational trends of content	++	+++	+
II. Feasibility of Educational Content			
7. Complexity and technicality of textbook	++	+	+++
8. Average amount of material in each lesson	+++	+	++
III. Presentation of Educational Content			
9. Development of students' ability for independent work	+++	++	+
10. Methodological presentation of language material	+++	++	+
11. Functional design of the textbook	+	+++	++

−, +, ++, +++ = feasibility of application of particular method

Conclusion: Language textbooks may be evaluated by the system presented. The number of criteria in this system is not fixed. We may choose to add new criteria or to subtract some of those currently recommended. The

choice of criteria will depend on the aims of the planned evaluation.

We may undertake a full-scale evaluation of a textbook or direct our attention to a particular aspect, e.g. the polygraphic quality of a textbook, its methodological presentation, etc.

In essence, a school textbook may be considered suitable for practical use if it receives satisfactory evaluation according to all of the criteria. If the evaluation is unsatisfactory according to any of the principal criteria, we may expect problems working with that textbook.

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STUDIES ON TEACHING MATERIAL READABILITY

Jaan Mikk

The requirement that the study material must be appropriate for the learner has been ignored in Soviet school for long years. By now the problem has acquired such importance that the education system is being radically altered and the amount of material the students are expected to know, reduced very much. The education system needs changes but they should not be excessively radical the way it happened in the 60s when the principle of scientific approach was introduced. The best way to solve problems of educational optimization lies in the all-round application of scientific advances in education.

Studies on readability of textbooks began in Estonia over 20 years ago, as even then it was clear that some textbooks were too sophisticated to match the pupils' learning skills. The basic problems studied have been the formulae of readability, their derivation and application in textbook appraisal, the rules of clear writing and their application in textbooks, and also determining the optimal level of text difficulty in school textbooks. I am especially interested in why the principally correct idea of readability formulae has found little practical application so far. Experimental methods of appropriateness assessment will also be dealt with.

I should like to start with experimental methods. In the 60s and 70s a large number of all-Estonian tests were carried out in schools of general education. The tests comprised the material of one academic year or sometimes, but not very often, the material of one semester. The time limit was one hour, so the number of questions was limited. The tests were done by several hundred, sometimes by thousands of pupils. The results of this all-Estonian testing may be taken, for lack of any better ones, to represent the level of the pupils'

knowledge in Estonia. The results revealed that the pupils had acquired 60-70% of the material on the average. One third of the testees failed to come up to the 50% margin, which is the lower margin for the satisfactory answer in Estonian schools.

In a number of analyses of tests, it was concluded that the poor results could be accounted for by the laziness of the pupils and the poor quality of teaching. But to come to think of it, if for years, one third of the pupils fail to come up to the required satisfactory level, should the fault, besides other things, not lie in the programs and textbooks in general use? These programs and textbooks had practically never been studied from the point of view of their level of readability. There were no data on how much time the material contained in textbooks would take to be at least satisfactorily learned. The teachers did not know how much of that material could be satisfactorily acquired within an hour or within an academic year for that matter.

This question can be given a generalized answer by analyzing the results of the all-Estonian tests. The assumption is that the study process has been organized correctly, when the assignments meet the abilities of the pupils. That means that the pupils should be able to acquire the study material they have been set to by making as much effort and spending as much time as generally accepted in our society. If they fail, the study material must be either too sophisticated or too extensive. By a stronger study motivation and better skills of learning, pupils can surely acquire more material at a time, but on the other hand, better skills of learning and higher motivation can be developed only by assigning tasks that are appropriate for the level of skills.

Thus, the material that the pupils can at least satisfactorily acquire when they make moderate effort under the existing conditions can be considered appropriate. Proceeding from this definition, the results of the all-Estonian tests can be used to calculate the size of the text and the degree of its readability in a textbook appropriated to the pupils. We shall give an example how the calculations can be made.

In 1973, 854 nine-form pupils wrote a unified test in geography. The test had four variants. The results were assessed on a 20 point scale. The results were as follows (Table 1).

The results reveal that the pupils, to be more

Table 1

The results of a test in geography

Score	1	2	3	4	5	6	7	8
Number of testees	1	3	8	6	22	24	31	44
Percentage of testees			1	1	3	3	4	5
Cumulative percentage			100	99	98	95	92	88

Table 1 (continued)

Score	9	10	11	12	13	14
Number of testees	59	73	80	67	103	80
Percentage of testees	7	9	9	8	12	9
Cumulative percentage	83	76	67	58	50	38

Table 1 (continued)

Score	15	16	17	18	19	20
Number of testees	67	59	53	30	29	15
Percentage of testees	8	7	6	3	3	2
Cumulative percentage	29	21	14	8	5	2

exact – 95%*, knew the material well enough to score six points. That means that the pupils should be given a satisfactory mark for a six-point score and consequently six points should represent the knowledge of

half of the appropriate material. (According to the grade program a satisfactory mark, presupposes that at least half of the material has been learnt.) The full amount of appropriate material in this text will be equivalent to 12 points. In other words, judging by the results of this test the degree of effort required by the geography program and the textbook is to be cut by (20 - 12) / 20 * 100% = 40%

As can be seen by the example, the results of a representative test can be easily used to calculate the amount of study material appropriate for the level of the respective learning skills**. The calculation can be made more precise if the model of frequency distribution of the test results, especially the end of the smaller values is used.

To study the appropriateness of the study material readability formulae have been in wide use. The formulae have been developed after examples in English literature (Chall J.S., 1958; Klare G.R., 1963). However, the readability formulae in use in Estonia have been modified and have their peculiarities.

The general principles according to which readability formulae are developed and used are simple. To work out a formula of readability for texts in a certain field of study, a score or two of texts (basic texts) are chosen. The degree of difficulty of these texts is experimentally assessed by asking testees to read the texts and answer a number of questions on the texts. The index of difficulty of the basic texts is compared with the values of text properties and with the help of regression analysis a formula is derived, which makes it possible to predict the percentage of the correct answers to questions on the basis of different text characteristics. The formula is later used in assessing the readability of new texts by measuring the characteristics of the text and using the results to compute the readability index according to the readability formula.

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* The scores of 95% of the pupils will be used in our calculations as smaller work loads will inevitably lead to a rise in learning effectiveness and the pupils' results will in fact improve to a greater degree than we can prognosticate.

** A unified and detailed program for geography and an approved textbook of geography were in use in Estonia.

The degree of difficulty of basic texts is established by answering questions on the text (5-10 questions per text). These questions, however, may be more difficult or easy than the average question of all the possible questions on the text. So the 5-10 questions used need not reflect the degree of text difficulty correctly. The questions on the text in the ideal case should be representative both in content and number.

To solve this problem, we investigated what characteristics of the question determine the correctness of the answer. Our experiment on 4 texts and 320 questions in physics gave us the following statistically significant results:

1. questions on terms were answered better than questions on facts or notions,

2. the longer the answer to the question in the text the fewer correct answers are given,

3. the larger the number of concepts to be associated for the correct answer, the more difficult it is to produce the correct answer,

4. the longer the words in the question, the fewer correct answers are given.

These are the factors that can be taken into consideration in drawing up questions on different texts. It is clear for example, that the ratio of questions on terms and facts should correspond to the ratio of terms and facts in the text, etc.

The representative number of questions on a page of text should clearly be more than 10. So in our experiment on texts on physics we drew up 80 questions per text. But it is unreasonable to present all the 80 questions to be answered by one and the same subject as some of the questions are close and some questions hold answers for others. All the questions were divided into 8 variants, each containing 10 questions. Consequently, the average percentage of the right answers should correctly represent the degree of text difficulty.

The degree of difficulty of basic texts is besides question-tests also assessed with the help of cloze tests, evaluations given by the readers and other methods. An experiment on popular-scientific texts showed that the above-mentioned methods yielded different results while the same texts were measured. This can be easily explained by the fact that the reliability of none of the methods is ideal, and moreover, these methods each measure text difficulty emphasizing slightly different aspects. To be able to have a summarized index of difficulty assessment in the experiment

on popular scientific texts we used factor analysis. Correlations between the difficulty assessments of the basic texts scored by different methods were calculated and the first factor established. The first factor correlations with the different methods represent the validity of the latter, allowing the first factor to be treated as a cumulative difficulty index. The values of the first factor were calculated for each basic text, as these values are more precise estimates of difficulty than the indices found by any isolated test method.

We tried to include new text parameters besides the generally accepted ones. As a rule, a hundred and more characteristics were assessed in the basic texts, and their correlations with text difficulty calculated. One of the important characteristics is the degree of abstractness of nouns in the text. The more abstract were the nouns in the text, the more difficult was the text. The degree of abstractness of nouns was assessed on the three-point scale:

1 - concrete nouns designating things directly perceivable by senses (e.g. book, horse),

2 - nouns designating phenomena and processes perceivable by senses (e.g. running, aurora),

3 - abstract nouns designating objects imperceivable directly by senses (e.g. atom, predicate).

More detailed scales of noun abstractness were also considered but their results were not significantly better.

We should like to present a formula of text readability we elaborated on the basis of Estonian popular-scientific texts.

$$C = 0.131X + 9.84Z - 4.59,$$

where C - text readability,

X - the average length of independent sentence units in the text in character spaces,

Z - the average abstractness of nouns repeating in the text.

The degree of noun abstractness was determined according to the three-point scale presented above. We considered that sentence units were all the simple and complex sentences and all clauses making up the compound sentences in the text. The multiple correlation coefficient in this formula was 0.67. To use the formula in assessing the readability of a book, the mean length of the sentence unit is to be calculated in eleven one-page randomized passages, and the mean value of noun abstractness on seven pages. The result will then be in the exactness range of one unit (Mikk J.

A., 1981).

The formula has been used to assess textbook readability in Estonia, Czechoslovakia (Smik L., Ganajova M., 1989) and elsewhere. The readability of over fifty Estonian general school textbooks was established. We also counted the pupils doing poorly in all the Estonian secondary schools. Correlating the two figures, it was clear that the more sophisticated textbooks resulted in larger numbers of pupils who cannot do satisfactorily in the subject (Figure 1).

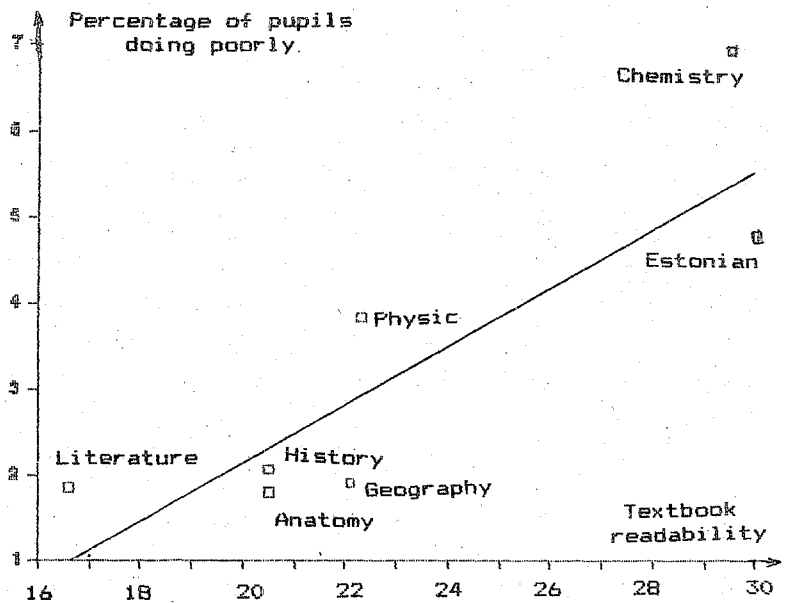

Figure 1. Relationship between textbook readability and the procentage of pupils doing poorly in Form 8.

The most difficult were the textbooks of chemistry and Estonian, the simplest the textbooks of literature, history and science. The differences in the analyzed textbooks lay first of all in the degree of noun abstractness.

The ideas of readability measurement have also been widely used in studying and assessing Estonian

textbooks of German and English (Liiv H., Poolakene K., 1977; Reiksaar T., 1982; Selg R., Tõevere H., 1978). From purely theoretical considerations an original formula of readability has been evolved by J. Tuldava (Tuldava J., 1975).

The formula of readability shows the degree of text difficulty, but it does not show whether the text is of optimal difficulty for a given reader. At first glance it seems that the simpler the text is, the better it is for the learner. In fact it is not quite so, as a text that is too simple does little to develop the learner. We should be able to provide each learner with an appropriate text ideally matching his or her level of development.

What ways are there to determine if a given textbook is of appropriate, optimal level of difficulty for a given group of learners?

Principally the question can be answered as follows. We should take a number of different texts, ask the students to work them through and find out which text contributed most to the growth of the students' knowledge. However, this method presupposes that the amount of information checked by a question is the same in all basic texts. The prerequisite is not easy to observe, so in our experiment we have had to satisfy ourselves by comparing the information gain of different students after reading one and same text. A text may be considered optimally difficult if the students gain most by working through the text. If the students of the average learning skills in the group gain most, the text may be viewed as a text of optimal difficulty for the given group of students.

An experiment aimed at determining the optimal textbook difficulty levels in geography, history and mathematics of the 7th form shows that the optimal amount of information previously known to the pupils must be about 20% of the material. The optimal level of the material acquisition is represented by 70% of the correct answers per text*. Any further rise in the amount of information acquired calls for a considerable extra time spent on learning the material. The optimal amount of the new material that can be learnt under given conditions is equal to 50% of the whole informa-

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*This is a somewhat lower result than usually reported in literature. This can be explained by the fact that we tried to establish the lower limit of optimal difficulty assessment.

tion in the text.

Proceeding from the above-mentioned criteria, the characteristics of the optimal readability for a textbook can be calculated. We proceed from the assumption that the final results in a study process must be optimal by using a textbook of optimal readability. Knowing the index of readability of two textbooks and the level of information acquisition we can linearly extrapolate the degree of textbook readability guaranteeing the optimal 70% level of acquisition. So we found the characteristics of the optimal level of textbook readability, which are summed up in Table 2.

Table 2

The characteristics of the optimal level of textbook readability

Sophistication characteristic	Form						
	5.	6.	7.	8.	9.	10.	11.
Readability according to Formula 1	15	16	15	17	20	24	28
Noun abstractness on a three-point scale	1.2	1.3	1.2	1.3	1.6	1.9	2.2
Length of independent sentences in units of character spaces	60	60	60	65	70	81	86
The volume of the text for a one-hour class in typed pages (Grundanforderungen..., 1984)	2.6	2.8	3.0	3.3	3.6	3.9	4.2

Table 2 reveals that the characteristics of the optimal textbook readability level remain unchanged from Form 5 to Form 7. This can be explained by the peculiarities in the development of pupils in this age bracket. The criteria presented are approximations as there are other, unstudied parameters influencing the process. However, it should be mentioned here that nearly the same results have been achieved by using other methods. For example, considering that an adult

reads 200 words per minute and information passes from the immediate memory to the short-term memory at the interval of 3-5 seconds, the optimal length of the sentence should be 10-17 words (Platzack C., 1974).

The actual degree of readability in the textbooks in use in Estonian schools proved to be much higher than the calculated optimal values, which once again points to the fact that learning requirements at Estonian schools are beyond the abilities and capabilities of many pupils.

The criteria for optimal readability show how complex the textbook for a certain form should be. What is to be done, if the real degree of readability should differ too much from the optimal one? Then the textbook is to be replaced or remodelled according to the rules of clear writing.

The rules of clear writing are based on correlations between the text characteristics and the academic progress achieved. For example, knowing the fact that a higher degree of abstraction in the text may contribute to poor academic progress, one can easily understand that one of the possible ways to improve the quality of teaching is to make the manner of material presentation more concrete. The rules have been repeatedly reported and discussed (Flesch R.F, 1960; Langer I, Schulz von Thun F, Tausch R, 1981; Baumann M, Geiling U, Nestler K, 1987) but they have not lost their topicality as people have always been interested in clear ways of expressing their thoughts. We shall present a systematic approach to making study texts appropriate for the learner. The system will be based on correlations and partial correlations between the Estonian text characteristics and indices of difficulty.

1. The information should be grouped round established centers. To do this, all the new elements of the material must be carefully defined, and the number of unknown units must be limited. A. Ussova suggests that a new concept must be introduced over a seven-stage period of teaching; for a new word to become familiar it must occur in the study text at least 5-7 times. Unknown elements in the text may be expressed as new facts, concepts or words. So it is reasonable to cut the number of terms, international words and in the junior forms even that of long words in the textbook.

2. The study material should be made more concrete. This can be done in two ways: including concrete examples and leaving out some abstract material. Abstract material presupposes the use of a lot of ab-

stract nouns, i.e. nouns of the third category according to the scale described above, or nouns including abstract suffixes. A text may be considered abstract, if its ideas cannot be perceived with senses. Texts become more concrete when they have been illustrated with figures, schemes or other visual ways of presentation. When the text speaks about people, then it is also perceived as something more concrete than pure abstractions. Everything associated with people rouses interest in the learner thus contributing to the effectiveness of the learning process.

3. The relationships in the study material should be clearly presented. It is of importance that all the bonds between the words in the sentence should be clearly exposed. For that purpose the words belonging together should be placed not far from one another in the sentences, a subordinate clause should not be parenthesized within the main clause, pronouns should be placed near the head words, etc. All the connections between the sentences should also be clearly presented. This is achieved by ordering the sentences in the sequence in which the events described in them take place, by bringing out the connections between the sentences with the help of special words or phrases, etc. The third type of text connection is presented by the logical relations within the text. A text should clearly present the way how facts can be generalized, how the new material becomes embedded in the system of the earlier learnt material and what problems are to be solved later on. These connections can be more easily found if the essential old material is revised before taking up the new material.

The effectiveness of the advice given above has repeatedly found proof in our experimental investigations. Certain chapters have been taken from textbooks in general use, they have been rewritten according to the recommendations given. The basic content of the material has been left unchanged. The experiment has been conducted in the crossing group method, i.e. first half of the group uses the old variant of the textbook and the other half the new variant. The roles are exchanged in the middle of the experiment. This method ensures that the same pupils will use both variants of the textbook, so the personality differences in the pupils can be ignored in analyzing the experiment results.

The experiment was conducted in learning physics, biology, geography and chemistry. The results showed

that the reduction of study text complexity led to a 12-60% rise in the effectiveness of learning. Using simpler texts the pupils can comprehend them better, they acquire the material more thoroughly and their knowledge of the subject grows more rapidly. It is also of importance that pupils have shown to remember the material a year later much better when they learnt it from simpler textbooks in comparison with the material acquired from more sophisticated textbooks. So the apprehension that the material learnt from simple textbooks tends to be forgotten easily, has proved groundless. The simplification of the study material makes it comprehensible more easily which guarantees a better long-term remembering of the material.

The experiment described above shows that it is possible to get better results and make better use of the pupils' learning capacity if the study material has been prepared more carefully. Finances spent on making better textbooks will be spent more effectively than the same sums spent on training teachers, as a good textbook can be used by a larger number of pupils in comparison with the number of pupils a good teacher can give instruction to.

To conclude the subject of the readability formula one more serious problem must be dealt with, viz. why the people called upon to give appraisal of textbooks often feel dissatisfied with the results obtained by applying the readability formulae. Why are the formulae criticized so much, while the idea forming the basis for them is beyond any reproof? This idea is that texts are analyzed to determine the characteristics that lie at the basis of the effectiveness of the study texts so that the text characteristics can later be used to assess or alter other study texts.

The criticism voiced against the formulae may have been brought about first by the fact that their long practical use in the USA has taught the authors of textbooks what is expected of the textbook and what criteria are used by editors in assessing the textbook manuscripts. The authors have started to accommodate themselves to meet the requirements. For instance, one of the arguments in the readability formulae is the length of the sentence. So the authors deliberately write in very short sentences and get a good readability index. However, by artificially hacking their phrases, they actually achieve the opposite, as vital connections between ideas are severed. It has been suggested that the formulae might be kept as a secret

tool of the editors. The authors of textbooks should better be kept in the dark as to the characteristics according to which their work will be appraised. Actually the authors should concentrate not only on the characteristics used in the formulae but on all the possible text characteristics which make for the effectiveness. That will mean the text will be made simpler. The kind of formula used to appraise the text will be of little importance.

Second, the same formulae have long been in use, as there is little experimental research to elaborate new, specific formulae. Many readability formulae in use in the USA are based on McCall-Crabbs tests. As the formulae have been worked out on the basis of the same experimental data, calculable values are also close. New research is needed into the experimental assessment of text difficulty to be able to derive new formulae of readability that could meet the modern reading situation. It is essential that the system of text analysis should be improved and new arguments introduced into the analysis. More emphasis in text analysis should be laid on the results of psycholinguistic studies (Davison A., 1986), as randomly chosen characteristics can hardly be expected to yield good results. Pioneer studies in this field are the theory of the four dimensions of readability (Groeben N., 1982) or the studies published by A.R. Lurija (Lurija A.R., 1979). Readability formulae should, in equal measure, cover besides the text all the other elements of the textbook, such as figures, tasks, etc. Prognostic testing should cover not only the comprehension of the text, but also the interest evoked by the text, the time spent on reading the text and other characteristics of the learning process.

Readability formulae do not take the learner's individual peculiarities into consideration and these individual peculiarities may make a lot of difference. Within one and the same group of students there is the stronger one third who may have advanced by up to three years in their development and there is the lower third who may be by three years retarded in their development in comparison with the other students of the same age bracket. That means that in principle absolutely new formulae of readability should be worked out which besides text characteristics would also take into consideration the peculiarities of the readers. By applying such a formula, concrete estimates of the reader's skills and text parameters are used to find

out if the textbook is appropriate for that particular reader or group of readers.

The last major shortcoming in the application of the readability formulae lies in the too small number of passages analyzed. It seems to be a wide-spread practice that only three passages (one taken from the beginning of the book, another lying somewhere in the middle of the book and a third at the end of the book) are used in calculating the readability index of the book. Such a choice of passages is not representative; in fact, tens of pages should be analyzed. In our research we have analyzed at least 10-30 pages of the textbook. The larger the text analyzed, the more precise results can be expected. It can be calculated how many pages of a given textbook should be analyzed to achieve the desired accuracy of assessment. There are several considerations supporting the idea that the whole book should be analyzed to establish for instance how many new words a foreign language textbook includes, how frequently the new words are repeated and other factors. The full analysis of a textbook gives a list of the terms used in it, the paragraphs in which the new terms occur and the frequency of occurrence.

In modern times an analysis of the whole text of a book is feasible when it is done by a computer. Consequently, automated systems of text analysis must be worked out. The simplest readability formulae for English texts have been programmed (Schuyler M.R., 1982).

To assess the appropriateness of a textbook besides the methods described above expert opinions can be made use of. Expert opinions help to elucidate the shades of the learning process that evade formula, or experimental treatment. Expert opinions may be asked for to determine the degree of text indispensability or the causes of text incomprehensibility. It was with questioning experts that W. Gray and B. Leary started their studies in readability (Gray W.S., Leary B.E., 1935). It is probable that a similar project to study the level of appropriateness of schoolbooks in modern times would result in interesting information and new ideas contributing to the research in study material appropriateness.

In conclusion we may say that research in study material appropriateness is to answer three questions: how the degree of textbook complexity and difficulty can be measured, what is the level that would guarantee the most rapid development of the learners and how the

level of textbook complexity should be altered for the textbook to become most appropriate for certain learners (Table 3). All the three problems have been discussed in this paper with the emphasis laid on the degree of textbook readability, ways of measuring it with the use of readability formulae, criteria of the optimal textbook readability and ways of simplifying texts in the textbook. The idea of readability formulae, which lies at the foundation of this trend of study, has been well grounded and is principally sound. However, the idea has been discredited by the people who derive the formulae and use them expecting maximum results with very little work. Ideas of text optimization, correctly applied in textbooks, will greatly contribute to learning success.

Table 3

Optimization of textbook difficulty and readability

	Textbook difficulty	Textbook readability
Analysis of the situation	Experiments to establish the level of comprehension of schoolbooks. Expert opinions.	Readability formulae
Indices of appropriateness	Previous knowledge - 20%. Material comprehension - 90% Acquisition of material - 70%	For example form 7 a) Sentence length - 10 words b) Degree of abstractness - 1.2 c) 1-2% of unknown words
Ways of making the material appropriate	Developing learning skills. Making textbooks of optimal readability.	Information compression round centres. Making the textbook concrete. Exposing the connections.

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THE PROGNOSTICATING EFFECTIVITY OF LEARNING A TEXT IN PHYSICS

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The effectivity of the studying process at school depends largely on the quality of the textbook. Low quality textbooks must not be used at school even for experimental studies because it leads to incorrect view of the world. That is one of the reasons why it is important to prognosticate the effectivity of a textbook before using it at school.

The aim of this research is to elaborate learning effectivity formulas for present-days physics textbooks in Russian. Effectivity of a text includes such units as students' achievement after the learning process and their interest in the text.

The Research Methods

For this research we have taken 40 paragraphs in the physics textbooks, that have been used for some years in the 9th and 10th grades at our compulsory secondary schools (Buchovtsev B.B., Klimontovich J.L., Mjakishev G.J., 1984; Mjakishev G.J., Buchovtsev B.B., 1985).

There are four texts that have been taken out of other textbooks for having a greater difference of readability. The paragraphs have been chosen in the second half of the physics textbook for the 9th grade and in the first half of the textbook for the 10th grade according to the table of random numbers. In this research only the basic text of a paragraph has been used.

The experimental determination of the effectivity of the texts was carried at 13 Russian secondary schools in Estonia*. This research was carried out at

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* To realize experiment participated G. Aleksina and S. Kvitko.

schools by the physics teachers who had been given an additional physics lesson per week.

The students had to study the paragraph of the physics textbook independently. At the beginning of a lesson to measure the students' knowledge before the learning process they had to pass the test (one of the eight possible tests on the material of the paragraph) during which they weren't allowed to use their physics textbooks or asking for the teacher's help. After doing the test (the teacher collected it) the students opened their textbooks and independently studied the paragraph during 15-20 minutes. They were not allowed to ask the teacher or other students for anything. After shutting their textbooks they filled in a form, where they wrote their opinion of how difficult and interesting the text was. Then the teacher gave the students a new test. Thus we have measured the students' achievements before and after the learning process.

In this experiment 427 students participated but for different reasons not all of them studied all the 40 paragraphs. In the following part we use the results of 304 students. They studied most of the 40 texts. There are some texts that less than 200 students studied.

The number of high-achievement-level students and low-achievement-level students influences the achieved result of the study material effectivity. It is correct to compare the material effectivity if all the texts have been learned by the students with the same ability, preparation, interest in physics, etc.

The possible influence of the difference in the students' abilities has been considered in the following way. We have calculated the average value of the students' points of tests for every paragraph. That average value shows the students' abilities, their preparation for the study process and their interest in the studies of physics. The arithmetical mean of the students' achievement (for 304 students) was 53 per cent and the standard deviation - 10 per cent. That value has been taken as the average value of the students abilities. After that the difference of every student from that average ability was calculated. That difference was subtracted from the student achievement of every paragraph. Thus we achieved the situation as if every student were of the average ability. Then it was possible to get the results of the students paragraph learning even if the students' abilities were not equal to the average ability.

The second available source of deviation of the effectivity index of paragraph learning lies in the fact that the test variants on the paragraph were not equal. It is possible that students got more difficult test variants on one paragraph and more easier test variants on another paragraph. In that case it is impossible to compare the learning effectivity indexes on various paragraphs. For avoiding that situation we calculated the arithmetical mean of all final test variants of all the paragraphs. Then we calculated the arithmetical mean of the average results of the test variants for every paragraph. In doing that we did not pay attention to the number of students who had done different variants. The arithmetical mean of the different test variants' results was taken as index of the difficulty for that paragraph. In this way we avoided possible deviations from the unequal distribution of the test variants.

The tasks of test variants were put together by G. Karu and H. Kukemelk. Statistical substantial differences between their tasks were not found. The percentage of the average right answers to the different authors' tests was equal. The paragraphs were also alike by their characteristics important for the prognosis of the study effectivity. Consequently G. Karu and H. Kukemelk had made up equal tasks and questions.

Three effectivity indexes were calculated for every paragraph according to the experiment results:

a) the student's average final achievement level in percentage;

b) the average index of interest in the paragraph. After learning the paragraph the students answered the question if that paragraph was interesting for them (2 points) or not (1 point). The arithmetical mean of that index shows the interest in the paragraph of all the students who took part in the experiment;

c) the summary index of the paragraph effectivity. That index was found by the following formula:

$$E = \frac{L - \bar{L}}{S_L} + \frac{I - \bar{I}}{S_I} \qquad (1)$$

where E - the paragraph effectivity index;

L - the students' achievement level in that paragraph;

$\bar{L}$ - the average value of L of all paragraphs;

S_L - the standard deviation of L;

I - the index of interest in the paragraph;

$\overline{I}$ – the average I of all the paragraphs;
S_I – the standard deviation of I.

The formula (1) is made up of the standardized indexes of the students' achievement and paragraph interest (Glass G.V., Stanley J.C., 1970). As the arithmetical mean of the standardized quantities is zero, then the average paragraph effectivity is characterized with zero. The negative index of the effectivity shows that the effectivity of that paragraph is smaller than that of the average paragraph. The standard deviation is equal to 1 for standardized quantities. It means that they are of the same kind and so we have the same influence on the index of the paragraph effectivity as regards the text interest and the level of the students' achievement.

We analyze the basic texts in the following parts. The aim of the analysis has been to fix such texts characteristics that may influence the paragraph learning effectivity. In general there are the following groups of the text characteristics: 1. The vocabulary knowledge: the larger number of unknown words in the text makes it more difficult for the students to understand and reduces the learning effectivity. 2. The abstract character of substance of the text being studied: more abstract texts are more difficult to connect with the students experiences and so these texts are more difficult to understand. 3. The length of sentences: here difficulties may arise in connecting several parts in long sentences by students. That in its turn may lead to fragmentary understanding of sentences. 4. The complication of the text structure: inversion, long distance between connected elements, etc. break up the logical presentation.

In this article we won't describe why and how the different paragraph characteristics were found. We are limited to their computer list (table 1). Table 1 presents the arithmetical mean and the standard deviation of quantities for describing better our basic texts and textbooks.

The paragraph analysis was carried out on three methods. First of all with the help of paper and pencil we analyzed the text on the basic of Russian grammar. So we determined the values of characteristics* No No

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* T. Borovskaja, U. Volmer, O. Orser, J. Sivenkova, L. Tomaš participated in this work.

3-121, 145-147, 252, 436 and 448. The second method was realized with the help of the computer. All the nouns in all the paragraphs were typed in the computer in their initial forms. Together with nouns, we put in their occurrence in different language frequency dictionaries. So were determined the values of characteristics* No No 237-260 (exept 252). The third method was completely automated. All the texts were typed in the computer and analyzed by programs of morphological analysis that had been worked out in Kiev by V.A.Dartschuk and her colleagues (Automatization..., 1984). Then the computer determined the frequency of every word in our paragraphs relying on the computer frequency list of the Russian speech**. The computer also counted the words in the paragraphs and the letters in the words. So were determined the values of characteristics*** No No 207-236 and 261-447 (except 436).

Table 1

The paragraph characteristics list****

No	The characteristics of paragraph	Arithmetical mean	Standard deviation
1	2	3	4
3	The number of printed signs	4000	1300
4	The number of words (including symbols, abbreviations)	500	170
5	The number of sentences	38	13
25	The total number of nouns	180	59
26	The total number of recurrent nouns	29	9
31	The number of illustrations in a paragraph	2.6	1.7

* I. Sozin, E. Mikk, T. Borovskaja participated in this work.

** The frequency list of words of the Russian speech was elaborated in Moscow University by Buchstab and colleagues.

*** T. Tamman and L. Urm participated in this work.

**** In the chart the computer numeration has been preserved though for different reasons unessential results have been left out.

Table 1 (cont.)

1	2	3	4
32	The number of formulas in a paragraph	2.7	3.6
33	The number of symbols in a paragraph	24	28
38	The average paragraph noun occurrence in the language	198	54
39	The average paragraph noun occurrence in the physics textbooks	400	160
40	The average abstractness of nouns in a paragraph	2.0	0.2
41	The average paragraph noun occurrence of the physic's textbook for grade 6.	30	22
42	The average paragraph noun occurrence of the physic's textbook for grade 7.	55	34
43	The average paragraph noun occurrence of the physic's textbook for grade 8.	83	59
44	The average paragraph noun occurrence of the physic's textbook for grade 9.	122	65
45	The average paragraph noun occurrence of the physic's textbook for grade 10.	135	133
46	The average paragraph scientific-technical noun occurrence	518	90
47	The percentage of 9-and-more-letter nouns	27	8
48	The percentage of 10-and-more-letter nouns	16	8
49	The percentage of 11-and-more-letter nouns	11	7
50	The percentage of 12-and-more-letter nouns	6.5	5.6
51	The percentage of 13-and-more-letter nouns	4.5	4.4
52	The percentage of 14-and-more-letter nouns	1.9	2.9
53	The percentage of 15-and-more-letter nouns	0.8	1.2

Table 1 (cont.)

1	2	3	4
54	The percentage of nouns that are not in the spoken language frequency dictionary	6.6	5.5
55	The percentage of nouns occurring less than 7 times in the spoken language	15	8
56	The percentage of nouns occurring less than 15 times in the spoken language	24	9
57	The percentage of nouns with abstractness 1	24	11
58	The percentage of nouns with abstractness 2	43	12
59	The percentage of nouns with abstractness 3	33	14
60	The percentage of nouns in a paragraph occurring less than 7 times in the 6th grade physic's textbook	67	14
61	The percentage of nouns in a paragraph occurring less than 7 times in the 7th grade physic's textbook	43	17
62	The percentage of nouns in a paragraph occurring less than 7 times in the 8th grade physic's textbook	56	16
63	The percentage of nouns in a paragraph occurring less than 7 times in the 9th grade physic's textbook	25	17
64	The percentage of nouns in a paragraph occurring less than 15 times in the 6th grade physic's textbook	74	13
65	The percentage of nouns in a paragraph occurring less than 15 times in the 7th grade physic's textbook	57	18
66	The percentage of nouns in a paragraph occurring less than 15 times in the 8th grade physic's textbook	64	16

Table 1 (cont.)

1	2	3	4
67	The percentage of nouns in a paragraph occurring less than 15 times in the 9th grade physic's textbook	33	19
77	The average number of letters in words	8.0	0.4
78	The average number of words in sentences	13.1	1.5
79	The average number of letters in sentences	105	11
80	The average number of words in independent sentences	12.7	1.6
81	The average number of letters in independent sentences	102	12
82	The average number of words in the parts of sentences	9.1	0.8
83	The average number of letters in independent sentences	73	8
84	The percentage of the parts of sentences with a length of more than 5 words	76	8
85	The percentage of the parts of sentences with a length of more than 6 words	67	9
86	The percentage of the parts of sentences with a length of more than 7 words	58	9
87	The percentage of the parts of sentences with a length of more than 8 words	49	9
88	The percentage of the parts of sentences with a length of more than 9 words	40	9
89	The percentage of the parts of sentences with a length of more than 10 words	32	7
90	The percentage of the parts of sentences with a length of more than 11 words	26	6
91	The ratio of participial-constructions number to the number of sentences	0.2	0.1

Table 1 (cont.)

1	2	3	4
92	The ratio of participial-constructions number to the number of parts of sentences	0.15	0.06
103	The percentage of infinitives as subjects	4.5	2.9
104	The percentage of predicates with the negative prefix "-"	6.2	4.0
105	The percentage of predicates in the passive	8.6	5.2
112	The number of illustrations pro 1000 words	5.5	3.6
113	The number of formulas pro 1000 words	5.6	8.2
114	The number of symbols pro 1000 words	50	64
116	The percentage of scientific-technical nouns in nouns	79	9
117	The average nouns occurrence in the physics textbooks vocabulary of the 6th to 8th grades	168	97
121	The number of nouns in parts of sentences	3.3	0.6
126	The students final achievement level (SFA)	54.4	10.7
127	The SFA after equalizing the students' abilities	53.7	10.4
128	The arithmetical mean of the SFA of different variants	53.8	10.3
144	The students' opinion of the paragraph-interest	1.55	0.16
145	The number of various nouns in a paragraph	68	22
146	The recurrence of nouns in a paragraph	2.61	0.5
147	The percentage of the nouns in a paragraph	36	5
153	The paragraph effectivity	0	1.7
207	The number of words used by the computer	462	148
237	The percentage of the nouns from the list of 4000 the most frequent words	53.4	10.5

Table 1 (cont.)

1	2	3	4
238	The percentage of the nouns from the list of 3500 the most most frequent words	86.1	8.2
239	The average occurrence of nouns in the spoken language dictionary by Buhshtab	24.4	14.3
240	The average number of selections by Buhshtab	17.0	9.3
242	The percentage of the nouns that do not exist in the Zasorina dictionary (4000 most ...)	43.2	10.5
243	The percentage of the nouns that do not exist in the Shteinfeld dictionary (4000 most ...)	54	13
245	The percentage of the nouns that do not exist in the spoken language dictionary	57	10
246	The percentage of the nouns without a statistical value in	15.4	8.3
247	The percentage of the nouns that do not exist in the Buhshtab dictionary	20.4	6.3
248	The percentage of the nouns with the occurrence less than 10 in the Buhshtab dictionary	61.1	9.0
250	The percentage of the nouns that do not exist in the scientific-technical dictionary (4000 ...)	13.9	8.1
252	The percentage of every-day nouns by Sozin	35	11
253	The percentage of the nouns with a statistical value less than 10 in the Zasorina dictionary	57.4	8.9
254	The percentage of the nouns with a statistical value less than 10 in the Josselson dictionary	45.1	10.4
256	The percentage of the nouns with a statistical value less than 10 in the spoken language dictionary	45.1	10.4
257	The percentage of the nouns with an average statistical value less than 10	43.1	9.5

Table 1 (cont.)

1	2	3	4
259	The number of different nouns in the text	67.4	20.8
260	The number of concepts by Sozin	75.5	36.2
261	The percentage of the sentences with a length of up to 5 words	12.4	5.6
262	The percentage of the sentences with a length of up to 7 words	22.5	7.3
263	The percentage of the sentences with a length of up to 9 words	32.9	8.9
264	The percentage of the sentences with a length of up to 11 words	46.1	10.6
265	The percentage of the sentences with a length of up to 13 words	57.1	10.4
266	The percentage of the sentences with a length of up to 15 words	67	9
267	The percentage of the sentences with a length of up to 17 words	75	8
268	The percentage of the sentences with a length of up to 19 words	82	7
269	The percentage of the sentences with a length of up to 24 words	92	6
270	The percentage of the sentences with a length of up to 29 words	97	4
271	The total number of sentences in a text	36.6	10.8
272	The percentage of the situations where there are no words between two verbs	7.1	5.3
273	The percentage of the situations where there is 1 word between two verbs	2.9	2.6
274	The percentage of the situations where between two verbs there are 2 words	3.2	3.0
275	The percentage of the situations where between two verbs there are 3 words	5.1	3.5
276	The percentage of the situations where between two verbs there are 4 words	6.8	4.0
277	The percentage of the situations where between two verbs there are 5 words	6.9	4.1

Table 1 (cont.)

1	2	3	4
278	The percentage of the situations where between two verbs there are 6 words	7.3	3.8
279	The percentage of the situations where between two verbs there are 7 words	6.3	4.3
280	The percentage of the situations where between two verbs there are 8 words	6.5	3.7
281	The percentage of the situations where between two verbs there are 9 words	5.6	3.4
282	The percentage of the situations where between two verbs there are 10 words	5.5	2.9
283	The percentage of the situations where between two verbs there are 11 words	4.7	3.6
284	The percentage of the situations where between two verbs there are 12 words	4.0	2.5
285	The percentage of the situations where between two verbs there are 13 words	4.4	3.8
286	The percentage of the situations where between two verbs there are 14 words	3.3	2.6
287	The percentage of the situations where between two verbs there are more than 14 words	21.1	9.2
302	The percentage of the nouns that do not exist in the spoken language dictionary	38.7	5.7
303	The percentage of the nouns that exist 1-10 times in the spoken language dictionary	28	6.7
304	The percentage of the nouns that exist 11-30 times in the spoken language dictionary	19.7	5.7
305	The percentage of the nouns that exist 31-80 times in the spoken language dictionary	8.5	3.9

Table 1 (cont.)

1	2	3	4
306	The percentage of the nouns that exist more than 80 times in the spoken language dictionary	5.7	3.0
308	The average occurrence of nouns in in the spoken language dictionary	21.4	9.0
309	The average occurrence of nouns in the text	2.1	0.4
310	The percentage of the nouns that do not exist in the spoken language dictionary of all words	39	6.5
311	The percentage of the nouns that exist 1-10 times of all words in the spoken language dictionary	59	10
312	The percentage of the nouns that exist 11-30 times of all words in the spoken language dictionary	63	11
313	The percentage of the nouns that exist 31-81 times of all words in the spoken language dictionary	57	12
314	The percentage of the nouns that exist more than 80 times of all words in the spoken language dictionary	8.4	4.4
315	The percentage of the nouns in the text	38.9	3.7
316	The percentage of the verbs that do not exist in the spoken language dictionary	21.1	7.3
317	The percentage of the verbs that exist in the spoken language dictionary 1-10 times	30.5	9.5
318	The percentage of the verbs that exist in the spoken language dictionary 11-30 times	20.7	6.4
319	The percentage of the verbs that exist in the spoken language dictionary 31-80 times	8.1	4.6
320	The percentage of the verbs that exist in the spoken language dictionary more than 80 times	19.0	8.0
321	The total number of verbs	45.2	16.7
322	The average occurrence of the verbs in the spoken language	313	246

Table 1 (cont.)

1	2	3	4
323	The average occurrence of the verbs in the text	1.3	0.1
324	The percentage of the verbs that do not exist in the spoken language dictionary of all words	5.4	1.9
325	The percentage of the verbs that exist 1-10 times of all words in the spoken language dictionary	16.1	5.7
326	The percentage of the verbs that exist 11-30 times of all words in the spoken language dictionary	17.8	7.6
327	The percentage of the verbs that exist 31-80 times of all words in the spoken language dictionary	14.8	8.1
328	The percentage of the verbs that exist more than 80 times of all words in the spoken language dictionary	7.3	2.8
329	The percentage of the verbs in the text	9.7	1.7
330	The percentage of the adjectives that do not exist in the spoken language dictionary	69	8
331	The percentage of the adjectives that exist 1-10 times in the spoken language dictionary	16.3	7.0
332	The percentage of the adjectives that exist 11-30 times in the spoken language dictionary	7.7	5.5
333	The percentage of the adjectives that exist 31-80 times in the spoken language dictionary	4.1	4.0
334	The percentage of the adjectives that exist more than 80 times in the spoken language dictionary	2.0	2.1
335	The total number of adjectives	58.8	23.7
336	The average occurrence of adjectives in the spoken language	10.7	8.3
337	The average occurrence of adjectives in the text	1.4	0.3
338	The percentage of the adjectives that do not exist in the spoken language dictionary of all words	22.9	5.8

Table 1 (cont.)

1	2	3	4
339	The percentage of the adjectives that exist 1-10 times of all words in the spoken language dictionary	11.2	5.0
340	The percentage of the adjectives that exist 11-30 times of all words in the spoken language dictionary	8.1	5.4
341	The percentage of the adjectives that exist 31-80 times in of all words in the spoken language dictionary	8.5	6.5
342	The percentage of the adjectives that exist more than 80 times of all words in the spoken language dictionary	1.1	1.0
343	The percentage of the adjectives in the text	12.7	2.9
344	The percentage of the adverb that do not exist in the spoken language dictionary	17.3	8.4
345	The percentage of the adverbs that exist in the spoken language dictionary 1-10 times	13.6	9.3
346	The percentage of the adverbs that exist in the spoken language dictionary 11-30 times	9.7	7.1
347	The percentage of the adverbs that exist in the spoken language dictionary 31-80 times	7.1	6.3
348	The percentage of the adverbs that exist in the spoken language dictionary more than 80 times	52.7	12.2
350	The average occurrence of adverbs in the spoken language dictionary	501	232
351	The average occurrence of adverbs in the text	1.3	0.2
352	The percentage of the adverbs that do not exist in the spoken language dictionary of all words	2.4	1.4
353	The percentage of the adverbs that exist 1-10 times of all words in the spoken language dictionary	3.9	3.4

Table 1 (cont.)

1	2	3	4
354	The percentage of the adverbs that exist 11-30 times of all words in the spoken language dictionary	4.8	3.9
355	The percentage of the adverbs that exist 31-80 times of all words in the spoken language dictionary	7.1	6.9
356	The percentage of the adverbs that exist more than 80 times of all words in the spoken language dictionary	12.5	13.7
357	The percentage of the adverbs in the text	5.3	1.8
358	The percentage of the prepositions that do not exist in the spoken language dictionary	0.02	0.16
359	The percentage of the prepositions that exist 1-10 times in the spoken language dictionary	5.4	5.2
360	The percentage of the prepositions that exist in the spoken language dictionary 11-30 times	1.8	2.2
361	The percentage of the prepositions that exist in the spoken language dictionary 31-80 times	3.9	3.6
362	The percentage of the prepositions that exist in the spoken language dictionary more than 80 times	89	7
363	The total number of prepositions in the text	44.2	13.7
364	The average occurrence of prepositions in the spoken language dictionary	2333	392
365	The average occurrence of prepositions in the text	3.1	0.6
367	The percentage of prepositions that exist 1-10 times of all words in the spoken language dictionary	3.1	3.4
368	The percentage of the prepositions that exist 11-30 times of all words in the spoken language dictionary	1.5	1.9

Table 1 (cont.)

1	2	3	4
369	The percentage of the prepositions that exist 31-80 times of all all words in the spoken language dictionary	7.3	7.5
370	The percentage of the prepositions that exist more than 80 times of all words in the spoken language dictionary	33.2	5.0
371	The percentage of the prepositions in the text*	9.7	1.3
400	The percentage of the words in the text that do not exist in the spoken language dictionary	38.7	3.9
401	The percentage of the words in the text that exist in the spoken language dictionary 1-10 times	18.2	3.2
402	The percentage of the words in the text that exist in the spoken language dictionary 11-30 times	11.7	2.4
403	The percentage of the words in the text that exist in the spoken language dictionary 31-80 times	5.6	1.9
404	The percentage of the words in the text that exist in the spoken language dictionary more than 80 times	25.4	4.8
406	The average occurrence of words of the text in the spoken language dictionary	692	100
407	The average occurrence of words in the text	1.8	0.2
424	The length of sentences in words	13.0	1.5
425	The length of sentences in letters	105	11
426	The number of numerals, symbols formulas and abbreviations in 100 words	6.4	3.5

* Similar caracteristics to those of 358-371 of the pronouns and conjunctions were not much in correlation with the indexes showing the effectivity of the text. That is why their list is not given here.

Table 1 (cont.)

1	2	3	4
427	The number of rubrications in 100 words	0.04	0.15
428	The number of numerals in 100 words	1.5	0.9
429	The number of abbreviations in 100 words	1.0	0.5
430	The number of symbols in 100 words	1.5	0.8
431	The number of formulas in 100 words	0.9	1.2
432	The number of foreign words in 100 words	0.1	0.2
433	The number of abbreviations in 100 words	1.2	1.3
435	Effectivity modification	14.3	9.1
436	The percentage of concepts according to Sozin	16.2	4.7
437	The number of the noun constructions with a length of 1 word in 100 words	17.8	2.8
438	The number of the noun constructions with a length of 2 words in 100 words	6.2	1.2
439	The number of the noun constructions with a length of 3 words in 100 words	2.0	0.9
440	The number of the noun constructions with a length of 4 words in 100 words	0.6	0.4
441	The number of the noun constructions with a length of 5 words in 100 words	0.2	0.2
448	The percentage of the scientific-technical concepts out of all words	31	4.7

Text Effectivity Factors of Physics Textbooks

In this experimental research we have fixed three students' final achievement indexes (indexes 126, 127, 128 in table 1), the index of paragraph interest (index

144) and the integral index of the paragraph effectivity (index 153) that was calculated by formula (1). All the three factors of student final achievement had linear correlations between theirselve and they were equal to 0.99. It means that these indexes are identical and we may use one of them. Thus the average level of students abilities in small groups is equal to the total average level. The unequal distribution of the variants has not brought about any noticeable deviation of the results.

We calculated linear correlations between all the text characteristics and learning effectivity indexes for finding the learning resultativity dependence on the text characteristics. The text characteristics influence the independent text-learning process if the correlation index is reliable. The reliable correlation coefficients have been given in table 2.

Let us have a look at what kind of paragraph characteristics the students' final achievement level depends on. The correlation coefficient was relatively great between the students' final achievement level and the percentage of the nouns in a paragraph (index 147). The greater percentage of nouns in the text conduces its learning because it minimizes the percentage of adverbs and participles in the text. But these two types of words make the text more difficult to understand (Granowsky A., Botel M., 1974). Clear texts have comparatively many verbs and nouns (Wiio O.A., 1968).

The second correlation coefficient in absolute value with student final achievement level was find at the average abstractness of nouns in paragraph (index 40). The greater is the abstractness of the text the lower is the level of student final achievement.

How the abstractness of the text influences its understanding was studied by many researchers some decades ago already (Flesch R.F., 1950; Mikk J.A., 1974).

The level of abstractness of the nouns was measured in our research by a 3-mark scale:

1 - nouns that mark the things and living creatures that a man can directly accept with sensory organs(for example: car, child);

2 - nouns that mark the phenomena that a man can directly accept with sensory organs (for example: light, sound);

3 - nouns that mark the mental constructions that a man can not directly accept with sensory organs

(for example: function, subject).
The nouns with the mark 1 were called concrete and

Table 2

The effectivity factors of the physics textbook
SFA - student final achievement level (index 126)
TI - text interest (index 144)
TE - text effectivity (index 153)

No	Name of factor	Correlation coefficients with		
		SFA	TI	TE
1	2	3	4	5
32	The number of formulas in a paragraph		-0.53	-0.38
33	The number of symbols in a paragraph		-0.57	-0.48
39	The average paragraph noun occurrence in the physics textbook		-0.70	-0.60
40	The average abstractness of nouns in a paragraph	-0.53	-0.52	-0.61
41	The average paragraph noun occurrence in the physic's textbook for grade 6.		-0.44	
42	The average paragraph noun occurrence in the physic's textbook for grade 7.		-0.58	-0.41
43	The average paragraph noun occurrence in the physic's textbook for grade 8.		-0.49	-0.44
44	The average paragraph noun occurrence in the physic's textbook for grade 9.		-0.68	-0.59
46	The average scientific-technical noun occurrence in paragraph		-0.57	-0.51
50	The percentage of 12-and-more letter nouns	0.40		

Table 2 (cont.)

1	2	3	4	5
52	The percentage of 14-and-more letter nouns		0.36	0.43
57	The percentage of concrete nouns	0.51		0.47
59	The percentage of abstract nouns	-0.40	-0.48	-0.51
61	The percentage of nouns in a paragraph occurring less than 7 times in the 8th grade physic's textbook		0.62	0.50
62	The percentage of nouns in a paragraph occurring less than 7 times in the 8th grade physic's textbook		0.38	0.39
63	The percentage of nouns in a paragraph occurring less than 7 times in the 9th grade physic's textbook		0.67	0.53
65	The percentage of nouns in a paragraph occurring less than 15 times in the 7th grade physic's textbook		0.60	0.46
66	The percentage of nouns in a paragraph occurring less than 15 times in the 8th grade physic's textbook		0.40	0.40
67	The percentage of nouns in a paragraph occurring less than 15 times in the 9th grade physic's textbook		0.65	0.52
79	The average number of letters in sentences		-0.40	
113	The quantity of formula in 1000 words		-0.46	
114	The number of symbol in words		-0.50	-0.40

Table 2 (cont.)

1	2	3	4	5
116	The percentage of scientific-technical nouns		-0.64	-0.49
117	The average nouns occurrence in the physics textbooks vocabulary of of the 6th to 8th grades		-0.59	-0.49
121	The number of nouns in parts of sentences	0.52		0.48
147	The percentage of the nouns in a paragraph	0.54		0.51
237	The percentage of the nouns from the list of 4000 the most frequent words		-0.55	-0.38
238	The percentage of the nouns from the list of 3500 the most frequent words		-0.44	-0.39
239	The average occurrence of nouns in the spoken language dictionary by Buhshtab		-0.37	-0.41
240	The average number of selections by Buhshtab	-0.34	-0.37	-0.44
246	The percentage of the nouns without a statistical value		0.48	0.44
250	The percentage of the nouns that do not exist in the scientific-technical dictionary		0.45	0.41
252	The percentage of every-day nouns	0.32	0.68	0.58
260	The number of concepts by Sozin		-0.39	-0.34
264	The percentage of the sentences with a length of up to 11 words		0.40	
265	The percentage of the sentences with a length of up to 13 words		0.40	

Table 2 (cont.)

1	2	3	4	5
266	The percentage of the sentences with a length of up to 15 words		0.40	
267	The percentage of the sentences with a length of up to 17 words		0.45	
268	The percentage of the sentences with a length of up to 19 words		0.37	
273	The percentage of the situations where there is 1 word between two verbs		0.36	0.43
287	The percentage of the situations where between two verbs there are more than 14 words		-0.41	
302	The percentage of the nouns that are not in the spoken language dictionary		0.48	0.49
306	The percentage of the nouns that exist more than 80 times in the spoken language dictionary		-0.35	
310	The percentage of the nouns that do not exist in the spoken language dictionary of all words	0.45	0.47	0.56
312	The percentage of the nouns that exist 11-30 times of all words in the spoken language dictionary		-0.55	-0.39
314	The percentage of the nouns that exist more than 80 times in the spoken language dictionary		-0.35	
317	The percentage of the verbs that exist in the spoken language dictionary 1-10 times		-0.36	

Table 2 (cont.)

1	2	3	4	5
318	The percentage of the verbs that exist in the spoken language dictionary 11-30 times		0.35	
326	The percentage of the verbs that exist 11-30 times of all words in the spoken language dictionary		0.34	
329	The percentage of the verbs in the text		0.35	
332	The percentage of the adjectives that exist 11-30 times in the spoken language dictionary		0.46	
337	The average occurrence of adjectives in the text		-0.43	-0.49
340	The percentage of the adjectives that exist 11-30 times of all words in the spoken language dictionary		0.38	
344	The percentage of the adverbs that do not exist in the spoken language dictionary	-0.33	-0.34	-0.37
346	The percentage of the adverbs that exist in the spoken language dictionary 11-30 times		0.45	0.33
354	The percentage of the adverbs that exist 11-30 times of all words in the spoken language dictionary		0.47	0.37
360	The percentage of the prepositions that exist in the spoken language dictionary 11-30 times		-0.37	
362	The percentage of the prepositions that exist in the spoken language dictionary more than 80 times		0.33	

Table 2 (cont.)

1	2	3	4	5
368	The percentage of the prepositions that exist 11-30 times of all words in the spoken language dictionary		-0.35	
371	The percentage of the prepositions in the text	-0.33		-0.32
407	The average occurrence of words in the text		-0.72	-0.68
426	The number of numerals, symbols, formulas and abbreviations in 100 words		-0.50	-0.44
430	The number of symbols in 100 words		-0.52	-0.53
431	The number of formulas in 100 words		-0.54	-0.43
436	The percentage of concepts according to Sozin		-0.58	-0.49
448	The percentage of the scientific-technical concepts out of all words		-0.57	-0.37

with the mark 3 - abstract. In table 2 we can see that the percentage of the nouns essentially influences the students' final achievements (SFA). The greater is the percentage of concrete nouns the better is the SFA. The greater is the percentage of abstract nouns the smaller is the SFA. Abstract words make the text more difficult to understand because they have little connection with the students' every-day life.

The level of abstractness of the nouns, the percentage of the nouns and verbs in a paragraph are the most important text factors that influence the SFA. In table 2 there is a relatively small number of factors that influence the SFA. But there are more factors that are in quite a high correlation with the students' opinion of the paragraph interest.

The students' interest in physics texts depends on many characteristics regarded, first of all on the vocabulary. In its absolute value the correlation was highest between the rate of the interesting text and the words frequency of occurrence in a paragraph (index 407). The more often words occur in the text the less

students want to study it. The next correlations in quantity are close to this in there essence. The more often words typical of the physics textbooks occur in the paragraph given the less is the students' interest in it (indexes 39, 44). This effect is not common. The higher noun frequency of occurrence makes the text more understandable and that must increase the students' interest in the text. It is possible that the same nouns are used too often in the physics textbooks (the average value - 400 times in five steps). Similar vocabulary makes examples and supplements for students not very interesting. It is also possible that some students do not like the physics terms.

That tendency was characteristic to other factors too (indexes 62, 63, 65, 66, 67). The last indexes mean that if in the text there are more nouns with a small frequency of occurrence in physics textbooks it is more interesting for the students.

The next factors (indexes 46, 116, 436, 448): scientific-technical terms - decrease the students interest in the text if they are used too often in it. The frequency of occurrence of scientific-technical words was fixed by the adequate dictionary (Denisov P.N., Morkovkin V.V., Safjan J.A., 1978).

This research has confirmed the hypothesis that the quantity of symbols in the text influences the students' interest in the text. Quantities or concepts marked with letters were considered symbols. We have found that a lot of symbols and formulas in the text make it uninteresting for the students (indexes 32, 33, 113, 114, 430, 431).

The text interest is considerably influenced by the average abstractness of the nouns (index 40). This influence is caused by proportion of the abstract nouns: its high value decreases the text interest of the students (index 59).

The students' interest in the text depends more on factors than their final achievement. Some factors make the text interesting but have no influence on how comprehensible it is or how easily it is mastered. But if a factor raises the students' final achievement as a rule it will also raise the students' interest in the text. The correlation of factors with SFA and TI have the same sign in table 2.

It is surprising how the percentage of the nouns that occur in speech influences the effectiveness of the text: the greater is the number of the spoken language nouns in the physics texts the lower is the

students' interest in these texts (characters 302, 310 and also 237). Thus the result puts in doubt the recommendation given by one of the dictionaries authors to rely on the 4000 most frequent words while writing schoolbooks (4000..., 1986). If we prefer words out of the most frequent 4000 words the tenth-form students' interest in the text will be higher. Obviously 4000 words are not enough to evaluate tenth-form students' schoolbooks - their vocabulary is much larger. The indices of the correlation of every-day nouns were traditional only with expert I. Sozin. He marked every-day nouns in paragraphs and their higher percentage raised paragraph effectivity (character 252).

The text effectivity depends on the same factors as the SFA and the students' interest of text. Therefore we don't analyze these factors.

We have two ways to use the factors of effectivity of learning texts: 1) by its values we can estimate the quality of learning a text. It is also important to pay attention to the factors (Table 1) that had no reliable correlations with the indices showing the effectivity of the text, e.g., the frequency of participles in the text (indexes 91, 92), the frequency of the passive voice and the negative sentences (indexes 104, 105), the frequency of long substantive constructions (indexes 440, 441) had no influence on the effectivity of the text, though psycho-linguistical studies have shown that such kind of constructions may make it more difficult to understand sentences. The text as a whole does not show the effect of all the possible factors of difficulty. One of the reasons for this may be that these factors occur in the text accidentally and rarely. It confirms the statement that the rules of a good text must be more extensive than the recommendations we can get in Table 2.

2) By using these factors it is possible to give recommendations for raising the textbook effectivity.

In order to estimate physics texts we have worked out some formulas in traditional way by regression analysis.

In the process of elaborating formulas we considered not only statistical validity of arguments but also their content.

The formula for prognosticating the summary effectivity of the physics texts worked out by us is the following:

$$y = -3.17X_{153} - 0.0103X_{40} + 0.0582X_{43} - 1.81X_{310} - 0.320X_{337} + 10.68X_{371} \quad (2)$$

In this formula

X_{40} – the average abstractness of nouns in a paragraph;

X_{43} – the average paragraph noun occurrence in the physic's textbook for grade 8.;

X_{310} – the percentage of the nouns that do not exist in the spoken language dictionary of all words;

X_{337} – the average occurrence of adjectives in the text;

X_{371} – the percentage of the prepositions in the text.

In this formula X_{310} has not a common sign. The available reasons of this effect are described some pages before.

The multiple correlation coefficient of formula (2) is equal to R = 0.88. It is a good result: this formula prognosticates about 80 per cent of the average effectivity of independent work with the physics textbooks in the senior forms.

The SFA level is predicated by the next formula:

$$y_{126} = 60.6 - 16.9X_{40} + 0.776X_{147} \quad (3)$$

In this formula

X_{40} – the average abstractness of nouns in a paragraph;

X_{147} – the percentage of the nouns in a paragraph.

The multiple correlation coefficient of formula (3) is equal to R = 0.64.

The next prognosticating formula has been worked out for the text interest:

$$y = -0.0034X_{144} - 0.020X_{79} - 0.45X_{360} - 0.042X_{407} - 0.0077X_{431} + 2.95 \quad (4)$$

In this formula

X_{144} – the average number of letters in sentences;

X_{79} – the percentage of the prepositions that exist in the spoken language dictionary ii – 30 times;

X_{360} – the average occurrence of words in the text;

X_{407} – the number of formulas in 100 words;

X_{431} – the percentage of the scientific-technical concepts out of all words.

The multiple correlation coefficient of the formula is equal to R= 0.86. It means that formula (4) prognosticates the student interest in the text in the limits of 74 per cent. In reality the exactness of the prognosis would be smaller because in this research some important factors of learning texts were not taken into consideration (for example the subject matter).

We can use formulas (2)–(4) all together or separately. We need not use the whole text while analyzing it with the help of the formulas described above. The previous researches have predicted that for quite an exact prognostication it is important to use about 30 paragraphs to fix the factors for these formulas.

Conclusion

This article is dedicated to working out the methods of analyze effectivity physics textbook. In the experimental part of the study we tried to get the more exact opinion of the difficulty of the basic texts. For this purpose eighty questions on each section we made up and given to different students in eight variants. Alongside with the right answers to the questions we were interested in the students' different opinion of the text. The basic texts were longer than usual – 500 words on the average.

While analyzing the text most of the work was done by computers using the morphological analysis program of the Russian language. It gave us different caracter-

istics of the occurrence of words .

The results of the study were unexpected because they showed that the more often the text had the words used in a physics textbook the lower was its effectivity. The main reason for the fall of the interest level was the high occurrence of the words in the section.

Evidently the vocabulary of the Russian physics textbooks is too limited and the amount of special terminology too great.

The abstractness of the nouns formed the next group of factors showing the effectivity of the physics textbooks. The result has been confirmed repeatedly in earlier studies.

The final achievement was too little influenced by the length of a sentence and it was also unexpected.

Relying on the factors of effectivity found we worked out the formulas for prognosticating the effectivity of a physics text. Three of those have been given in the article.

The prognosticating exactness of these formulas is high, the multiple correlation coefficient is about 0.86. Despite that we have to take into consideration that the real effectivity of a textbook is somewhat different from the effectivity we get while prognosticating the textbook.

This research has not taken into consideration all the factors of the paragraph effectivity in physics. For example we did not investigate the logical structure, methodical system, illustrations, the system of tasks of a textbook, etc. The textbook was investigated in the course of the students' independent learning. But teachers' explanations may change the influence of the textbook characteristics on the effectivity of the learning process.

Despite these remarks we hope that the formulas enable us to get the first assessment of schoolbook effectivity before we begin to experiment the textbook at school.

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THE DEPENDENCE OF THE LEARNING TIME ON THE TEXT CHARACTERISTICS

Hasso Kukemelk

Learning time is an important variable of a learning process. It shows how effectively a student can acquire lesson.

In our epoch rich in information it is very important to study a material in the shortest possible time. Human life is limited and we cannot to use up too much time on students mastery learning.

According to J.B. Carroll learning time depends on a student's abilities, the quality of instructions and instructional quality (Carroll J.B., 1963, 729-730). Instructional quality, in its turn, depends greatly on the textbook's characteristics. This article studies the quality of a text more radically.

The problems of a text have been studied by several Soviet and Estonian researchers. J. Mikk has studied how complicated the text presentation is and how it influences the learning effectivity (look up the article by H. Kukemelk and J. Mikk in the same collection, Mikk J.A., 1981). A.M. Sohhor has studied the relation of the logical structure of a text with the students' achievement (Sohhor A.M., 1974).

The following part of the article estimates how the text learning time depends on its characteristics. We solved the problem experimentally. Students learned some texts, we measured the learning time and then investigated which text characteristics influenced the time.

The Course of the Experiment

An experiment was carried out with 102 17 years old the eleventh form secondary school students. The students for the experimental research were

chosen by the table of random numbers. There were 54 girls and 48 boys in the sample. The students were to learn 40 mathematics, physics and astronomy texts independently. Every text had about 2600 (the standard deviation S=236) letters. Each time at the beginning of a text learning the students knowledge was fixed. At the end of the process the students achievement was fixed. The final achievement was fixed with the test the structure of which was similar to the test for checking preliminary knowledge. The time used for learning was fixed quite exactly. The mistake was up to a minute. Every student was to learn for such a time that he got 80 per cent of points at the end of the learning process. The students' final achievement level was taken equal to 80 per cent of points because some researches (Block J.H., Anderson L.W., 1975; Cristoffersson N.-O., 1971, 135) have found that about 80 per cent is optimal level of acquiring of learning text. If the student's result was lower the text was returned to him and he had to study it again. So it could happen three times. Every time the learning time was fixed and added to the total time. If a student could not achieve the necessary points during three periods the experimenter asked him orally and told him that he had achieved the aim and could start with the next text. But the experiment did not take such a learning time into consideration because its mistake was too big and the student had not achieved the demanded level of knowledge independently.

The students' abilities were fixed with the Estonian variant of Amthauer IQ test - AS-test. That test had 9 subtests and which enable to fix various students' abilities. In our experiment the arithmetical mean of IQ-s was 103. As the normal mean for IQ being 100 we may admit that the students in that experiment were of average abilities (the standard deviation of a students abilities was 9).

The Correlation Between the learning time and the text characteristics

Alongside with experimental fixing of the learning time we found out several characteristics that would influence it. The dependence of the text learning time on the text characteristics was found by the correlation analysis results represented in table 1. All correlation coefficients in that table are statistically essential (at the 95 percentage level).

All these mentioned characteristics except the rate of the interesting text increase the learning time. Only by making the text more interesting helps us to decrease the time necessary for learning. Here there are some possible reasons for this:

1) It is quite difficult to compile a complicated text in an interesting way (the text would not be interesting if a student could not understand it).

2) An interesting lesson fascinates a student's attention. He is more deeply engaged in the text and thus he can achieve good results in a shorter learning time.

3) The laws and facts in an interesting text are so different from the rest of the information that the students master it more quickly (these parts of sentences irritate the human brain more than the usual information).

These rules may be combined in a real learning process at school.

The rate of the interesting text (the characteristic 12) in correlation with the learning time was the highest. Partly it could have been due to the process of carrying out the experiment (students were large to master the material very quickly). Therefore we should consider the fact that an interesting text is equal to the text quickly mastered.

The next correlation coefficients of the learning time are with the text graph characteristics 7 and 8. It says that learning time depends essentially on the concept number and their logical structure (8). The logical graph shows how the concepts of the paragraph are connected with each other. So the graph nodes are connected concepts and the graph edges are the logical connections between them. If there are a lot of concepts in the text and they have a lot of relations between themselves, then a student has to learn that text for a long time. In that way the text with a complicated structure takes a lot of time to be mastered.

The learning time also depends on the percentage of nouns (10) in the text because a lot of nouns in the sentence make its structure more complicated and it takes much time to learn. The learning time depends in the same way on the number of punctuation marks (3). A lot of punctuation marks refer to dependent clauses, a list of various things and so on in the sentence. So the number of punctuation marks shows how complicated the sentence structure is.

Table 1

The dependence of the learning time on the text characteristics

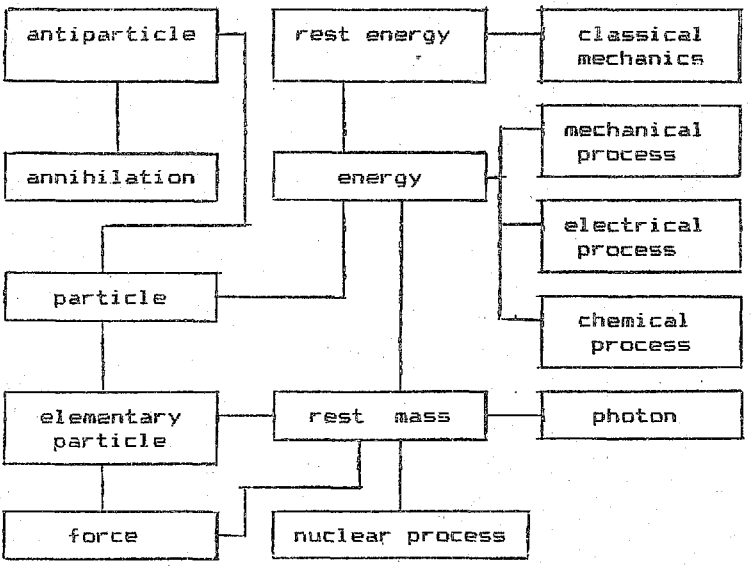
R - the correlation coefficient.
A - the arithmetical mean of the characteristic value.
S - the standard deviation.

No	Characteristics	R	A	S
1.	The percentage of 10-and-more-letter nouns of the total number of words	0.38	41.3	11.8
2.	The percentage of 12-and-more-letter nouns of the total number of words	0.36	25.3	10.2
3.	The number of punctuation marks	0.51	93	42
4.	The word length in letters	0.36	6.9	0.4
5.	The number of the defined concepts and rules	0.45	3.1	2.5
6.	The graph rank of the logical structure of the text	0.39	2.6	0.5
7.	The number of the graph nodes of a text logical structure	0.64	14.3	4.6
8.	The number of the graph edges of a text logical structure	0.66	18.9	8.0
9.	The percentage of nouns of the total number of words	0.55	35.6	5.4
10.	The percentage of the nouns with an abstractness 2 of the total number of the words	0.37	11.2	8.2
11.	The number of the formulas in a 100 words of the text	0.45	0.85	2.11
12.	The rate of the interesting text as estimated by the students	-0.84	1.59	0.19

Here is performed an example of physical learning text and it's logical graph.

Rest energy in classical mechanics is an entirely unexpected quantity. This is the energy that is stored into particles at the moment they are formed. It is their internal characteristic. In mechanical, electri-

cal and chemical processes this energy is unnoticed as the forces taking part neither create nor destroy elementary particles of the substance and the rest energy remains unchanged. In nuclear processes only a small part of rest energy becomes transformed into other forms of energy. In transforming processes of elementary particles the rest mass can disappear altogether. In the process of annihilation of particles and antiparticles their rest mass is transformed into the energy of photons with zero rest energy.



Defined concepts and rules in the text are usually to be learned by heart. For that reason their number (5) has quite a high correlation coefficient with the learning time. Formulas have always been a great problem for the students. A formula is a succinct sentence full of information. Every formula is a coded sentence. Before using the formula students have to decode it into an ordinary sentence. For that the student's brain has to do some operations, in addition. Accordingly a lot of formulas in the text make it more difficult to comprehend and the learning process

takes more time.

The learning process is longer if there are longer nouns in the sentences. A longer word contains more information than a short one (Mikk J.A., 1981, p. 35) and it takes more time to learn.

There is quite an essential dependence of learning time on nouns with various abstractness. It can be explained in the following way: nouns with an abstractness 1 are similar to understand and so they do not influence the learning time at all. Nouns with an abstractness 3 are too general and the students cannot understand their full meaning. They study those nouns by heart. That is why nouns with an abstractness 2 influence the learning time.

Depending on the table 1 it is possible to make some conclusions for composing new learning texts in order to avoid the student excessive learning time:

1) the texts must be interesting;

2) use only the terms and rules that cannot be avoided while estimating and mastering;

3) use only necessary connections between the terms and the rules;

4) do not use long sentences especially with some dependent clauses;

5) do not use formulas for all dependencies;

6) use fewer abstract words (especially if you can use concrete ones instead);

7) use shorter words if possible.

The formulas for prognosticating learning time.

Regression analysis was used for all text factors (look at table 1). In that way we worked out some different formulas in order to prognosticate the learning time for a 1.5-page text. These formulas can be used for prognosticating the learning time of the students whose IQ is between 92 and 112 points. In this interval these formulas give good results in the sciences (physics, mathematics, astronomy).

For practical experience the following formula gives good results.

$$t = 0.27X_4 + 0.17X_5 + 0.18X_6 + 0.11X_7 + 2.87 \quad (1),$$

where t – the learning time in minutes;
X_4 – the number of the formulas in 100 words of the text;
X_5 – the number of the logical graph edges;
X_6 – the percentage of the nouns of all the words;
X_7 – the percentage of the nouns with an abstractness 2 of all the words.

The multiple correlation coefficient for formula (1) is $R = 0.79$. The other factors in table 1 were not used in formula (1) because they have statistically essential correlations with these factors.

It is possible to analyze the learning process by the boys and the girls separately. In the present situation we have found small difference between the formulas of the boys' and girls' learning time. The ability test fixed some differences between them. It is logical that the boys' and girls' abilities are not identical (the structure of their abilities is different). Thus we got two formulas. The first is the formula of the girls' learning time.

$$t = 0.26X_4 + 0.21X_5 + 0.23X_6 + 3.03 \quad (2),$$

where the multiple correlation coefficient is $R = 0.76$ and the names of the factors are the same as in formula (1).

The formula of the boys' learning time is the following:

$$t = 0.27X_4 + 0.17X_5 + 0.18X_6 + 0.11X_7 + 2.85 \quad (3),$$

where the multiple correlation coefficient is $R = 0.79$. As we can see the differences between the formulas (2) and (3) are not very big. The most important difference lies in factor X_7. That factor is not very important for girls.

The experimental research enabled us to make up three formulas related the students' text learning time to its factors.

The most valid formula is (1) for evaluating the textbooks in the science subjects. This conclusion is based on the following assertions:

1) All indices of formula (1) are quite simple and they can be fixed in one and a half pages of a text (about 2600 letters) operatively.

2) The multiple correlation coefficient is quite high ($R = 0.79$) and so the formula describes about 60 percentage of the variance of learning time.

3) Formula (1) has been drawn up on the basis of the average abilities of 11th-form students. It means that this formula enables to analyze the textbooks on the sciences.

4) When we enter the textbook materials into a computer we can use some programs for analyzing the textbook quality and for prognosticating the students' learning time.

This formula also has some disadvantages.

1. It does not take into account the fact that the students differ in their abilities, i.e. we cannot prognosticate the learning time of very slow and very quick learners.

2. The field of the usage of formula (1) is not very large. It is possible to get good results in Form 11 and quite normal results in Form 10 and Form 12 but not in Forms 7-9 because the formula has been drawn up for the students of certain abilities.

3. The formula does not hold the students' abilities. Formula (1) cannot be applied to students with different abilities (bright learners, average learners and less bright learners, especially). The reason is very simple - we haven't found any essential differences between their learning times. If the average learning time of a group was, for example 19 minutes, the less bright learners group spent 21-22 minutes and the bright learners' group 16-17 minutes. But the differences here were quite small that the formulas for the groups did not have any essential differences.

The Prognostication of the Learning Time in Practice

In order to prognosticate the students' learning time in practice we have to enter the numerical values

of the factors into the formula.

For example if we want to know how much time boys would spend on learning a two-pages text we have to take formula (3) and find the following factors in a 2600-letter text:

X_4 - the number of formulas in 100 words of the text (in our example it is 1,8);

X_5 - the number of logical graph edges of a text logical structure (27) (this factor we have to find as normed value on 2600-letter text);

X_6 - the percentage of nouns of the total number of words (45);

X_7 - the percentage of the nouns with an abstractness 2 of the total number of the words (24);

Now we can enter these values into formula (3):

$t = 0.27 * 1.8 + 0.17 * 27 + 0.18 * 45 + 0.11 * 24 + 2.85 = 19$ minutes.

As the length of the text is two-pages we will have to multiply this time by 1.33 (2 divided by 1.5). As a result we prognosticate the real learning time as 25 (19 multiply to 1.33) minutes for boys in case if they have the positive learning motivation.

It is also possible to use the other formulas for prognosticating the learning time in the same way. It is important to fix the numerical values of factors in a 2600-letter text and then, by using these formulas, we can predict with 60-70 per cent probability the learning time needed.

On the basis of the textbook these formulas enable us to predict how many lessons for example, in physics, the students of the certain age group need to master the material independently. Thus we can predict whether the textbook is really suitable for the students or not.

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MATHEMATICAL VERBAL PROBLEMS: DIFFERENCES IN SOLVING DIFFICULTIES

Madis Lepik

Introduction

A central theme of mathematical instruction is to help students to develop their problem solving skills. The role of a teacher and a designer of instructional materials is to create a learning environment in a way that optimizes the student learning process. According to K.Pfeiffer et al.(Pfeiffer K., Feinberg G.,Gelberg G., 1987), the problems of too easy as well as the problems of too difficult level do not inspire students to solve problems. Problems that are too easy are not rewarding to solve, they are just dull routine work. Problems that are too difficult do not guarantee enough success to be inspiring, and students tend to give up. Research indicates that the best results are achieved when success is likely in about 50%.

To find better ways of teaching problem solving skills one has to study the relative difficulty of problems. There is a number of studies that deal with the relationship between the problem variables and the difficulty level in mathematical verbal problems. It was assumed that the relative difficulty of problems could be determined by analyzing the construction of the wording of the problem. Most of such variables (that aid or interfere with the pupil's performance in solving verbal problems) fall into the following groups:

(1) variables describing the textual presentation of the problem - readability variables (Jerman M., Mirman S., 1974; Austin J. D., Lee M. A. B., 1982; Moyer J. C., 1984);

(2) variables describing data, calculable values and mathematical operations in the problem - computational variables (Jerman M.,Mirman S., 1974);

(3) variables describing the logical structure of the problem - logical variables (Sohhor A. M., 1974; Lepik M., 1990);
(4) variables describing the presence or absence of verbal cues that help in selecting operations (Byers V., Erlwanger S., 1985; Nesher P., Teubal E., 1975);
(5) variables describing the interest and problem solving experience of the student (Wright J. P., Wright C. D., 1986).

In my previous paper (Lepik M., 1990) the influence of 31 linguistic, computational and logical variables on algebraic verbal problem solving performance was studied. To examine the logical structure of the problems in greater detail problem graphs were used. This approach enabled to define a number of problem variables used to describe the complexity of graphs in graph theory. To study the influence of problem variables on the proportion of correct strategies and the rate of solving, correlation analysis was used. Six variables were found to be statistically significant in predicting the values of these performance variables. They were structural variables, mostly definable on the basis of the problem graph.

In the present paper we are going to study the influence of the subject's abilities on the significance of problem difficulty variables. According to O.Magne error patterns of high-achievers and low-achievers differ greatly (Magne O., 1989). V.A.Krutetskii has observed that mathematical achievement may depend on psychological features which are highly individual (Krutetskii V. A., 1976). In his contrastive comparisons he observed typical differences between the high-achiever and the low-achiever in three basic aspects:
(1) information gathering, including initial orientation to a problem;
(2) information processing in problem solving;
(3) information retention.
So, the question arises whether the role of the problem variables in building up problem difficulty is the same for students of different achievement levels.

The purpose of the present paper is to attempt to differentiate the problem variables essential in problem solving by the excellent student, the average student and the poor student.

The variables

All the mathematical problem variables defined in a previous paper (Lepik, M., 1990) were analyzed separately for the three groups of students of different achievement levels mentioned above.

The definitions of the variables are as follows.

Linguistic variables

X_1 - Space characters: The number of space characters in the problem;

X_2 - Letters: The number of letters in the problem;

X_3 - Words: The number of words in the problem;

X_4 - Number of words, figures and units in the problem;

X_5 - Mean word length: X_2 / X_3 ;

X_6 - Number of words of 6 or more letters;

X_7 - Proportion of words of 6 or more letters: X_6 / X_3 ;

X_8 - Number of sentences in the problem;

X_9 - Mean sentence length in space characters: X_1 / X_8 ;

X_{10} - Mean sentence length in words: X_3 / X_8 .

Structural variables

The structural components of algebraic verbal problems are quantities and their mathematical relations. All quantities of the problem can be divided into three groups: known, calculable and auxiliary quantities. The mathematical operations between values required to solve the problem are determined by the formulation of the problem, and expressed by the formulas used and equations composed. To examine the logical structure of the problems the graphs representing all the values and their relations in the problem, were studied (Lepik M., 1990). The problem

graphs can function as structural models of the problems. All values of the problem are denoted as nodes in the graph; all the formulas and equations are denoted as graph vertices. Graph nodes are connected with vertices by graph arcs. Each connection denotes the relation between a value and its formula or equation. All the structural variables are listed below:

X - The number of values given;
 11

X - The number of calculable values;
 12

X - The number of auxiliary values (values not given
 13

in the problem, but needed to solve it);

X - The number of values not given: X +X .;
 14 12 13

X - The whole number of values in the problem:
 15

X +X ;
 11 14

X - The number of formulas required;
 16

X - The number of equations required;
 17

X - The whole number of logical operations: X +X ;
 18 16 17

X - The whole number of structural components:
 19

X +X ;
 15 18

X - The number of relations between the values and
 20

operations;

X - The maximum number of relations per value;
 21

X - The maximum number of relations per operation;
 22

X - The average number of relations per value:
 23

X /X ;
 20 15

X - The average number of relations per operation:
 24

X /X ;
 20 18

X_{25} - The rank of the problem graph: X_{25} / X_{20} ;

X_{26} - The number of cycles (closed contours formed by arcs) in the graph.

In addition to the variables listed above, a variable integrating linguistic and structural features of the problem was used:

X_{27} - The average number of words in the problem per relation: X_{27} / X_{20} .

To determine the values of listed variables a standard solution algorithm was written for each problem tested and a problem graph was built. Most of the problems could be presented in a clear algorithm. Where two or more different algorithms could be constructed, the choice depended on how the problem was solved in the standard elementary-level textbook of mathematics.

Design

To start the study 100 verbal problems were pilot tested to determine their relative difficulty (in terms of the percentage of the correct answers). 35 problems representative for their level of difficulty were chosen. It is important to note that all the problems were similar to those presented in the standard textbooks and their solution had been drilled beforehand. The chosen problems were distributed among 6 tests of 5 or 6 problems. On the basis of the results of the pilot study the problems were arranged starting with the easiest ones in the order of growing difficulty. The typed-out tests were given to groups of students to be individually solved. The time for each task was not limited, but the whole testing session was invariably 45 minutes. All the test problems were solved by all the students in six sittings. The students were instructed to do all their work on the test sheets. To record the individual time spent on solving a problem an electrical digital timer was in good view in front of the classroom and the students were asked to write down the time when they started and finished each problem.

Subjects

Students aged 13-15 of five junior secondary schools were the subjects of this study. The 150 students were known to be of different levels in their mathematics progress.

To determine the achievement level of a student, the percentage of the correct solutions of the possible number was used. According to their scores all the students were grouped into "above average", "average" and "below average" groups. The "above average" groups included the students whose results were higher than P+0.5∂; the "average" groups was made up of students who scored in the interval from P-0.5∂ to P+0.5∂; the "below average" group embraced the students whose results were lower than P-0.5∂, where P is the mean percentage of the correct solutions and ∂ is its standard deviation.

There were 48 students the "above average" group, 34 in the "average" group and 48 in the "below average" group.

Results

Performance variables.

Two variables were used to measure performance:
(1) the average percentage of the correct answers;
(2) the average time needed.

C o r r e c t a n w e r s. A point was given for each logically correct presentation, even if the final answer was incorrect. As the test was designed to measure problem-solving skills and not computational ones, this approach seemed to be rational.

T i m e. This variable measured the time spent in solving a problem. It did not define how much of the time was actually spent on task-solving and how much on other activities such as looking around or daydreaming.

Correlation Analysis

To find out the role of problem variables in guaranteeing a performance success, the correlation analysis was used. According to the aim of the paper the analysis was carried out separately on the results of the two contrasting groups of "above average" students and of "below average" students. The results of the analysis are summarized in Table 1.

As can be seen in Table 1 the linguistic variables were insignificant in predicting performance results in both groups. The only variable to be significant was X_{27} - the average number of words per each relation ("below averages": r=0.38, "above averages": r=0.49). It is the variable of information density in the wording of the problem. That means that a careful and more detailed verbal presentation of the problem will help to get a better insight into the mathematical connections and relations of the problem. However, most of the linguistic variables proved to be significantly correlated with the other performance variable - the time spent to solve the problem. Besides the correlation was regularly higher in the group of above averages. The problem's textual readability being more significant for "above averages" seems to be an unexpected finding. Obviously, it does not measure reading difficulties, but indicates differences in the problem solving strategies in the two groups of students. "Above averages" seemed to be more skilled in and more attentive to the information in the wording of the mathematical problem. The students of above-average academic progress seem to be aware of the importance of the stage of information analysis and choice of working strategy in problem solving whereas the students of below-average progress underrate it. That is why the linguistic variables of the problem are better correlated with the time variables in the group of "above averages" and are not significantly correlated with the proportion of the correct answers. Maybe the point is that the "below averages" are more oriented to mechanical application of formulas they know and have used before than to the study of the underlying mathematical relations in the problem.

As can be seen in Table 1, the used structural variables appeared to be applicable in predicting both performance variables in both groups of students. X_{13} - the number of auxiliary quantities required in solving the problem correlated best with the proportion of correct answers (r=-0.51, r=-0.56). The best predictor of time variable was X_{12} - the number of computable quantities (r=0.75, r=0.55). The role of different logical operations (formulas, equations) manifests

Table 1

Correlation between the problem variables and the performance variables in student groups of different academic achievement.

Variables	Below average		Above average	
	Proportion of the correct answers	Time	Proportion of the correct answers	Time
1	2	3	4	5
X 1	-0.15	0.34*	0.07	0.45*
X 2	-0.14	0.33	0.05	0.43*
X 3	-0.14	0.41*	0.09	0.51*
X 4	-0.13	0.40*	0.11	0.52*
X 5	-0.09	0.13	-0.17	-0.11
X 6	-0.22	0.13	-0.07	0.18
X 7	-0.20	0.19	-0.25	0.22
X 8	-0.21	0.36*	0.05	0.46*
X 9	0.02	0.16	0.11	0.24
X 10	0.05	0.28	0.15	0.23
X 11	0.03	0.31	0.15	0.38*
X 12	0.15	0.75*	0.08	0.55*
X 13	-0.51*	-0.25	-0.56*	-0.10
X 14	-0.45*	0.22	-0.55*	0.25
X 15	-0.31	0.38	-0.29	0.46*
X 16	-0.33*	-0.29	-0.12	-0.33*
X 17	-0.24	0.41*	-0.46*	0.46*

Table 1 (cont.)

1	2	3	4	5
X_{18}	−0.47*	0.24	−0.56*	0.27
X_{19}	−0.41*	0.35*	−0.44*	0.41*
X_{20}	−0.40*	0.41*	−0.42*	0.44*
X_{21}	−0.34*	0.42*	−0.29	0.38*
X_{22}	−0.11	0.45*	−0.03	0.52*
X_{23}	−0.32	0.36*	0.17	0.36*
X_{24}	0.09	0.37*	0.17	0.45*
X_{25}	−0.31	0.42*	−0.29	0.43*
X_{26}	−0.30	0.47*	−0.30	0.44*
X_{27}	0.38*	−0.17	0.49*	−0.17

* $p<0.05$

differences between the achievement groups. In the group of "below average" students X_{16} – the number of formulas needed in the solution is significantly correlated with the proportion of the correct answers ($r=-0.33$) but X_{17} – the number of equations composed appeared insignificant ($r=-0.12$). In the group of "above average" students on the contrary, the number of applied formulas is not significant ($r=-0.24$) and the number of equations required is highly correlated with the proportion of the correct answers ($r=-0.46$). These results indicate that the "below average" group may solve the problem provided that only some known formulae are to be applied, but when it comes to making up equations then the problem proves too difficult for them. The students of below-average academic progress seem to be short of skills to synthesize and process information needed in the verbal presentation of the problem. Formula application is no problem in the advanced group and so the correlation between the number of formulas and the performance variables is low. The statistically significant negative correlation

between the number of equations in the solution and the proportion of the correct answers indicates that there are specific difficulties in information synthesizing in the "above average" group, too. But these difficulties (contrary to those in the "below average" group) can be overcome.

Summary

Difficulties experienced by many students in solving routine problems seem to be related to their failure to identify the properties of the problem. To solve the problem one must identify the relationships between the data presented and choose a good strategy of processing and utilizing them. The understanding of the underlying mathematical relationships in a problem requires skills of identification of and operation with the different forms of expression of the relationships. This is difficult for low achievers. They usually have gaps in their knowledge of mathematics. Their operation skills are also unstable. So several pupils could choose and carry out the first operation but they were unable to proceed. The task of keeping the result of the first operation in mind and using it in the next step was beyond them.

The results of the study show that students of poor academic progress are often short of information processing and strategy-choosing skills. The skill of seeing isomorphism in problems of identical mathematical structure could be observed only in good problem solvers. On the contrary low achievers were unable to apply analogy in problem solving. They took each problem as a new one requiring original solution.

The study shows that low achievers need special instruction in problem solving, in analyzing the structural properties of problems and classifying them into types of problems.

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A MORPHOLOGICAL ANALYSIS PROGRAM FOR THE ESTONIAN LANSUAGE

ERICH MIKK

The Department of Education of Tartu University has been conducting research on measuring schoolbook readability. Mathematical formulas have been used in textbook evaluation. However, counting textual markers has been time-consuming. Ways for automatic text processing are being sought. Some success has been achieved in automatic readability measurement of Russian texts (See the article of H. Kukemelk and J. Mikk in this volume) and of English books (Schuyler M.R, 1982). This is still a problem in assessing Estonian texts.

A morphological analysis program is needed to make automatic text analysis possible. Computer aided text analysis is based greatly on morphological, syntactical and semantical analysis of the text.

First, there must be a program to identify words and their grammatical form markers, in other words: a program of morphological analysis. Textbook compilers, who make textbooks for Estonian schools, need a morphological analysis program of this kind badly. English schoolbook writers find computerized word-processors of great help. Readability analysis suggests ways of reducing textual difficulty and complexity.

This paper is to acquaint the reader with a possible way to automated analysis of the morphology of Estonian texts. The article is divided into two parts: Part One is about the principles of Estonian word form generation and Part Two introduces the program.

Some characteristics of Estonian morphology

This part of the paper is based on the investigations of H.Oim and co-workers (Litvak S., Roosmaa T.,

Saluveer M. and Õim H. 1980, pp. 82-84).

Estonian is a highly inflected language. The primal form of a word goes through great changes in declination or conjugation. It is characteristic of the Estonian language that changes may affect either the word's ending or the whole stem. Word form generation rules are complicated and difficult to program. There is a collection of stems called stem lexicon. Each word has principal forms from which other forms are generated. All word forms may be generated from the corresponding stems by adding endings according to form generation rules. And the other way round, in text analysis a word is recognized by its stem and endings and its primal form can be restored. The question is now, what forms must be treated as basic in form generation and what endings and form-formation rules are there in the Estonian language.

Declinable words

It is characteristic of the Estonian language that there are 14 cases. Case endings are mostly the same for all the declinable words: (nouns, pronouns, numerals and adjectives) both in the singular and plural. The plural forms differ from the singular forms by their plural markers.
For instance, let us analyze the declination of the word 'juus' (hair) in some cases.

Table 1

Noun declination

Case	Question-word	Singular	Plural
nominative	who? what?	juus	juukse!d
possessive	whose?	juukse	juus!te
partitive	whom? what?	juust	juukse!id
illative	where to?	juukse!sse	juus!te!sse juukse!i!sse
inessive	where?	juukses	juukse!te!s juuste!s

The case endings and plural markers in the example are separated with '!' from the stem. Big changes in the primal form are well demonstrated.

The singular has no special markers. The plural markers are -d (in the nominative), -de or -te (the possessive and all the other cases derived from it). The so called i-plural has the markers -i-, -e- or -u- (in the possessive and all the other cases derived from it).

There are parallel case forms in use: in illative singular and in the plural forms from illative to ablative. The parallel plural forms are formed after the plural partitive form.

The case forms, both in the singular and in the plural, are formed from a limited number of basic cases. In Estonian the basic cases are the singular nominative, possessive, partitive and illative cases and the plural nominative, possessive and partitive cases. For each declinable word these seven case forms have to be added to the stems lexicon for the morphological analysis program. All the other word forms can be generated from the corresponding stems by adding case endings and plural markers.

There are homonymous case forms, which makes it impossible to single out the case form by morphological criteria. Syntactical and semantical information is needed, but that analysis remains outside the scope of our study. For example the word "kaevu" may be either the partitive or the illative case form. Consequently the possibilities offered by the morphological analysis are restricted.

Conjugation of verbs

There are four moods in the Estonian language: indicative, imperative, relative and conditional moods. A verb can be conjugated in the present or in the past tense, the latter having three forms: of the imperfect, present perfect and past perfect tenses. The system of the conjugation also holds forms after which all the other forms are derived.

Our morphological analysis program uses five verb forms as the basic forms: the ma- and da-infinitives, the singular form of the first person in the present tense of indicative mood, the present tense form in the impersonal mood and the first person in the imperfect. For each verb these five forms have to be formed and added to the stem lexicon for the morphological analysis program. The derivation rules of the other forms are simple.

For example the ma-infinitive is the basis for the derivation of the following verb forms: the case forms of the ma-infinitive, imperfect form with si-marker, form of the relative mood, the v-participle. The da-infinitive serves as the basic form for the infinitive, nud-participle, the moods of the imperative mood, etc.

As an example let us discuss the conjugation of the verb 'valama' (pour) in the present and past tenses in the indicative mood.

Table 2

Verb conjugation

person	tense			
	present	imperfect	present perfect	past perfect
1. ma	valaln	valalsiln	olen valanud	olin valanud
2. sa	valald	valalsild	oled valanud	olid valanud
3. ta	valalb	valals	on valanud	oli valanud
4. me	valalme	valalsilme	olelme valanud	olilme valanud
5. te	valalte	valalsilte	olelte valanud	olilte valanud
6. nad	valalvad	valalsild	on valanud	olild valanud

The verbal endings and the imperfect tense marker 'si' are separated with '|' from the stem in the example.

It is to be noted that the past perfect and the present perfect tense forms are of two words. The main purpose of our program is to recognize separate words. It does not include a procedure to search for the two words that make up the past perfect or the present perfect tense forms.

Big changes in the words by conjugation deserve special mentioning. For example the verb 'minema' (go) has the first person form in the present tense of the indicative mood as 'lähen', but the form of the imperative mood is 'mine'.

It is the same with verbs as it is with declinable

words: there are homonymous forms with a number of verbs which render the morphological computer analysis inexact.

The morphological analysis program

A usual procedure in the automatic morphological analysis of inflected languages such as Estonian, is to break words up into stems and final affixes. As shown above , such analysis can be easily accomplished in the presence of complete lists of stems and affixes and a set of combinability rules (Kaasik U., Tuldava J., 1980, p.54). We used this method in our study. The algorithm is based on works of Prof. H. Õim and his team (Litvak S., Roosmaa T., Saluveer M., Õim H., 1980).

Data structures

The morphological analysis program (further simply the program) employs two input files: a text file and a stem lexicon, and two output files: a file of identified words and a file of unidentified words. The program reads words from the text file. Then it selects morphological information for each word in the stem lexicon file which is a random access file. The information is excerpted from the stem lexicon and the two auxiliary tables for declinable and conjugational words. The tables are included in the program. The information is then entered into one of the two output files.

It is assumed that the text file is coded in the ASCII code. Big text files are broken into parts and only one part can be put into memory at a time.

The stem lexicon file consists of records, each of them has the following fields: stem, word class, digital stem word form index, primary form. The records are ordered in the alphabetical order of stems.

To illustrate the case, parts of the stem lexicon of the words 'aasta' (year) and 'jooksma' (run) are given.

Word class No. 1 consists of verbs. Word class No. 2 holds nouns. Stem word form indices are corresponding to the basic forms for declinable words and verbs.

Table 3

Excerpts from the stem lexicon

stem	word class	numbers for auxiliary tables	primary form
aasta	2	12	aasta
aastai	2	4	aasta
aastat	2	3	aasta
aastà	2	5	aasta
jooks	1	1	jooksma
jookse	1	3	jooksma
joos	1	24	jooksma

Here are examples of the auxiliary tables.

Table 4

Part of the auxiliary table for declinable words:

stem word form index	case ending	number (singular or plural)	case
1	''	1	1
2	''	1	2
2	'sse'	1	4
2	's'	1	5
4	'le'	2	7
4	'l'	2	8

All numbers in the table are codes that correspond to certain attributes. The stem word index represents the basic case form from which the corresponding forms are derived. Together with the case endings in Column 2 they provide for the formation of the required form. Column 3 provides information about the number of the word form: 1 corresponds to singular and 2 to plural. Column four indicates the case.

Table 5

Part of the auxiliary table for verbs.

stem word form index	verbal ending	number	person	tense	infinitive	affirmation	mood
1	'sin'	1	1	2	*	1	1
2	'nud'	*	*	3	5	*	*
3	'n'	1	1	1	*	1	1
1	'ma'	*	*	*	1	*	*
3	'vad'	2	6	1	*	1	1

An asterisk ('*') signifies that there is no parameter or it is impossible to determine its exact value. For instance, the example presented in the first line with the verbal ending of 'sin' cannot be functioning as an infinitive form. The example in the second line – a verbal form with the ending 'nud' may be part of the present or past perfect tense forms in which the number, person and the mood are determined by the form of the auxiliary verb.

The algorithm and the program

The unit to be analyzed is a word. The program ignores the fact that the words originally formed sentences, and the structuring of the initial text (chapters, paragraphs and sentences) is not formalized in the output.

The program determines the case and the number (singular or plural) of declinable words. It considers the number, person, tense, infinitive form, affirmation or negation and mood. The data are called from the auxiliary tables.

Let us see, how the program manages it. We assume that a word has been divided into stem and final affix and the stem is found in the stem lexicon. The lexicon gives us the following data: the word class, stem word form index and primal form. The key to read the auxiliary table consists of an index and the word's affix. The key helps the program read the corresponding data from the auxiliary tables. Keys must be drawn up with

every index from the set of the indices in the stem lexicon. One or more keys may fit the conditions. All possible outputs are to be fixed. If all keys fail, the word is to be treated as unidentified.

This is the algorithm in outline.

Every input word is entered either into the identified word file or into unidentified word file.

As an example we shall analyze a sentence.

Table 6

The results of the analysis of the sentence
'TÕdruk ja poiss läksid õle suure silla'
(A girl and a boy went over a big bridge).

primary form	word class	data from auxiliary tables	meaning of the data
tÕdruk	2	101	noun, singular, 1. case
ja	6		conjunction
poiss	2	101	noun, singular, 1. case
minema	1	122*11;232*11	verb, singular, 2. person imperfect, affirmation, indicative mood OR all the same, but the 3. person plural
õle	48		adverb or preposition
suur	7	102	adjective singular 2. case
sild	2	102	noun singular 2. case

Word form 'läksid' is the same in the singular and plural, that is why two possibilities are to be considered . All the words were identified.

Realization

The program is written in the Turbo Basic programming language under the operating system MS DOS. Hard disk or two floppy disk drives are to be used.

The stem lexicon comprises about 3500 most frequent Estonian words and holds over 10 000 stem forms. There is also a noun lexicon with frequency indices.

Conclusion

The algorithm, described above, is a possible automated way of analyzing the morphology of the natural Estonian language. The main goal is to create software to determine readability indices of schoolbooks.

The program will facilitate text analysis and assessment as well as the creation of new readability formulas. This may also be of help in compiling frequency lexicons. Our stem lexicon is small at present, but it may be enlarged with new words that will be analyzed. Naturally, all basic forms of the new words are to be added. It takes time, but when stem lexicons for different subjects have been compiled, the number of unidentifiable words in a new text will reduce rapidly.

At present our team is engaged in analyzing the physics textbook for Form 7 "Valgusõpetus" (The Theory of Light).

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COMPUTERIZED READABILITY ANALYSIS OF TEXTBOOKS OF ENGLISH*

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Estonian schools badly need new textbooks. Estonian teachers, who, for years, have had to teach their subjects by unified textbooks uniformly in use all over the Soviet Union, have become used to the very difficult and bulky textbooks. Some original Estonian textbooks have also manifested a tendency of becoming more sophisticated with every new edition. A breakthrough in these matters must be effected to improve the level of Estonian school education.

There are two ways of developing and promoting modern, interesting textbooks. Competitions for new textbooks may yield good results, provided they catch the attention of authors with fresh ideas; and a multi-aspect and objective assessment of the manuscripts can be effected. The other way is the introduction of the results of theoretical study into teaching practice. This paper will be concerned with an aspect of theoretical study aimed at improving the school textbook.

To improve the quality of textbooks they must be less sophisticated and complex, they must be readable. A textbook that will make interesting and easy reading will contribute to motivated learning, to students' self-confidence and discipline. The present study in textbook assessment has resulted in a number of positive shifts in teaching in Estonian schools. For example, a quantitative analysis of the texts in the text-

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*Authorized translation from Haridus, 1990, N6, pp 16-19.

**In the work participated also students J.Aringo, P.Kotka, A.Rästas, K.Kork.

books of German served as a good basis in re-editing the books; the authors of new study aids for the course of light in school physics were helped in their work by theoretical recommendations of simple presentation of the material and clear writing. And yet, the long-term experience in readability studies in Estonia has not led to the ousting of all the over-sophisticated textbooks from schools yet. The reason, besides the fact that only the unitary textbooks could be used, lies in the readability measurement being very time-consuming.

Now, with computers becoming more and more available, the process of readability measurement will become easier and less time-consuming. That means that it will become a regular procedure in writing textbooks for schools. When the Valgus Publishing House (Tallinn) starts using computers in textbook printing all textbooks can be analyzed for their readability level before printing.

The aim of this paper is to present some experience in computerized readability and size analysis of Estonian textbooks of English carried out by a group of researchers at Tartu University. Personal computers of IBM type were used. The languages used were GWBASIC, Turbo Pascal, dBasic and some others. We shall present the analysis of the textbooks for Forms 4, 5, 6 (Sets 1, 2 and 3 respectively).

Method

The material of the textbook for Form 4 was entered into the computer without any technical aid. The material of the textbook for Form 6 was entered by a Hewlett Packard reading machine. The reading machine has its photo lens moving along the lines of a text, the letters will be fixed and compared with the letter shapes in the machine's memory and recognized or rejected. The machine must be first adjusted to make it able to read a new kind of type. When the machine fails to recognize a symbol, the operator will supplement the machine's store of standards. The machine may err when it has to read a print of poor quality. So the disc file of the machine is to be looked through and the possible errors corrected, but it is still a very time-saving device.

All the basic and supplementary texts in the textbooks mentioned were analyzed. In this our method differs from the method in use in the USA where only

three pages of text in a textbook are analyzed. We think that analyzing only three pages of a textbook will considerably contribute to the unreliable random character of the analysis outcome. We did not analyze the assignments, vocabularies nor exercises in the textbook.

The text analysis program was drawn up after Schuyler's program (Schuyler M. R. 1982). In our program words were recognized after the blanks between them. The ratio of the number of words to the number of sentences in the text was the mean sentence length in words - an important index of text appropriateness in readability formulae. Another index in American readability formulae is the mean word length either in letters or syllables. In computerized analysis it is easy to count the letters in a text. It is a little more difficult with counting the syllables. We proceeded from the statistically proved fact that on the average an English syllable holds 3.1 letters. Words of 3 or more syllables are considered long and they will later be referred to as long words. As a rule long words are difficult to recognize and learn.

The selection of words for an elementary course in a foreign language is of utmost importance. Attention should be paid to frequent words, so that the learners could easily acquire the bulk of the vocabulary of the texts. To assess the vocabulary selection in the textbooks 3,000 most frequent English words on Dale's Word List were entered into the computer's memory. Analyzing a text, its vocabulary was listed in the alphabetical order and the frequency of occurrence for each word was indicated. Then each word was checked against the list in the memory. The number of words not listed among the 3,000 most frequent English words was found for each text and also for the whole textbook, and their respective percentage calculated. It is possible to check the vocabulary of a lesson against the vocabulary of the previous lessons and thus establish the new words of the lesson. When a word was not found in the vocabulary stored in the computer's memory, the endings -est, -ing, -ies, -ly, -er, -ed, -es and -s were dropped and the remaining word form was checked again against the computer's vocabulary. Vocabularies of the most frequent words in the textbooks were drawn up, and lists of words occurring in the textbook five or fewer times were made. Words of low occurrence will not be remembered by most students and they hamper progress in foreign language learning.

Apart from specific text readability indices all general characteristics were found for the textbooks analyzed. Formulae in wide use in the USA were applied for the purpose. We used, for instance, the simple Fog index:

RGL = 0.4 (k + j)

where RGL stands for the number of the grade for whom the text will be appropriate,

k - the percentage of words of three and more syllables in the text,

j - the mean sentence length in words.

The formulae of Flesch, Powers and Tuldava also have the sentence length and the word length as their arguments. The formula elaborated in Estonia by J. Tuldava is as follows (Tuldava J. A. 1975)

$$R = i \log j$$

where R - the readability index (but not the class number),

i - the average word length in syllables,

j - the average sentence length in words.

The formula of Dale-Chall differs in principle from the above-mentioned ones. It reads

RGL = 0.158 t + 0.0496 j + 3.64

where RGL is the number of the grade for whom the text will be appropriate,

t - the percentage of words not included in Dale's List,

j - the mean sentence length in words.

As we can see the American formulae can be used to find the grade where the analyzed textbook will be appropriate.

Results and analysis

Indices of size and readability are calculated for each lesson (Table 1), making comparison of lessons in a textbook possible. It is reasonable for texts to grow gradually in size and readability. The size and the degree of readability of a text might be complementary, i.e. longer texts might be simpler, and shorter texts more complicated. These requirements have been satisfactorily met in the textbook analyzed. There is no significant connection between the length and index of readability of a text. The latter remains stable all through the textbook.

Comparing the analyzed textbooks for their degree of readability (Table 2) one can see that the basic requirement of the appropriate grading of the material

has been observed, viz. the textbook for a senior form has higher readability index than the one for a junior form. Text readability grows gradually but the gradient is more marked between the textbooks for Form 4 and Form 5. It is considerably smaller between the textbooks for Form 5 and Form 6. Some readability indices there are practically the same. Table 2 also shows that the textbook for Form 4 would be appropriate for American Grade 3 and the textbooks for Forms 5 and 6 for Grade 4 of American schools of general education. This parallel can be drawn when judging by the mean values of sentence length and word length. Judging by the Dale-Chall readability formula the textbooks of English in Estonian schools will be appropriate for somewhat lower grades in America.

Table 1

Results of the computerized analysis of the second lesson in the textbook of English for Form 6 in Estonian schools

Characteristic	Value
Number of letters	1573
Number of words	388
Number of sentences	46
Number of syllables	505
Number of words not found in Dale's List	13
Mean word length in letters	4.05
Mean sentence length in words	8.43
Percentage of three-syllable and longer words	4.38
Grade level after Fog	5.12
Grade level after Flesch	5
Grade level after Powers	4.37
Grade level after Holmquist	4.25
Grade level after Coleman	4.53
Grade level after Dale-Chall	<4
Readability index after Tuldava	1.2

In the vocabulary analysis of the textbook we were interested in the words which could not be found in Dale's List (Table 3). As the List includes 3,000 words, it is necessary to keep the number of words remaining outside it small at the initial stage of a language course.

Table 2

Comparison of readability of different textbooks

Index	Form 4.	5.	6.
Mean word length in letters	3.7	3.9	3.9
Mean sentence length in words	5.5	8.4	8.4
Percentage of long words	2.0	2.8	3.5
Grade level after Fog	3.0	4.4	4.7
Grade level after Flesch	<4	4	4
Grade level after Powers	3.6	4.1	4.2
Grade level after Coleman	-	3.3	3.8
Grade level after Dale-Chall	<4	<4	<4
Readability index after Tuldava	0.85	1.1	1.16

The frequency vocabulary, which marks how many times a word occurs in a paragraph has been made (Table 4). The vocabulary can be put to good use in manuscript editing. For example, when a new word occurs in the text only once or twice, it is not enough for the learner to remember it. The new word must be repeated in the text 6-7 times. When there are too many unfamiliar words in the text, some of them must be replaced by familiar words. The table is also of help in deciding which words occur in the textbook for the first time and should be presented in the list of unknown words at the end of the text. For example, checking on the presentation of new words in Lesson 2 of the textbook for Form 6 it can be noted that all the eight new words presented do occur in the textbook for the first time, but the word "sun" has been left out and the word "grass" included although it occurred in the textbook for Form 5.

The vocabularies of the three textbooks analyzed were printed out (Table 5). This table can be used the same way as Table 4.

Now we should like to dwell on the indices of textbook readability (Table 6). The size of texts was the biggest in the textbook of Form 5 (11,355 words), the number of hours allotted for teaching English was the largest in Form 4 (3 hours a week). The number of new words was the largest in the textbook for Form 5 (352). The number of new words per lesson was 3 in Form 4, which is close to the optimal number. The lessons in

Table 3

The words of Lesson 2 in the textbook for Form 6, which have not been included in Dale's List

Word	The number of the sentence in which the word occurs
hiking	16, 42
bike	18, 19, 22, 23
cycling	18, 24, 42
schoolyear	31
sledging	36, 41
usually	41

Table 4

The frequency of occurrence of words in the textbook for Form 6 (Extract)

Word	Lesson							
	3.	5.	9.	10.	16.	17.	19.	22.
across							1	
always	1				4	1		
bad			1					1
bag		4		2				

the textbook for Form 5 contained more new words than the optimal number of three. Some new words occurred only in one textbook. According to our data there were 654 - 555 = 99 words of this kind in the textbook for Form 5 and 285 in the textbook for Form 6.

The repetition index for the new words in the textbook is high in the textbook for Form 4 (24), in the textbooks for Form 5 and 6 the repetition index is sufficiently high (4-6), but remembering that there are some words which occur more frequently than the average, there must be words of a low repetition index too. There are many words which occur five or less times in the textbook. The number of words of low index

Table 5

An extract of the vocabularies of the textbooks analyzed

Word	Frequency of occurrence		
	Form 4	Form 5	Form 6
a	259	248	226
about	3	36	24
across	0	1	1
alone	0	1	0

of repeated occurrence is especially large in the textbook for Form 6. It may be that the words of low repetition frequency may have occurred in the textbooks for the junior form and they may be well acquired by the students, but it is more likely that these words occur rarely in the textbooks for junior forms (see Table 5). However, the fact that one third of the vocabulary of the textbook for Form 4 is repeated less than 6 times should be considered as a shortcoming of the textbook, as these words will not be soundly acquired by most of the class. The number of words not found on the list of the most frequent words of English is not big but it accounts for 10% of the vocabulary of the textbooks. As the average repetition rate of these words is also low then they offer a good chance of reducing the degree of textbook sophistication by replacing them by words known by the class. The data presented in Table 4 will be of great help in this work.

As it is the first attempt of analyzing the degree of readability of the Estonian textbooks of English in current use, no resolute conclusions as to the appropriateness of the textbooks can be drawn. To be able to make concrete recommendations, the computerized readability indices are to be supplemented by data on the effectiveness of the textbooks at school. Comparing the three textbooks one can say that judging by the length of texts and the number of new words in them the easiest textbook is the one for Form 4 and the most difficult is the textbook for Form 5.

Table 6

Comparison of readability indices for the analyzed textbooks

No	Index	Form 4.	5.	6.
1.	Number of hours per week	3	2	2
2.	Number of words in texts (repeating words included)	7,132	11,355	8,853
3.	Number of different words in texts	302	555	636
4.	Number of different new words	302	352	267
5.	Mean repetition rate for the new words	24	7	4
6.	Average number of new words in a lesson	3	5	4
7.	Total number of different words learned by the end of the form	302	654	921
8.	Number of words repeated less than 6 times in the textbook	118	283	420
9.	Mean repetition rate for words of low occurrence	2	2	2
10.	Number of words not found on Dale's List	25	34	65
11.	Mean repetition rate for the words not present on Dale's List	5	4	4

Conclusion

For years has the Department of Estonian under V. Maanso at the Research Institute of Education studied the vocabulary of textbooks for Estonian elementary schools. Now this work will be greatly facilitated by the introduction of computers. It will be possible to find out what terms at what frequency rate are being used in textbooks, what unknown words have been included and other factors contributing to lessening textbook readability. Careful editing of textbooks after computerized vocabulary analysis will render the textbooks more readable. When the screen of the computer displays a rare international word which has been used only once in the textbook then it is to replace by some simple word in the manuscript.

Computerized automatic editing programs are in wide use in many foreign countries. They point out spelling mistakes, calculate readability indices and produce lists of rare words to be replaced. In all probability they have contributed to the high quality of textbooks. In this country we have a long way to go before we have worked out a well-adjusted system. First of all we need software for morphological analysis of Estonian texts. For that purpose an extensive vocabulary for computerized analysis is needed to spot spelling errors and calculate readability indices. The data can be put to use in improving the quality of Estonian school textbooks. A vocabulary of synonyms is needed to help the authors of textbooks in finding words to replace the rare ones in texts.

The system of textbook analysis described above will come handy in assessing new sets of textbooks for Estonian schools. The readability indices and vocabulary characteristics described above should be included in the criteria of manuscript assessment. The criteria will be a valuable tool in studying the changes that have taken place in the Estonian textbooks over years.

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Appendix

Papers on Textbook Problems in the Collections of Papers of Tartu University "Soviet Pedagogy and School" (in Russian)

	Issue	Pages
J.A.Mikk. Readability and Connections in the Text	II	5 - 72
J.A.Mikk. Readability Formulae	V	67 - 76
J.A.Tuldava. On Text Statistics	IX	5 - 33
J.R.Bormuth. Cloze Procedure	IX	65 - 67
J.A.Mikk. Ways of Setting Up Readability Formulae	IX	78 - 163
L.Loigu, J.A.Mikk. On the Use of Readability Formulae	IX	164 - 189
J.A.Mikk. The Optimal Size of the Text in Cloze Procedure	X	99 - 115
J.A.Mikk. Criteria for Optimal Difficulty in Study Texts	X	116 - 128
J.A.Mikk, A.K.Piirimägi. Text Readability and Learning Effectivity	XIII	76 - 93
T.E.Reiksaar. Readability in Textbooks of German for Estonian Schools	XIII	94 - 102
T.E.Reiksaar. Text Gradation and Readability in Textbooks of German for Estonian Secondary Schools	XIV	66 - 77
E.A.Lukas. Text Structure and Learning Effectivity	XIV	78 - 94
J.A.Mikk. Criteria for Optimal Difficulty and Readability of Study Material	XIV	95 - 110
J.A.Mikk. On Optimal Readability Criteria for Study Materials and Their Effectivity	XIV	111 - 130
K.A.Saks. On the Presentation of Teaching Aims in Instructions on Methods	XVII	6 - 19

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