

SCHOOLCHILDREN'S EXPRESSION OF ABILITIES IN THE PROCESS OF COMPLETING THE ASSIGNMENTS OF PHYSICS: A DIDACTIC ASPECT

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Abstract. Research seeks to establish comprehensive school graduates' abilities to complete drills (knowledge and comprehension) and problem solving assignments (knowledge application) on physics. In 2000 – 2003, following the indexes confirmed by the exam centre, the tasks of the national A-level exams were grouped into arduous, hard, optimal, easy and very easy. The assignments of each of the groups were classified into drills and questions to be solved. It has been discovered that none of the groups of difficulty of the assignments of physics has ever statistically approved a deviation of relative frequency. Thus, when completing drills and problem solving assignments of physics a deviation of schoolchildren's abilities is also statistically invalidated.

The assessment of tasks agreeably to resolution of an assignment indicates that more problem solving assignments than drills of physics are included into the groups of the tasks of a proper and very proper resolution. A statistically approved deviation of relative frequency of drills and problem solving assignments of physics that can be found in the groups of a proper and very proper resolution reveals that the learners whose abilities in completing problem solving assignments are more outstanding better cope with all tasks of the national A-level exams in physics.

Key words: didactic assignments, physics teaching, natural science education.

Introduction

The content, methods and objectives of teaching influence the educational process as they create an opportunity to choose between ability to impart more knowledge, to develop schoolchildren's skills or to be involved in different activities. „The Dictionary of Pedagogy“ defines knowledge as a result of reality perception that provides verbal or nominal information about objects, phenomena and their correlation (Jovaiša, 1997, p. 260). Ability, in a broad sense, is understood as physical or psychical power to perform a certain action or activity. Educology explains *ability* as a precondition and consequence of a skill. If supposed that ability is acquired after having learned something, a term „skill“ is used (Jovaiša, Vaitkevičius, 1989).

The taxonomy of cognition sees knowledge and abilities as different levels. Knowledge is the first level of cognition (Bloom, 1956). The knowledge obtained by a learner helps him/her to remember and repeat facts and rules. Ability is the second level of cognition. They comprise such psychical processes as comprehension, analysis, synthesis, evaluation. The acquired abilities help the student to grasp and interpret phenomena in any other situation (Bak, 1997; Lee, 1993; Eichinger, 1993; Peterson, 2000; Wahlquist, 2000; Bone, 200).

Along the reformation of comprehensive school that is taking place in Lithuania as well as in other East European countries (Kallen, 1997; Fullan, 2000) the objectives of teaching that define pupils' expression of knowledge and abilities have varied in the educational practice of subjects. The alteration of the educational targets has been determined by new methodological attitudes and suitable models of teaching. The instructive model of teaching that emphasized schoolchildren's knowledge was prevailing in the educational practice of subjects by the start of the reform in the Lithuanian schools (1990). Another model which is constructive becomes predominating under the circumstances of school reformation. The latter gives educational priorities to abilities to apply knowledge and to critical thinking when making a decision (ISTE, 1998; Traub, 2000; Lee, Eichinger, Anderson (1993) and others). The methodological roots of instructive and constructive teaching models differ. The instructive model of teaching is based

on the philosophy of realistic education while the constructive one – on the philosophy of pragmatism (Rusnak, 1998; ISTE, 1998; Tepperwein, 1998; Fullan, 2000; Traub, 2000). The attitudes towards constructive teaching are stressed by a new curriculum of General natural science education (2002). It finds important that learners should learn to apply gained knowledge of sciences as well as their abilities in unlike situations at school and in life.

Teaching content of different subjects, including physics, impose preconditions for developing schoolchildren's cognitive, general and communicative skills in educational practice. Lately, new textbooks on physics have been released. Other didactic means ensure the implementation of the model of constructive teaching. Moreover, the principles and methods of teaching have changed under the circumstances of school reformation. At the moment, they are reflecting the constructive model of teaching that is oriented towards pupils' abilities to apply knowledge in practice, to solve problems and to extend education. How has the alteration of teaching content and educational methods influenced the formation of students' abilities?

Research at national level (research of the sixth-formers' achievements at national level, 2002) is conducted in order to find out knowledge and abilities of Lithuanian schoolchildren. International experience has encouraged to make a decision that the research of students' achievements at national level of the year 2002–2005 should help to evaluate a general level of learners' progress in the four main fields of educational content – the Lithuanian language, mathematics, natural sciences and social science. The results of the research of the sixth-formers' achievements reveal the degree of the pupils' knowledge and abilities at all levels considering their dwelling place (city site, rural area), a position of the school (basic school, gymnasium), the sex of the learners.

Information about learners' abilities is obtained in the process of international comparative research of students' achievements (the TIMSS (1995) and the TIMSS-R (1999)). Lithuania involvement into the TIMSS (1995) and TIMSS-R (1999) examination has afforded a great opportunity to find out basic school pupils' background and natural science literacy. Schoolchildren's knowledge and abilities to apply them in practice when dealing with problem solving assignments have been evaluated within the process of investigation. According to the chosen criteria of research, the assessment of the Lithuanian children's knowledge of physics revealed that our country was among those with rare achievements in 1995. Agreeably to Lithuanian schoolchildren's abilities and knowledge of physics Lithuania was in position 37 among 41 countries that took part in the survey. A noticeable point is that the results of the survey of physics of the Lithuanian and Latvian students agreed ($\bar{\chi} = 51.3$, when $JkSe = 0.7$). In conclusion, the educologists of Latvia (Geske, 2002; Kangro, 2002) and Lithuania (Vaitkus, 1996, Motiejūnienė, Lekevičius, 1996) claim that basic school learners are not able to practically apply knowledge of natural science. Repeated research (TIMSS – R) indicated that the abilities of basic school children to employ knowledge of natural science and mathematics in practice had improved as the results of the Lithuanian learners approached world average in 1999.

International research (TIMSS and TIMSS-R) on pupils' knowledge and ability to apply its evaluated how they had completed assignments that corresponded different didactic objectives. They included drills and the tasks of a problem solving format. Drills are devoted to specify individual characteristics of concepts, to solidify the correlation between physical dimensions, to name the units of their measurement and to establish their physical meaning (Luin, Songer, 1991; Means, Blando, 1993, Oslon (1993) and others). Problem solving assignments encourage to relate acquired knowledge of sciences with obtained life experience, to predict the consequences of individual behaviour in nature, to construct hypotheses and to try to base and check them. Issue solving based on problem solving assignments imposes preconditions for schoolchildren to better adapt in an environment created by the man, to investigate it and to overcome true-to-life problems (Scarr, Eisenberg, Deater-Deckard, 1994, Popov, 2003).

International research in Lithuania has revealed detailed pupils' knowledge and abilities to use information on natural science and the tendencies of their alteration. The identification of

the state of these abilities is an urgent detail in the process of teaching various subjects. Moreover, students' abilities to implement acquired knowledge in practise at the end of their studies at comprehensive school seem to be an important purpose. *These are the criteria that have determined the problem of our research which is to find out whether comprehensive school graduates are able to finish physical assignments of a problem-based format and what is the correlation between these abilities and the abilities of performing drills.* Research object is schoolchildren's abilities to fulfil the tasks of physics of a problem-based character as well as to learn drills. *A goal of research* is to compare comprehensive school final year students' abilities to accomplish drills and problem solving assignments of physics and to discover expression relation of these abilities. *The following methods of research* are applied in order to achieve the goal: comparative assessment of literature, a quantitative analysis of the content of the accounts delivered by the national exam centre, a statistic analysis of empiric data, applying a criterion of statistic significance of a deviation of relative frequency. A statistic data analysis has been made applying the computer program of data processing SPSS 8.0.

Research methodology

Research methodology is based on the two trends of education philosophy which are a realistic trend and the one referring to pragmatic provisions. Realistic education philosophy has been chosen because it mainly consists of experience accumulated by a society and, first of all, of the conclusions of sciences that are directly transformed to schoolchildren. The content of training promoted by the ideas of realism is considered to be an objective of education while pupils' knowledge is primarily gained in the teaching process.

The ideas of a pupil's interaction with a real natural and social environment, teaching him/her to find out optimal forms of behaviour in relation with surroundings are offered as the basis of pragmatism education philosophy. Thus, the whole education must be problematic. Scrupulous attention has to be directed to mastering the method of scientific problem solving. Research takes a position that the introduced philosophy trends complement one another and see no objections.

The chosen methodological approach is not new for the investigation. In the light of contemporary tendencies of natural science education, the compatibility of realism and pragmatism is stressed by the Lithuanian (Bitinas, 1996, Motiejūnienė, Lekevičius, Vildžiūnienė, 1996), and foreign educologists (Fullan, 2000).

Research instruments

In order to establish schoolchildren's expression of different abilities and their correlation when dealing with both types of the tasks on physics, a decision to refer to the results of the national A-level exams has been made. Annually, the national Lithuania's exam centre produces statistical assessment of the A-level exams. Statistical assessment of the national A-level exams in physics of the school year 2000-2003 has been used. As examinations are taken by the students of different schools from all parts of the country, it can be maintained that a designed system of taking is similar to that used in the international IEA (*International Association of the Evaluation of Educational Achievement*) investigations, i.e. when schools and forms are randomly chosen in order to control a high level of reliability of statistical data and to make the administration of testing easier.

Statistic evaluation of every multiple choice task of physics and of separate parts of complex tasks is provided in the statistic assessment of the A-level exams in physics. A statistic account of the national A-level exams introduces complexity index of a task, assignment resolution, the correlation between an individual task and the whole system of tasks. Annually, the mentioned statistic parameters of the tasks are calculated by the exam centre on the basis of different taking (Table 1).

Table 1. The number of the school-leavers that passed a national A-level exam in physics in 2000-2003.

Year	The number of schoolchildren
2000	1285
2001	2215
2002	2905
2003	3595

Task index is established in the following way: a sum of the points scored by pupils for an individual task is divided from a sum of the points that could be theoretically scored by all the learners that have been taken an exam in case they all completed the task (Physics. Statistinė valstybinio brandos egzamino užduoties analizė, 2000 – 2003). Task complexity is expressed by percentage. Thus, the figure methodology of task complexity index chosen by the exam centre indicates that complexity index is higher if a task is easier. Consequently, the complexity index of a very easy assignment is more than 80% while that of an extremely difficult one is less than 20%. The statistic theory of tests discloses that the most effective are the tasks having an index of complexity 50%, approximately. The exam centre counts the indexes of task complexity in order to evaluate the correctness of exam assignments. Depending on the indexes of task complexity we can make decisions if the assignments of the A-level exam are suitably chosen.

Our research has decided to use the indexes of task complexity provided by the exam centre and to estimate what the indexes of complexity drills and problem solving assignments are. The expression of pupils' abilities can be evaluated in conformity with the established index of task complexity. If the index of task complexity shows it being difficult, it might be schoolchildren are not skilful enough to complete an assignment. On the contrary, if the index of task complexity defines it as easy comprehensible, a prediction can be made that learners' abilities to complete an assignment corresponding to didactic objectives are good (Bak, 1997, Scarr, Eisenber, Deater (1994)).

50% of the assignments of physics A-level exams require only knowledge and comprehension. According to the didactic objectives they are drills while the other part of tasks consists of problem solving assignments.

Research results and assessment

Agreeably to the level of difficulty statistic analysis of physics A-level exams delivered by the national exam centre divides all tasks into following groups: arduous (complexity index is up to 20%), hard (from 20% to 40%), optimal (from 40 to 60%), easy (from 60 to 80%) and very easy (complexity index is more than 80%). The assignments of these groups have been subdivided into drills (knowledge and comprehension) and problem solving assignments (table 2). The tasks of the year 2000-2003 have been classified following the produced scheme. Relative frequency of drills and problem solving assignments has been rated.

Research shows that both problem solving assignments and drills have the index of the arduous task. Thus, some assignments requiring only knowledge and understanding have been extremely complicated to schoolchildren. Chosen classification of tasks reveals that problem solving assignments appear in the group of arduous tasks every year. However, it has been noticed that a few problem solving assignments have the indexes of the very easy task. Their relative frequency varies from 0 to 0.06. These are nominal values of relative frequency of the assignments. Nevertheless, the index of the arduous and very easy task is characteristic for a very small number of drills and problem solving assignments. The appearance of the latter in the group of very easy tasks allows to presuppose that schoolchildren have obtained necessary abilities to complete problem solving assignments.

Table 2. Relative frequency of drills and problem solving assignments in the groups of different complexity level.

Year	Format of an assignment	Index of task complexity				
		Arduous	Hard	Optimal	Easy	Very easy
2000	Drills	0.04	0.15	0.12	0.10	0.06
	Problem solving	0.03	0.16	0.19	0.13	0.03
2001	Drills	0.01	0.21	0.15	0.10	0.07
	Problem solving	0.03	0.12	0.09	0.15	0.06
2002	Drills	0.02	0.10	0.22	0.15	0.05
	Problem solving	0.07	0.10	0.17	0.10	0.01
2003	Drills	0.01	0.09	0.16	0.15	0.06
	Problem solving	0.03	0.10	0.21	0.16	0.03

The biggest (0.05) deviation of drills and problem solving assignments in the group of arduous tasks during the comparative period was established in 2002. It formed because the number of problem solving assignments was higher in the group of arduous tasks that year. However, only problem solving assignments of physics were included into the group of very easy tasks the same year.

The comparison of assignment relative frequency in the different groups of task complexity indicates that the majority of them have been put into the group of optimal complexity. However, prevailing deviation of relative frequency between drills and problem solving assignments has not been found into the group of the optimal complexity format.

In order to statistically compare interdependently unlike didactic objectives that correspond to assignment relative frequency, statistical significance of a deviation of relative frequency of these tasks has been rated (Table 3).

Table 3. Statistical significance of a deviation of relative frequency of drills and problem solving assignments in the groups of different complexity.

Year	Statistical criterion of a deviation significance	Index of task complexity				
		Arduous	Hard	Optimal	Easy	Very easy
2000	t	0.91	0.91	1.25	1.02	1.02
2001	t	0.98	1.55	1.11	1.05	0.91
2002	t	1.05	0.05	1.05	1.05	1.11
2003	t	0.02	0.91	0.91	0.91	1.02

Statistical significance of a deviation of relative frequency is statistically insignificant at chosen level of reliability $\alpha = 0.05$ in all cases of comparison. The indexes of task complexity have been established depending on the points given for correctly finished assignments. Therefore, a relation between drills and problem solving assignments allows to forecast preconditions about schoolchildren's abilities to complete the assignments of a different type. If the learners' abilities to complete the assignments requiring only knowledge and comprehension

(drills) should differ from abilities to apply knowledge (problem solving assignments), the deviation should be confirmed by the one of relative frequency. First, a statistically significant deviation should be placed into the group of arduous and very easy tasks. The investigation demonstrates that in terms of complexity index, a deviation of relative frequency of drills and problem solving assignments is not statistically approved in the indicated groups (Table 3).

Research has been carried out whether drills or problem solving assignments pointed out to the schoolchildren that were the best or the worst during the exams at national level. Task resolution has been applied as a statistical parameter of assignment evaluation. Statistical assessment of the national A-level exams in physics suggested by the national exam centre shows that in accordance with their resolution, all tasks have been distributed in the following way: a) low resolution tasks (resolution is less than 20%); b) satisfactory resolution tasks (from 20 to 40%); c) high resolution tasks (from 40 to 60%); very high resolution tasks (more than 60%). A statistic theory proposes that the questions having high (from 40 to 50) and very high (more than 60) resolution the most effectively mark the best and worst candidates. The investigation has discovered that drills as well as problem solving assignments fell into the separate resolution groups (Table 4). The study has found important those groups of resolution that were the most effective at the distribution of final year pupils who got the lowest and highest marks in the exam in physics. The groups are supposed to have high and very high resolution. Annual grouping of physics tasks agreeably to their resolution discloses that a deviation of relative frequency of drills and problem solving assignments in the groups of high and very high resolution is more raised than that in the groups of low and satisfactory resolution.

As a matter of fact, individually, the number of problem solving assignments rather than drills is larger in the group of high resolution. A precondition can be accepted that the abilities to complete problem solving assignments of the schoolchildren that have achieved good and bad results differ from the abilities to build up drills.

Table 4. Relative frequency of drills and problem solving assignments of the groups with different resolution.

Year	Format of assignment	Task resolution			
		Low	Satisfactory	High	Very high
2000	Problem solving	0.07	0.12	0.36	0.07
	Drills	0.04	0.10	0.15	0.09
2001	Problem solving	0.10	0.18	0.25	0.09
	Drills	0.06	0.12	0.15	0.05
2002	Problem solving	0.08	0.10	0.31	0.08
	Drills	0.03	0.23	0.08	0.10
2003	Problem solving	0.02	0.21	0.28	0.09
	Drills	0.05	0.12	0.10	0.14

The resolution of all investigated problem solving assignments and drills is positive. The schoolchildren that have better fulfilled the whole task of an exam usually get more points than those who have not quite succeeded. On the contrary, task resolution should be negative. Increased relative frequency of problem solving assignments in the group of the tasks of high resolution indicates that all tasks of the national A-level exams in physics are accomplished by the pupils whose abilities to finish problem solving assignments are more developed.

In order to check statistic significance of a deviation of relative frequency of problem solving assignments and drills in the groups of different resolution, the indicators of statistic significance of a deviation of relative frequency have been rated (Table 5).

Table 5. Statistic significance of a deviation of drills and problem solving assignments in the groups of different resolution.

Year	Task resolution				
	Statistical criterion of a deviation significance	Low	Satisfactory	High	Very high
2000	t	0.54	0.26	2.04*	0.31
2001	t	0.60	0.69	1.55	2.35*
2002	t	0.76	1.27	2.11*	0.24
2003	t	0.67	0.99	2.22	0.65

Statistically significant deviations at certain level of importance ($\alpha = 0.05$) between the drills and problem solving assignments have been established in the groups of the tasks of high and very high resolution. A deviation of relative frequency in the group of high resolution between problem solving assignments and drills is statistically insignificant and was obtained in the assessment of the used physics tasks in the exam at national level in 2001. However, the same year, it was found as statistically significant in the group of very high resolution.

Conclusions

Educational practice of all subjects, including physics, constantly faces a problem of training quality. The evaluation of teaching quality raises a question whether an increased schoolchildren's sophistication or acquired utilitarian abilities are more important to society? A trivial proposition that both are relevant cannot be accepted. An optimal decision must obtain synthesis conformation, i.e. one of the antithesis acts as basis while the other one is included into the structure of the former. This synthesis has been stressed in the methodology of research.

Traditional foreign educational practice suggests priorities given to practical schoolchildren's activities that highlight and develop their needs as theoretic background depends on them. The changes of methodological approaches of educational practice gradually admit learners' abilities to apply knowledge in practice in Lithuania. Gained knowledge and acquired abilities of physics of the graduates of comprehensive school are approved by the results of the national A-level exams in physics.

The statistic parameters (task complexity and resolution) of the assessment of the tasks of the national A-level exams in physics in Lithuania have revealed that both problem solving assignments and drills have the index of the arduous task. The selected classification of the tasks confirms that annually, drills exist in the groups of arduous and hard tasks.

Problem solving assignments are periodically included into the group of very easy tasks. A deviation of relative frequency of drills and problem solving assignments has never statistically been confirmed in any of complexity groups of the physics assignments.

The complexity indexes of physics assignments have been established agreeably to the number of points got by the pupils for accomplishing individual tasks of physics. Therefore, the indexes of task complexity help with a decision on the expression of personal students' abilities. Hence, a deviation of pupils' abilities to succeed in drills and problem solving assignments of physics has not statistically approved.

Considering task resolution, the analysis of drills and problem solving assignments has disclosed that more problem solving assignments (knowledge application) rather than drills (knowledge and comprehension) have been included into the groups of the tasks with high and very high resolution. A statistically confirmed deviation of relative frequency of problem solving assignments and drills contained in the groups of high resolution demonstrates that all national

A-level exam tasks of physics are better performed by the learners whose abilities to complete problem solving assignments are more developed.

In conclusion, the results of research state that schoolchildren's abilities to deal with drills and problem solving assignments when passing a national A-level exam in physics are of equal value in Lithuania. Nevertheless, the differences of ability expression are more poorly uncovered in the groups of the students that have better passed physics exams. The abilities to complete problem solving assignments are developed on the basis of drills. Thus, physics educational practice should not make a didactic objective as well as a methodological approach (realism or pragmatism) as an absolute unit. Educational practice should comprise both models of teaching constructive and instructive. It should also offer drills and problem solving assignments that undertook different didactic goals.

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Резюме

ЗНАЧИМОСТЬ СПОСОБНОСТЕЙ УЧАЩИХСЯ ПРИ ВЫПОЛНЕНИИ ФИЗИЧЕСКИХ ЗАДАНИЙ: ДИДАКТИЧЕСКИЙ АСПЕКТ

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Исследованием установлены способности учащихся, которые заканчивают среднюю школу, выполнять тренировочные (знания и понимания) и проблемные (применение знаний) задания по физике. Задания по физике во время сдачи государственного экзамена на зрелость в 2000-2003 годах, ссылаясь на индексы сложности, установленных экзаменационным центром, были распределены на группы: очень сложная, сложная, оптимальной сложности, лёгкая и очень лёгкая. Задания групп разной сложности были дополнительно распределены на две подгруппы: тренировочные и проблемные.

Установлено, что ни в одном году, ни в одной группе сложности (тренировочных и проблемных) заданий по физике среднестатистическая разница неподтверждена. Это значит, что разница в способностях учащихся при выполнении тренировочных и проблемных заданий по физике также неподтверждена статистически.

Проанализировав задания по их разрешающей способности утановлено, что в группы с хорошей и очень хорошей разрешающей способностью попало больше проблемных, а не тренировочных заданий. Статистически подтверждено, что сдавая государственный экзамен по физике, все задания выполняют те учащиеся, у которых лучшие способности к выполнению проблемных заданий.

Ключевые слова: дидактические задания, учение физики, естественнонаучное образование.

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