SECONDARY SCHOOL STUDENTS AND PHYSICS TASKS

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Abstract

The aim of this paper is to discuss the non-ttractivity of the solving of quantitative examples in Physics. The problem was find out not only in teaching and learning Physics at secondary and high schools, but also during various competitions (Physical Olympiad, Physical Kaleidoskope, Fermi Questions tournament). The discussion in this paper will be based on the research that was done in 2009. More than 335 respondents completed our questionnaire about examples. The questions inquired about reasons why students solve examples, if they understand the settings or if they will prefer an animation (video) of the situation and the problem of the classification rating. The statistical evaluation was realized by using the chi quadrate test. The results of this research will be used in our next activity – we will prepare a set of interactive physical examples to make use of the motivation effect of multimedia and ICT technology in Physics education.
Key words: *physics tasks, research, questionnaire.*

Introduction

Evidently only a few people deny, that physics is one of the most important disciplines for the development of modern civilization. Computers, cars, power plants and many other devices could not be constructed without the knowledge of physical laws. Solving physics tasks is an integral part of practically every physics lesson. Physics tasks play an integral role in teaching physics and the ability to solve physics tasks reflects on the student's knowledge of physics and mathematics.

According to the results of the international research PISA 2003 Czech students achieved above-average results in science problem solving tasks. Problem solving tasks in PISA are understood as the ability of individuals to use cognitive processes to solve real-curricular situations in which there is no immediately obvious the way of task solving that fall outside the field of mathematics, science or reading regarding content or type of literacy (Palečková & Tomášek, 2005). Despite of the fact that Czech students have achieved above average results in the problematical solving tasks, science subjects belong to the least popular subjects. Based on the results of the project MedVěd 2007 for Czech students are the least popular subjects physics followed by chemistry and mathematics. (http://www.projektmedved.eu/vysledky.htm).

In accordance with the results of the international research TIMMS 1995 and 2007 the unpopularity of science subjects is still growing. For example, in 1995, 14% of interviewed Czech students rejected physics. In 2007 27% of Czech students rejected physics. A similar tendency can be seen is also in other science subjects such as mathematics, in 1995 14% of students rejected mathematics, and chemistry - 17% of Czech students rejected it. In 2007 rejected mathematics 26% and chemistry 22% of Czech students (Martin, 1997, Tomášek, 2008). The problem of low popularity of physics among the Czech students was studied within the framework of the research "Perception of importance of physics and mathematics at secondary school students"(Poschl, 2005). This study indicates how students perceive physics and how they define physics. According to this study physics is for students: remote, boring, old, ugly, complex, slightly dull, useful and active. According to the same study for students physics is connected with the concepts of mathematics, theory, formula, school and duty.

According to the results of the research project NPVII Nr. 2E06020 carried out by the Faculty of Mathematics and Physics at the Charles University, Prague, the solving of physics tasks together with the deduction of physics relationships is the least liked activity during physics classes. (http://kdf.mff.cuni.cz/vyzkum/NPVII/zpravy.php).

Recent studies had shown (Akatugba, 1999) that students have difficulties with translating physics tasks into mathematical statements, symbols and relations. Mathematical reasoning is essentials for students´ success in high school science courses (Akatugba, 1995). But not only mathematical difficulties are problems in solving physics tasks. Multiple research techniques, for example observations, interview, questionnaires were used to study students concerns, meanings and construction of problem solving in physics. Akatugha, 1999 read that students could not perform mathematical operations that were not directly obvious from the physics tasks. Beland and Mislevy (1996) studied learners´ problemsolving behavior in terms of concepts and schemas. The major impact on the ways students interpret and solve their problems has their everyday meaningful context of the physics problem. Very important according to the constructivist view of learning is the active role of the learner in acquiring knowledge (Holubová, 2008).

These factors imply that the issue of physics tasks cannot be treated lightly and that it is necessary to seriously consider and investigate the causes of the current situation. It is simply not possible to exclude physics tasks from physics classes nor is it possible to update them in such a way that they satisfy the current needs of students. In order to be able to carry out a more in-depth investigation of the problem of the low popularity of physics tasks, it is necessary to conduct an analysis of the entire situation and to identify exactly what it is that students don't like about solving physics tasks and conversely to identify the types of tasks that they do like, which tasks are preferred by boys and which tasks are preferred by girls. Although there are not any statistically significant differences between boys and girls in science literacy according to the results of the international researches PISA 2000, 2003 and 2006. The results of boys and girls are in the European average (Straková 2002, Palečková & Tomášek, 2005, Palečková, 2007). To date only very few studies into the issue of physics tasks have been carried out, which may also be the reason why the form of physics tasks hasn‘t changed in decades and why they clearly fail to meet the current needs of Czech students. Following text contains a description, procedure and results of a pilot study investigating the issue of physics tasks.

The fundamental question of our research was: What relationship do secondary school students have to physics tasks? The generally formulated objective of the research was in practice divided into several specific questions. They helped to divide the problem into smaller sections that could be processed more easily. The research want to therefore bring empirical evidence to the following questions: What is the general relationship of secondary school students to physics tasks? What level of ability do students have in finding information for solving tasks? To what degree do students understand the examples presented in textbooks and collections of tasks?

Methodology of Research

Preparation of research

A quantitative approach to the research defined in this manner was chosen in order to collect information from the widest possible sample of respondents from various locations in the Czech Republic. The quantitative approach offers a set of specific research procedures. Due to the nature of the topics and the research requirements, a questionnaire methodology was chosen (Chráska, 2008).

Creation of questionnaire

The questionnaire for this research has been created in accordance with procedures presented in a range of methodological textbooks. During the initial creation of the questionnaire entries a total of 21 closed entries were created, with each entry having three prepared answers. The preparation of answers to individual entries is the most important phase in the preparation of the entire research because individual answers must respect the rules for the questionnaire structure and at the same time offer the respondents full opportunity to express their opinions and attitudes. The answers to individual entries were therefore created on the basis of an interview with about 30 secondary school students. Individual answers, therefore, respect their opinions and attitudes.

Verification of questionnaire

After verifying that all the rules for the creation of a quality questionnaire were adhered to during the creation of the questionnaire, a group of 28 first year secondary school students in the age composition of 15–16 years and the demographic composition of 16 boys and 12 girls was selected. The verification of the questionnaire focused primarily on the identification of the following facts: unambiguity, comprehensibility, non-suggestion, correct ordering of individual entries, comprehensibility of instructions for filling in the questionnaire and the willingness of the respondents to cooperate. The result of the verification was that one entry of the questionnaire was incomprehensible for the students and was therefore removed from further testing. Overall the testing was successful and the questionnaire was approved as an appropriate tool for the execution of the research. The questionnaire was authorised for the research with a total of 20 closed entries.

Selection of participants

The next phase of the research comprised of identifying secondary schools appropriate for the execution of the research. Several requirements were set for the selection of an appropriate school: age composition of the students is from 15 to 18 years of age, students must have at least three hours of physics lessons per week, physics must be a part of the curriculum in all years of study, students must have the option of taking a school leaving examination from physics at the end of their studies. Requirements set up in this way conformed best to the research objective. The final significant aspect for the execution of the research was to gain approval of the school principal for the execution of the research.

Participants in research

On the basis of all the mentioned requirements and conditions two secondary schools were selected as appropriate for the execution of the research (grammar schools in Uherský Brod and Vysoké Mýto). Students from the Grammar school in Uherský Brod were chosen in the age of 15 to 18 who study 1st, 2nd and 3rd year class. Students from the grammar school in Vysoké Mýto were chosen in the age of 15 to 17 who study 1st and 2nd year class.

Implementation of research

The research was realized from February 2009, to April 2009. In the subsequent analysis and sorting of the filled out questionnaires the following facts were identified. The total number of received questionnaires was 339. From this number of questionnaires 4 were without the gender of the respondent being marked or not all the entries of the questionnaire were marked. These questionnaires were excluded from further analysis. The total number of questionnaires for analysis was 335. Table 1 and table 2 show the number of research participants from the Grammar schools in Uherský Brod and Vysoké Mýto

Table 1. The numbers of participating respondents in the individual years of the Uherský Brod Grammar School.

Year of study	I.	II.	III.	Total no. of students
Boys	41	12	37	90
Girls	68	13	63	144

Table 2. The numbers of participating respondents in the individual years of the Vysoké Mýto Grammar School.

Year of study	I.	II.	III.	Total no. of students
Boys	17	15	0	32
Girls	33	36	0	69

Analysis of questionnaire

The analysis of questionnaires took place in several stages in the manner which is customary for the analysis of nominal data. In the first phase there were prepared contingency tables with the observed and expected frequency responses of boys and girls. From the number of rows and columns of the tables were determined degrees of freedom according to the formula $f = (r – 1).(s – 1)$, r is the number of rows and s is the number of columns of the contingency tables. For the purposes of this research were developed contingency tables with 2 degrees of freedom.

The second phase of the research focuses on the formulation of alternative and zero hypotheses and verifies their validity using a test of goodness of fit chi-square. This test allows you to determine whether there are statistically significant differences between the views of boys and girls. A part of the test of goodness of fit chi-square (χ^2) is determination of the level of significance. For the purposes of this research was chosen level of significance 0, 01. The level of significance is expectation that we incorrectly refuse the null hypothesis which means that between the views of girls and boys are not statistically significant differences. For the level of significance 0, 01 and 2nd degrees of freedom can be found in the statistical tables critical value $\chi^2 = 9{,}210$ (Chráska, 2008). If the value χ^2 is higher than the critical one, it is not possible to reject the null hypothesis. For the calculation of χ^2 here was identified relationship $c^2 = \sum \frac{(P-O)^2}{O}$ where P is the observed frequency and O is the expected frequency.

In the third stage of the analysis of questionnaires there was created a sign pattern that allows interpreting the results contained in a PivotTable using the interpretative statements. For the construction of the sign scheme is usually used test criteria z (z-score). To calculate the test criteria z was identified relationship $z = \frac{P_{\%} - O_{\%}}{\sqrt{O_{\%}(100 - O_{\%})}}\sqrt{n}$, where n is the total frequency in the contingency table.

Determine reliability and accuracy

To determine the reliability and accuracy of the collected data a reliability measurement of the questionnaire was carried out. To assess the reliability of questionnaire results the social science literature recommends several models (Chráska, 2008). As the best model for measuring

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questionnaire reliability appears to be the measurement of reliability using Cohen's kappa coefficient. Using Cohen's capacity coefficient can be detected reliability of measurement in the terms of knowledge of certain field, not statistics. The practical importance of Cohen's proposal is that the differences are standardized by standard deviation. Cohen determined for his effect size index (ES) following conventional values: ES> 0.8 = large; ES 0.5 to 0.8 = middle; ES <0.5 = low. One of the main advantages of the coefficient is that it does not depend on the sample size *n*.

When compared with other models, this model has the advantage in that it does not require repeated measurement nor distributing another questionnaire, because it is based purely on the data collected during a single questionnaire survey. Category observation techniques mostly require that the value of Cohen's kappa coefficient is at least 0.8. This criterion is appropriate also in the case of this research. Table 3 shows the values of the Cohen's kappa coefficient for the individual entries of the questionnaire.

Table 3. The values of the Cohen's kappa coefficient for the individual entries of the questionnaire.

Entry number	1	2	3	4	5	6	7	8	9	10
Cohen's kappa coefficient	0.86	0.82	0.93	0.96	0.97	0.91	0.84	**0.68**	0.95	0.83

Entry number	11	12	13	14	15	16	17	18	19	20
Cohen's kappa coefficient	**0.75**	0.93	0.93	0.86	0.83	0.91	0.98	0.86	0.87	0.81

For entry numbers 8 and 11 the Cohen's kappa coefficient is only 0.68 for entry number 8 and 0.75 for entry number 11. Due to the low reliability and accuracy the entries 8 and 11 were excluded from further analysis. In the following part of the text the most important and interesting results are presented. The test of significance of the entire research was carried out at a level of significance 0.01

Results of Research

The questionnare see Appendix 1. The views of boys and girls see Appendix 2.

In analyzing the research results there were detected statistically significant differences in the responses of boys and girls in areas that should have discovered the following factors:

- What attracts students to the physical tasks?
- What type of physical tasks students like the most?
- Why students solve physical tasks?

What attracts students to the physical tasks (questionnaire Nr. 2)

In this field of the research, students commented on the question: What makes physical tasks attractive to you?

a) You are interested in the solution to the example
b) The tasks present you with interesting information
c) Nothing

The examination of this area shows a figure number 1.

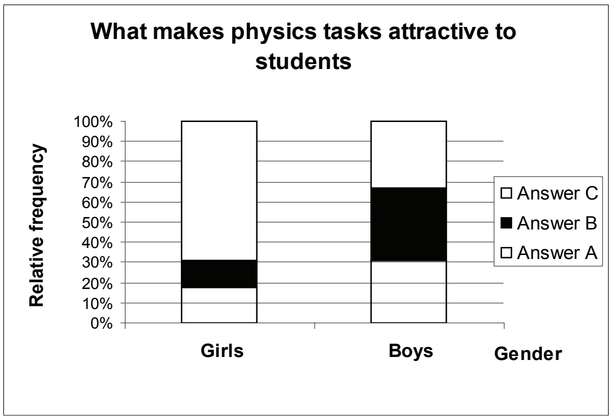

Figure 1. What attracts students to the physical tasks.

The figure shows that more than 69% of girls agreed with a statement that the physical tasks are not attractive at all. On the contrary, from the total number of boys agreed 32% of them with this statement. With the statement that physical tasks provides interesting agrees 36% of boys. With the same statement agrees only 13% of girls. The rest of the boys and girls claim that they are interested in solving physical problems.

What kind of physical tasks students like the most?

In this field of research, students commented on the question: What type of physical tasks do you like solving the most?

a) Problem
b) General
c) None

Figure Nr. 2 shows the results of this examination.

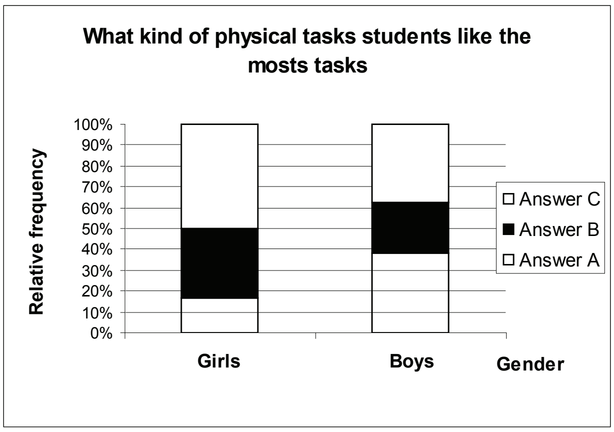

Figure 2. What kind of physical tasks students like the most.

The figure shows that 49% of girls agree with the statement that they do not like to solve physical tasks. With the same statement agree 37% of boys. On the contrary, 38% of boys agree with the statement that they like the most solving problematic physical tasks. With the same statement agrees only 16% of girls. The rest of the boys and girls agree with the statement that they like the most solving general physical tasks.

Why students solve physical tasks

In this field of research, students commented on the issue: You solve physical tasks, because?

a) You are interested in the solution or the result
b) You must
c) You never solve them

Figure number 3 shows the results of this examination.

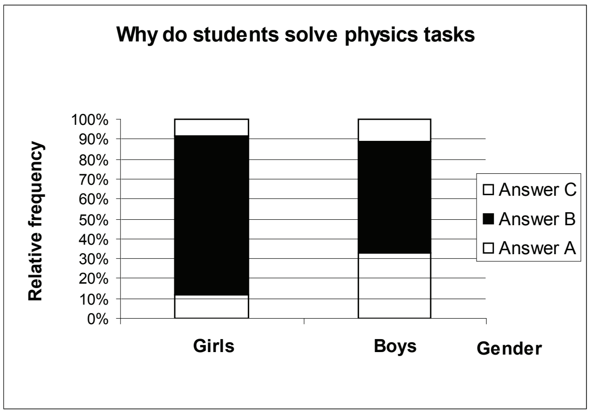

Figure 3. Why students solve physical tasks.

The figure shows that 79% of girls agrees with the statement that they do physical tasks only when they have to. With the same statement agrees also 55% of boys. Only 12% of girls agrees with the statement that they do physical tasks if they are interested in solution and outcome. With the same statement agrees 32% of boys. The rest of the boys and girls agree with the statement that they never do physical tasks.

The findings of statistically significant differences between girls and boys in the above areas can be supported by the research (Hofer, 2005). In this research was stated that there is statistically significant difference in relation of girls and boys to physical theory and practical applications of physics in favor of boys and statistically significant difference in doing homework in favor of girls. The claim that boys are better for physical theory and physical applications supports the result that boys have physical exercises in vogue more than girls and they also like physical tasks better than girls. On the contrary argument that girls prepare more for school than boys supports result that girls solve physical tasks only when they have to more often than boys.

In other examined areas statistically significant differences in opinions of boys and girls were not found. The views of boys and girls are shown in figures number 4 and 5

Conclusion

The results of the research provide an answer to the question: What relationship do boys and girls have to physics tasks? From the results it is clear that the opinions are mostly the same, but in two results a significant statistical difference was recorded between the opinions of boys and girls. This related to the entries inquiring:

- What makes physics tasks attractive to students?
- Why do students solve physics tasks?

The statistically significant differences in the above mentioned entries give rise to the question: Why are there statistically significant differences in the opinions of boys and girls specifically for these entries?

The following text offers one possible explanation.

Physics is a field that requires a specific type of thinking and a focus more on the technical and theoretical. Therefore it is important for every physicist to have an overview of not only physics but also of chemistry, biology, technology, geography and simply all sciences related to the study of our planet. That is because physics is a science that describes things and events taking place around us. The physics teacher is not always able to explain a physics task in such a way that students understand it, but also isn't able to create a quality visualisation of the situation being solved. Therefore it would maybe make sense to create such physical tasks consisting partly of animations or videos, which is confirmed by the results of the research. The focus of the physics tasks should be focused on the abilities useful for life and on principles of how things around us function.

An unqualified and unproven intervention into the difficulty, amount and structure of physics tasks could manifest itself in the future in, for example, a declining success of university students in physics related subjects. The research is therefore not solely focused on the question "What is the relationship of students to physics tasks?" but presumes that it is not possible to investigate the relationship of students to physics tasks without an investigation of the context affecting the students' relationship to physics tasks. According to the results of this research we will struggle to find an acceptable form of physics tasks (examples) using multimedia and interdisciplinary relations.

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Appendix 1. Wording of the questionnaire entry for the students:

1. **For what reason do you not calculate the physics task?**
   a) You are not getting the correct answer
   b) The formulation is too complex
   c) You never solve physics tasks

2. **What makes physics tasks attractive to you?**
   a) You are interested in the solution to the example
   b) The tasks present you with interesting information
   c) Nothing

3. **Would students be interested in physics tasks located on the internet containing animations, hints and a final assessment of their work?**
   a) Yes
   b) I don't know
   c) No

4. **What type of physics tasks do you like solving the most?**
   d) Problem
   e) General
   f) None

5. **Formulation of physics tasks in textbooks:**
   a) You understand most formulations of physics tasks
   b) You understand some formulations of physics tasks
   c) You don't understand most formulations of physics tasks

6. **If you initially do not understand the physics task:**
   a) You attempt to understand the physics task no matter what
   b) You attempt to understand the physics task only for a while
   c) If you do not immediately understand the physics task, you do not solve it

7. **Do you find the pictures that are a part of the formulation?**
   a) Always clear
   b) Only some are clear
   c) They are mostly non-clear

8. **As a part of the formulation you appreciate:**
   a) A video or animation
   b) Pictures
   c) A text formulation is sufficient

9. **If you are not having success calculating a physics task it is usually because:**
   a) You misunderstand the situation that is being solved
   b) You don't know how to visualise the situation being solved
   c) You don't have sufficient knowledge

10. **You solve physics tasks, because:**
   d) You are interested in the solution or the result
   e) You have to
   f) You never solve them

Appendix 2.

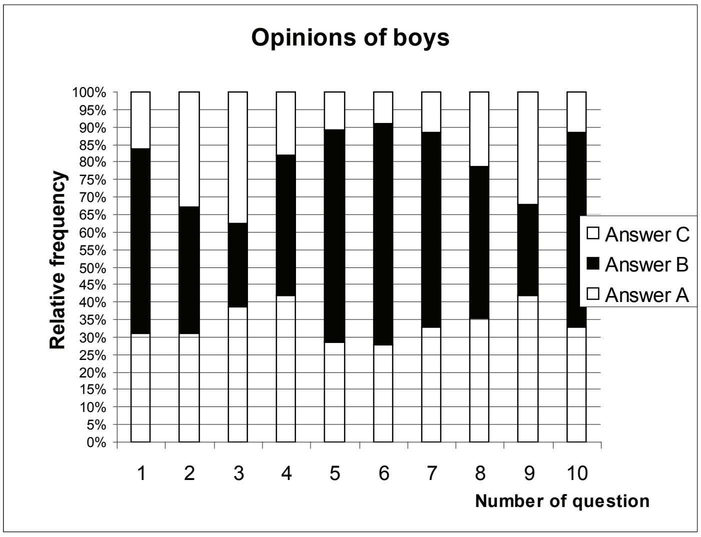

Figure 4. Opinions of boys.

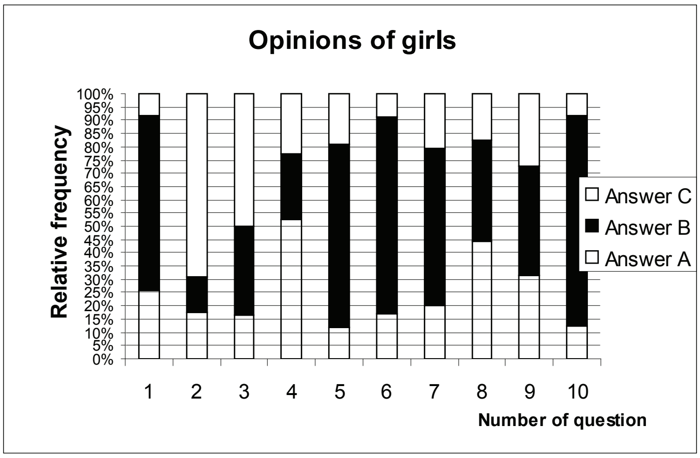

Figure 5. Opinions of girls.

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