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Students' Difficulties in Solving Physics Problems

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Abstract. Students often contend with many difficulties during solving physics tasks at high school. To mitigate the problem, it is important to determine the cause of these difficulties. To accomplish this, questionnaires for high school students were prepared. The goals of the survey were to find out strategies that students use in problem solving and to discover any methods and steps that help students to solve the tasks correctly. Results of the research are summarized in the contribution.

Introduction

Students at high schools often struggle with many difficulties during solving quantitative physics tasks. What is the main cause of these obstacles? Do students use suitable methods and strategies for solving physics tasks? Do students know what methods or strategies should be used? These and other questions led to a realization of the presented questionnaire survey. This research had a qualitative character.

The main goal of the presented questionnaire survey was to find out students' views of solving physics tasks. The questionnaire also analyzed what steps and methods high school students claim they use in solving physics tasks and if there are any proven steps that help students to solve the tasks correctly.

The survey is a part of more extensive qualitative research concerned with the problem solving in physics education and it follows the literature search presented in *Snetinova* [2011]. The research will continue with developing of detailed methodological materials for high school teachers.

Description of the questionnaire survey

The survey contains two questionnaires for students (marked Q01 and Q02) and was inspired by the research described in *Ogilvie* [2009]. The first questionnaire consisted of five open format questions and one rating scale question about strategies that students use during problem solving in physics. The second questionnaire included only five open format questions. The list of all open format questions is shown in Table 1. Some questions were the same in both questionnaires.

The main difference between the questionnaires was in the format of questions concerning strategies that students use during solving physics tasks. In the questionnaire Q01, this question was designed as the rating scale question with nine preselected students' strategies. The question with the

Table 1. List of open format questions from the questionnaire survey.

Questionnaire Q01	Questionnaire Q02
What is your biggest problem during problem solving in physics?	Do you have any proven steps you use during problem solving in physics? What methods do you use if you don't know how to solve the problem at first sight?
Is there anything that helps you with solving physics tasks?	What mistakes do you have to watch for?
What is – according to you – the purpose of solving physics tasks?	What is – according to you – the purpose of solving physics tasks?
Do you think that you can use these approaches even in other situations? In which ones?	Do you think that you can use these approaches even in other situations? In which ones?
Which steps were recommended or shown to you to help you solve physics problems?	Which steps were recommended or shown to you to help you solve physics problems?

Table 2. Rating scale question; questionnaire Q01.

Question:	How often do you use strategies mentioned below?
Possibilities:	often – sometimes – rarely – never
Strategies	**Description used in the questionnaire**
Rolodex equation matching	"I try to select an equation largely because the equation has the same variables as the list of knowns and unknowns."
Rational thought	"First I solve the task in my mind and then I do arithmetic."
Listing known and unknown quantities	"After reading the assignment I make a list of known and unknown quantities."
Prior examples in text or lecture	"I try to find similar task (in textbook, notes or elsewhere)."
Prior experiments in lecture	"I try to remember if we did some experiment similar to the task in lecture."
Sub-problems	"I try to solve the task step by step and divide it into smaller sub-problems."
Diagram	"I try to draw some diagram (sketch, chart ...) to every task."
Concept first	"First I think about the ideas and physics concepts involved in the problem."
Real situation	"I try to imagine the problem in the real situation."

Table 3. Categories used to sort student reflections.

Limiting strategies	**Expansive strategies**
Rolodex equation matching	Rational thought
Listing known and unknown quantities	Sub-problems
Prior examples in text or lecture	Diagram
Prior experiments in lecture	Concept first
	Real situation

explanation of the strategies is described below in Table 2. The main goal of this question was to find out strategies that students use in problem solving in physics.

The strategies mentioned in Table 2 can be divided into two categories used to sort student reflection. The categories are *limiting strategies* and *expansive strategies*. The division is shown in Table 3. Limiting strategies are strategies that "may work well for well-structured, end-of-chapter exercises, but they begin to fail as the problems become more complex." The expansive strategies "can be readily applied to more ill-structured challenges, and these strategies have also been identified as characteristic of expert problem-solving approaches." This division and description are adopted from *Ogilvie* [2009].

Both questionnaires were answered by 772 students from 8 Czech high schools. The students were from all four grades of high school, when the physics is taught. The questionnaire Q01 was completed by 408 respondents and the questionnaire Q02 by 364 respondents.

Main results of the research

One of the main goals of the questionnaire survey was to determine which strategies and methods students indicate that they use in solving physics problems. It is evident from the Figure 1 that 85 % of respondents often make a list of knowns and unknowns. This is a relatively unsurprising result, because students are taught since primary school to write this list just below the assignment. Other noticeable result is using the Rolodex equation matching. 55 % of students use this limiting strategy in solving physics tasks often. For many students it can be the easiest way how to obtain a result, but it is totally unsuitable for improvement of their problem solving skills and understanding the physics concepts. *Buffler and Allie* [1993] claim that use of this strategy can be caused by "the instructor may mention what principles or concepts are being applied, but generally only writes down the associated equations" approach when illustrating physics concepts by solving particular problems.

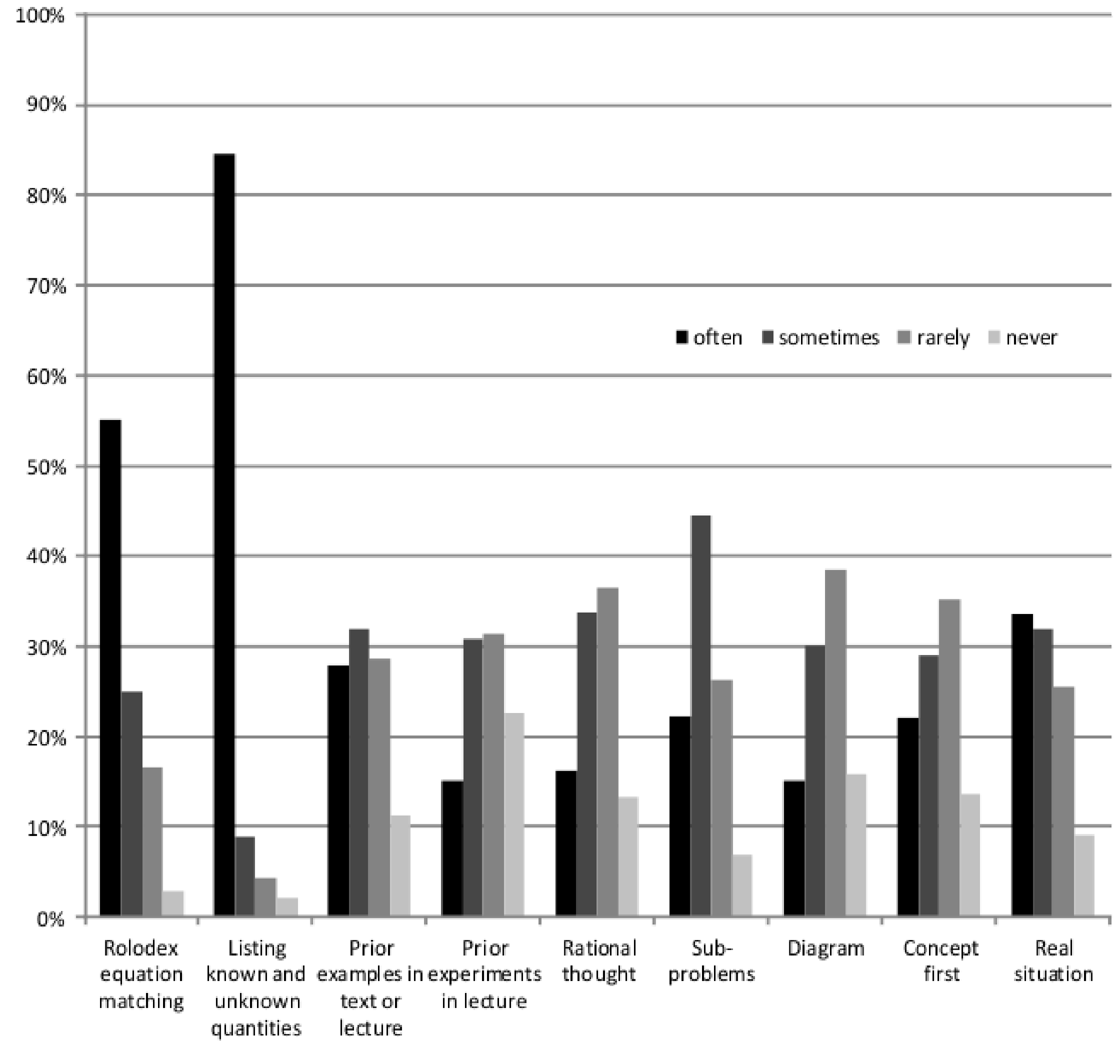

Figure 1. Answers to the question: "How often do you use strategies mentioned below?" (Questionnaire Q01, 408 respondents).

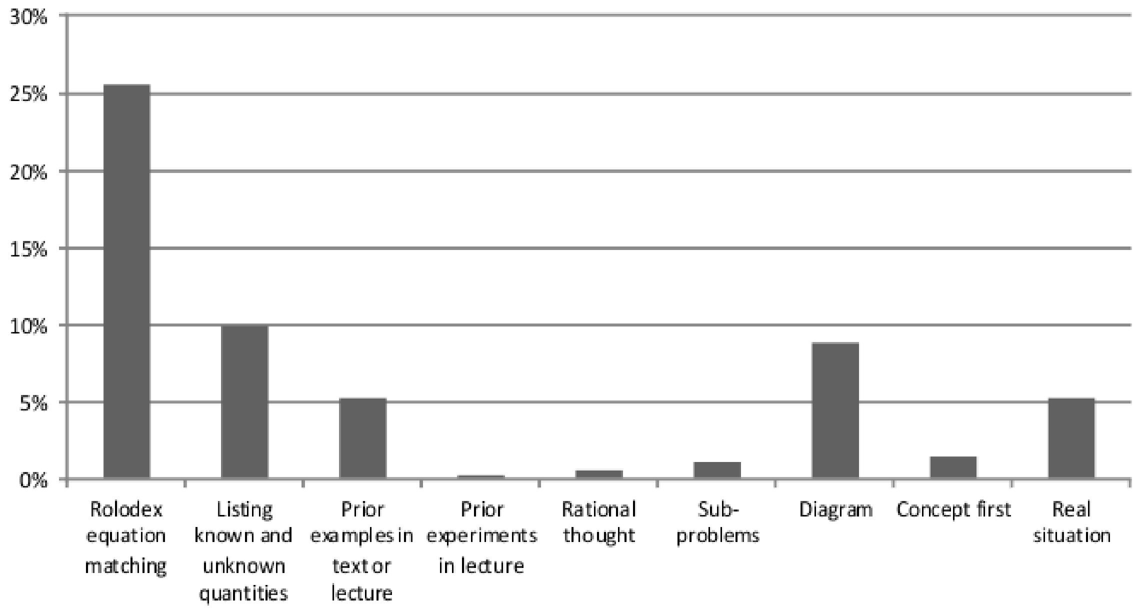

Figure 2. Frequencies of students' answers in questionnaire Q02 – only the answers analogous to questionnaire Q01 were considered. (Questionnaire Q02, 364 respondents).

On closer examination of the expansive strategies it is evident that more than one third of respondents, exactly 35 %, only rarely think about physics concept while solving problems. 14 % of students even say that they never use this method. 38 % of respondents stated only rarely drawing diagrams. Use of these two mentioned strategies differs between beginners (students) and experts [*e.g., Leonard et al.*, 1996; *Van Heuvelen*, 1991]. *Harper* [2006] stated a really good reflection why students often skip the qualitative steps in solving physics tasks: "One reason for students' reluctance is their unawareness of the valuable information contained in these qualitative representations. Students need to be explicitly and repeatedly reminded of the connections between the different representations (for instance, how a good free-body diagram leads to the correct equation for Newton's second law)."

The results concerning students' strategies from the second questionnaire (Figure 2) are different in several aspects. It is likely caused by the open format question, because most of the students wrote only the first strategy that occurs to them. It is important to note that the character of the survey was qualitative and therefore every single answer in the questionnaires could be important. Students often stated only one strategy they use and some of the nine chosen strategies need not to be considered as a problem solving strategy or method. But even in this questionnaire it is confirmed that students often use the Rolodex equation matching strategy (26 % of respondents). More answers to the question concerning students' strategies are stated in Table 4.

Table 4. Other frequently mentioned methods and strategies, (questionnaire Q02, 364 respondents).

Strategies	Percentage representation
Thinking about the problem	8.0 %
Cooperation	7.7 %
Reread the assignment several times	6.9 %
Trying to combine "everything with everything"	6.3 %
Postponement of the task for later	5.8 %

Conclusion

The aim of the described questionnaire survey was to uncover the big picture about solving physics tasks at Czech high schools. This survey is however only a part of a larger research concerned with solving quantitative physics tasks.

The survey showed which strategies and methods students assert that they use them during solving physics tasks. One of the most mentioned strategies was the *Rolodex equation matching* (i.e. finding equations that contain the same variables as the list of knowns and unknowns). According to our teaching experiences, this process often runs without thinking about physics concepts involved in the problem and therefore solving the task often turns into simple mathematical manipulation with formulas.

On the basis of literature search and the described questionnaire survey, methodological materials will be prepared. The materials will consist of detailed instruction for high school teachers and worksheets for students. Collaboration with several Czech high schools is planned during creation of these materials. The usability of the prepared worksheets will be verified by a case study research.

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References

Buffler, A., S. Allie, Towards an active learning environment in physics: developing problem solving skills through cooperative learning, in: *Proceedings of the Annual Conference of the South African Association of Academic Development*, ed. by C. Boughey & B. Leibowitz, Bellville, pp. 15–29, 1993.

Harper, K. A., Student Problem-Solving Behaviors, *The Physics Teacher,* 44(4), pp. 250–251, 2006.

Leonard, W. J., R. J. Durfense, J. P. Mestre, Using qualitative problem-solving strategies to highlight the role of conceptual knowledge in solving problems, *American Journal of Physics*, 64(12), pp. 1495–1503, 1996.

Ogilvie, C. A., Changes in students' problem-solving strategies in a course that includes context-rich, multifaceted problems, *Physical Review Special Topics – Physics Education Research,* 5(2), 2009.
Snetinova, M., *Quantitative Physics Tasks,* in: *WDS'12 Proceedings of Contributed Papers: Part III – Physics*, ed. by J. Safrankova & J. Pavlu, Prague, Matfyzpress, pp. 61–65, 2011.
Van Heuvelen, A., Learning to think like a physicist: A review of research-based instructional strategies, *American Journal of Physics*, 59(10), pp. 891–897, 1991.