Support for use of probeware in science for teachers and pupils

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Introduction

The interest of students in science and technical branches has in many countries decreasing tendency (Osborne et al, 2008). For example, in the Czech Republic, the science knowledge dramatically decreased between years 2006 to 2009 and the deterioration was the second worst among the countries involved in research (Palečková et al, 2010). There is a variety of reasons, however, one of them is that the science subjects, especially physics, chemistry and mathematics, are considered to be very complex and academic. To enhance the situation, it is important to introduce more visual concepts (presentations, illustrations, experiments, interpretations etc.) into science education as well as to make a better link between the education and common and professional life. These two approaches come together in microcomputer based laboratory (MBL). MBL, today mostly called probeware, is one of various ways how to support science education. Its advantages in science education are immediate feedback during measurement, usually low consumption of chemicals and other equipment and, especially, a way of experimental work which reflects real work in current science laboratory. The variability of measurements can be fruitfully employed in inquiry based methods. Barnea et al. (2010) refer that using probeware together with inquiry increased the number of students in science course for advanced students. The disadvantage of probeware is still lack of suitable educational materials, lack of experience and pedagogical knowledge and possible technical problems that can discourage teachers. Hence, there is an effort to create appropriate teachers' and students' materials regarding probeware so that teachers can have the theoretical support when implementing new educational tool into science education. Such materials were/will be prepared in a framework of projects Přírodní vědy a matematika na středních školách v Praze (Science and Math at secondary schools in Prague, Faculty of Science, Charles University in Prague) and COMBLAB (2012). At the same time, laboratory courses for teachers and pupils were held and evaluated. This contribution presents results from last five courses for secondary school students. Contributors tried to find out students attitudes to probeware and arranged courses.

Methods

An orientation questionnaire research was used to evaluate attitudes, opinions and expectations of students related to probeware. The questionnaire was filled by the students after a laboratory course oriented to general chemistry phenomena during which probeware was used as a main didactic resource. The laboratory course was focused on pH measurements (including calibration), conductivity measurements related to water analysis (conductivity of water, conductometric titration), and spectroscopy measurements (qualitative and quantitative analysis). The questionnaire contained 12 questions, few of them (3) were targeted to personal information as age, sex and class, the rest (9) was focused on opinions and attitudes to instruments (probeware) as advantages and disadvantages of the instruments (3), acquired knowledge (3) and organization of the course (3). All the questions were open, so that wider variability of the answers could be acquired. Consequently, the answers were analyzed and sorted into groups of the same or similar meaning and converted into charts describing percentage ratio of the answer group. Experimental systems Pasco and Vernier with appropriate sensors (pH, conductivity, spectrophotometer), USB converter (USB link or Go! Link) and computer with control software (DataStudio by Pasco and/or Logger Lite by Vernier) were used for the lab course.

Sample

The study group consisted of totally 99 secondary school (gymnazium) students (66 females and 33 males). These students were divided into two groups. The first group - "regular class" - consisted of 59 students (41 females and 18 males, age was 15 - 17 years) without any preferences to science subjects. The second group – "science class" – included students of science seminar held at school for students with preference to science subjects. In this group, there were 40 students, 25 females and 15 males, 17-18 years old. None of the students has worked with the probeware before. The students´ subject preferences were verified by answers to one question of the questionnaire related to the favorite subjects of the students. The results confirmed that students of the "science class" mostly preferred science subjects (biology, chemistry, mathematics) while students of the "regular class" preferred languages (English, Spanish, French,…), social sciences and Czech language.

Results and discussion

In general, the answers of males and females did not differ very much which confirm our previous results (Šmejkal et al, 2011) that gender is not a key factor in using probeware in science subject education. Hence, the expectations, attitudes and opinions as well as handling with probeware are similar for both, boys and girls.

The answers to the first ("What was a goal of the lab exercise?") and the second question ("What are the advantages of employment of instrumental techniques in chemistry education?") reflected students attitudes and expectations. Regarding the first question, the most frequent answers referred to measurement of some quantity (about 50 %), to learning to work with instruments (more than 40 %) and to improvement of chemistry knowledge (more than 40 %); purpose and didactic aspects of using of probeware in chemistry education were also mentioned. Hence, the answers indicate that students mostly consider and expect educational as well as practical benefits of the lab course. In the case of second question, more than 35 % students (see Chart 1) appreciated precision of the probeware.

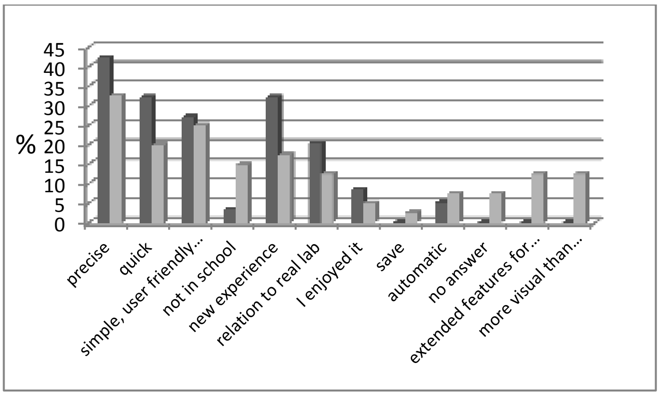

Chart 1: Students´ answers to question "What are the advantages of employment the instrumental techniques in chemistry education?" – dark grey – "regular class", light grey – "science class"

This answer reflects students' positive attitude and uncritical confidence to modern technologies. Students often rely on the results provided by instruments (and computers) and do not consider the factors which can influence the results (human factor – e.g. lab skills, quality of sensors, weather conditions, software problems, etc.). It can lead to incorrect implications and, hence, it is really important to stress the attention to correct interpretation of measured data, theoretical background and interpretation of factors which can influence the measurement and its results. About 25 % of students also mentioned that the measurement is quick and there is a simple and user friendly handling with the probeware and control software. It indicates that students working with appropriate and suitable probeware system can focus on the nature of followed phenomena, better than to the control of system. That is important for implementation of suitable probeware system in science subject education.

Some students also mentioned didactic effect of the probeware. More than 10 % mentioned that they can acquire new knowledge, and more than 10 % of students presented employment of instruments in common "real life" laboratory and in common life. As presented in Chart 1, the answers of both groups ("regular class" – dark grey vs. "science class" – light grey), and, to some extent their ratios, were similar, nevertheless, the "seminar class" students mentioned more advantages, e.g. extended features of probeware for chemistry education and that the experiments made using probeware can be more visual than traditional experiments (always more than 10 %). That implies that students of "seminar class" can distinguish, expect and, probably, apply more possibilities provided by the probeware than the students of "regular class". In the case of possible disadvantages (question "What are the disadvantages of employment of instrumental technique in chemistry education?"), more than 20 % of students mentioned that there are no disadvantages or did not write any answer (about 12 %). That supports statement that handling the probeware is simple and measurement is user-friendly. On the other hand, the measurement showed to be complex for more than 25 % of students. Deeper analysis of the answers showed, that the "complexity" is more related to management of the measurement overall, not to handling the devices and measurement technique. During the course, students have to coordinate a lot of actions in a limited time: sensor handling, controlling the measurement by software, application and/or gathering lab skills, understanding the theoretical background and interpretation of the results. That can be stressful and evoke the feeling of complexity. This fact should be taken into consideration in organization of laboratory course and related worksheet preparation. Hence, teacher should let "some space" for students to manage not only the measurement and data interpretation, but also to acquire some new lab skills, understand the background etc. Some fraction of students (ca 7 %) also mentioned high price as disadvantage. It is not surprising, nevertheless, the fraction is relatively small and price does not seem to be a principal factor for students, which would hinder employment of probeware in science subjects education. Although, in the most cases, we did not observed any significant difference between the "regular class" and the "science class" in answers to the question related to disadvantages of instrumental devices, the "regular class" students mentioned more than the "science class" students that they can break the device or the sensors (see chart 2), while "science class" students wrote that "The measurement can fail". In this answer, a higher self-assurance in usage of probeware of "science class" students was reflected, which was also confirmed by a test of acquired knowledge (3 questions), in which, the students of "science class" showed better results.

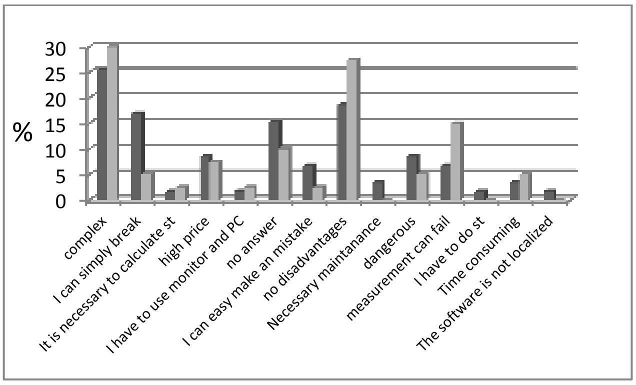

Chart 2: Students´answers to question "What are the disadvantages of employment the instrumental techniques in chemistry education?" – dark grey – "regular class", light grey – "science class"

The results also showed that students of "science class" were more familiar with the content and scientific background of the lab course and with a background of technical function of probeware and they could better deduce their strong and weak points. On the other hand, the acquired knowledge was not perfect in the case of "science class", because only about 15 % of students of this group answered correctly the questions related to the course and 55 %

answered correctly only one or two questions. 30 % of students of the “science class” did not answered or answered incorrectly all the questions. Nevertheless, in comparison to the answers of “regular class” (6 % correct answers, 28 % not exact answers and 66 % wrong or none answers), preference in science subjects in the “science class” was shown. Not very good results in acquired knowledge, as well as in the group of the “science class”, support the previously stated idea that the content of the lab course is rich and students have to manage not only to understand the phenomena and/or theme studied, but also a lot of other operations including lab skills, understanding of theoretical background, measurements specifics etc. It is also important to connect the findings together to understand the studied phenomena and, unfortunately, the Czech students are not in general able to do that. Hence, it is difficult for students to remember and connect together all the important knowledge acquired during the lab course and, consequently, they fail in a test. That stress attention to good preparation and organization of course, including related things as worksheets, warming up activities, questions etc. with regard to previous related knowledge of students in order to minimize all the mental as well as physical activities not related to the studied phenomena. The students were also asked to express problems that they faced during the measurement (“What were the problems during the measurement? – see Chart 3”).

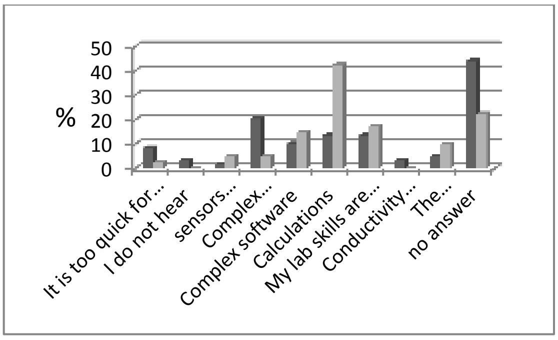

Chart 3: Students´answers to question “What were the problems during the measurement?” – dark grey – “regular class”, light grey – “science class”

More than 40 % of “regular class” students and more than 20 % of “science class” students did not provide us with any information. The higher percentage of blank fields regarding this question for “regular class” students can be explained by a lower motivation and lower involvement in the measurement due to their preferences. These students were not able to fully identify their weak and strong points; therefore the spectrum of answers was not as wide as in the case of “science students”. About 40 % of students of the “science class” reported problems with calculation, which was more than in the case of the “regular class” students (about 12 %). On the other hand, about 20 % of the “regular class” students mentioned as a problem “complex principles” of measurement in comparison to around 5 % of “science seminar class”. The differences in percentage can be explained in the following way: the students of “regular class” have probably poorer theoretical background than the students of “science class”, hence, the problems are more complex for them (including, to some extent, “calculation” problem) and they mention more “complex principles” to cover their obstacles appeared during measurement. The “science class” students mention more particular obstacles like calculations and sensor manipulation that are identified by them. On the basis of lectors’ observations, calculation is a problem for majority of students, but only few students were able to identify it. A significant part of students of both groups (about 20 %) also reported that their lab skills are not good. That was also confirmed according to observation of lectors, moreover, it can be estimated that insufficient lab skills were observed in both student groups. In this observation, decreasing tendency in number of laboratory courses and activities held at Czech schools manifested itself. It can be concluded that there has to be paid some attention to lab skills training before involving probeware in Czech school laboratories. The answers from previous questions were also reflected in the question "What would you improve during the laboratory course?" More than 35 % of "science seminar" students and 25 % of "regular class" students asked for easier and slower lab course, which showed that they had problems with managing the work. In a feedback, majority of provided courses were evaluated by the lectors as too overestimated compared to students' skills. Although lectors responded to actual situation and tried to adjust the tasks during the course, the course overall seemed too complex for students. This misunderstanding and inappropriate course level was mostly caused by incoming teacher's unreal or excessive demands. They presented their students to lectors as experienced students, but lectors revealed the truth until they started the course. On the other hand, in the questionnaire, more than 20 % of "science class" and 10 % of "regular class" students wrote that they do not want to change anything. Quite high percentage, 35 % of "regular class" students and more than 20 % of "science class" students did not answer anything. For "regular class" students, it can refer to low motivation for science at all. Some students (10 % in both groups) would prefer more workspace, so that more members of the group could personally handle the devices.

Conclusions

The results of the orientation questionnaire inquiry showed positive attitude of majority of students of the both followed group ("regular class" and "scientific class") to probeware measurements. Some students are also able to identify the practical as well as didactical benefits of probeware. On the other hand, the results of testing of acquired knowledge accompanied with the answers to the particular questions of the questionnaire showed that during the course, students have to coordinate a lot of actions in a limited time: sensor handling, controlling the measurement through software, application and/or gathering laboratory skills, understanding the theoretical background and interpretation of the results. Hence, the content of the probeware lab course should not be overestimated and students´lab skills, previous knowledge, theoretical background and other factors influencing the course have to be taken into account for preparation of the lab course with probeware.

Acknowledgement: The financial support by CZ.2.17/3.1.00/32121 project awarded by ESF and 517587-LLP-1-2011-1-ES-COMENIUS-CMP (COMBLAB - EACEA-517587) project awarded by European Commission, Directorate-General for Education and Culture, are gratefully acknowledged.

References

Barnea, N., Dori, Y. J.; Hofstein, A.*: Development and implementation of inquiry-based and computerized-based laboratories: reforming high school chemistry in Israel. Chemistry Education Research and Practice*. 2010, 11, 3, s. 218-228.

Members of COMBLAB project. *The acquisition of science competencies through ICT real time experiments.* (2012) Available at: http://ec.europa.eu/dgs/education_culture/eve/alfresco/n/browse/workspace/SpacesStore/f1ea18cb-2bf8-11e1-ae22-537b3dc6e0b9, cited: 12-06-26.

Authors of FACULTY OF SCIENCE, Charles University in Prague, *Přírodní vědy a matematika na středních školách v Praze: aktivně, aktuálně a s aplikacemi*. Available at: http://www.aaa-science.cz/, cited: 12-06-26.

Osborne, J., Dillon, J. *Science Education in Europe: Critical Reflections. A Report to the Nuffield Foundation.* (2008), Available at: http://www.nuffieldfoundation.org/fileLibrary/pdf/Sci_Ed_in_Europe_Report_Final.pdf, cited: 10-06-26.

Palečková, J., Tomášek, V., Basl, J.: *Hlavní zjištění výzkumu PISA 2009. Umíme ještě číst?* Praha: Tauris, divize Ústav pro informace ve vzdělávání, (2010). ISBN 978-80-211-0608-6.

Šmejkal, P., Stratilová Urválková, E.: *Microcomputer based laboratory in chemistry – are pupils interested in performing it?* In *Alternativní metody výuky 2011*. (2011), Available at http://everest.natur.cuni.cz/konference/2011/prispevek/smejkal_stratilova_prispevek.pdf, cited: 12-06-26.