Experiments in teaching and learning natural sciences

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MBL ACTIVITIES USING IBSE: LEARNING BIOLOGY IN CONTEXT

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Introduction

Project COMBLAB

The contribution presents a methodology of creation and implementation of six biology activities based on inquiry education approach and using probeware in laboratory, microcomputer-based laboratory, MBL. Activities were created within a European Comenius multilateral project COMBLAB (competency microcomputer-based laboratory) named The acquisition of science competencies using ICT real time experiments, that is now in its final third year of existence. One of the project objectives is to create synergies among six partners interested in probeware and MBL: (1) Universitat Autònoma de Barcelona (Spain), (2) Charles University in Prague (Czech Republic), (3) University for Teacher Education Lower Austria, Vienna (Austria), (4) Universitat de Barcelona (Spain), (5) University of Helsinky (Finland) and (6) Matej Bel University in Banská Bystrica (Slovakia). Partners have been working on developing and testing new designed chemistry, physics and biology activities for MBL. Other important COMBLAB output is to disseminate activities among school teachers and to create network of teachers using MBL in their teaching practice.

IBSE approach in microcomputer-based laboratory

COMBLAB partners agree with previous researches made on MBL efficacy in science education [e. g. Redish et al. 1997]. Gathered data from sensor projected on screen allow real time visualization of monitored variables. These immediately obtained data in graph skip a need of plotting the data manually. Therefore students have more time for interpretation and analysis that happens often simultaneously with gathering data itself. MBL also enables performing experiments that present variables difficult to observe in traditional arrangement. Generally accepted advantage is a possibility to perform experiments with special time requirements (e. g. long-termed observations in biology or short-termed experiments in physics).

The team of COMBLAB researchers agreed on designing activities involving students in learning process that would make sense and reveal the application of formerly remembered knowledge. At first, the predict-observe-explain (POE) concept was accepted by the team. To emphasize the aspect of students' own impact on designing the experiment in given context, the inquiry based science education (IBSE) approach was implemented as well. IBSE approach is recognized for its efficacy at primary and secondary level when increasing students' interests in learning process and teachers' motivation at the same time and positive impact on students' IT skills and cooperation and communication competencies by working in groups [Barnea et al 2010, Hofstein et al 2005]. This approach can also help to build mental models of chemical phenomena by developing higher-order thinking skills [Aksela 2005].

Methods

Refining didactic sequence

To fulfil the requirement of an inquiry-based biology activity the traditional cook-book instructions were abandoned and the didactic sequence was refined [Šmejkal et al 2013]. The newly developed activities are designed in scheme that can be divided into several parts:

(1) Engagement: at the beginning students are introduced in a situation or relevant context that aims to arouse interest and curiosity (story, problem to solve). From the introduction the

initial question arises. First tasks (2 - Warming up) usually relate to students‘ previous knowledge (counting, variables) and to learn how to use the MBL equipment (purpose of using a particular sensor). After getting know to sensors, students model the real situation, design an experiment according to their suggestions and perform it in a laboratory (3 - Experiment designing and conducting). (4) Drawing final conclusions: when students measure the data they interpret the obtained data or can change the experiment set up if they are not satisfied with the results and make final conclusions that correspond with the data. In the end they (5) communicate the results not just in conclusion, but they have to apply their new knowledge to communicate the conclusions e.g. in email to their friend or in a letter to the magazine that received reader's question.

Implementing, testing, revising

The main authors of six biology activities created according to refined didactic sequence are researchers from Department of teaching and didactics of chemistry (Charles University in Prague). Preliminary versions of activities were prepared and sent for feed-back to partner from Matej Bel University (Slovakia) and to a colleague at the department of biology education, Charles University in Prague. New revised students' worksheets with implemented suggestions were prepared in Czech language, then translated to English and to local languages (Catalan, German, Finnish, Slovak). Prepared biology activities were implemented and tested during autumn 2013 at the department of chemistry of Matej Bel University (Slovakia) with secondary school students from four grammar schools. Implementing and testing in the Czech Republic was carried out in spring 2014 at three Czech grammar schools and with a group of students at the laboratory of department of biology education. The testing brought useful experience that led to creating the re-revised versions of the activities.

Results

Biology activities – students worksheets and teachers guides

Currently, the final versions of six biology activities in Czech and English are available: the activities involve the issue of influencing life conditions - fermentation (Life of yeast), plant topics photosynthesis (Is it safe to sleep in bedroom full of plants?) and germination (Wake up, seed, wake up, it's time to get up!), human issues electrocardiogram (What makes your heart flatter?) and blood pressure (Doctor's assistant), and ecologic issue eutrophication (Plant predators). Parallel to students' worksheets the teachers' versions were prepared: at first, the hints for teachers were coloured in students' versions, finally the teachers' guides consist of part with students version on the left and the commentary part for teachers on the right. Teachers can find there the results of warming up tasks, expected answers, tips for arranging the experiment, tricky parts of the experiment, often mistakes made by students, expected results and specific questions that can be given to students in the end of laboratory lesson to find out whether students understood the activity and the obtained results.

Implementing and testing in the Czech Republic

Two schools from Prague were involved in testing the activities and one secondary grammar school from Moravian town Třinec; in total 5 teachers implemented the biology activities in their laboratory lessons. For evaluation of prepared activities, three evaluating tools were administered to students: before performing the activity students were given a pre-test for motivational orientations and after the activity the post-test for motivational orientations; these tests were adopted from Pintrich at al. [1991] and McAuley at al. [1989]. The third research tool – a COMBLAB questionnaire, was also distributed after performing the activity. It is related to activity itself and brings important feedback on how students perceive each activity, what do they like and dislike the most and other aspects. Detailed information about the concept and evaluating method of used questionnaires can be found in the article of Marek Skoršepa (Matej Bel University) concerning the results from Slovak Republic.

The first author of presented contribution was one of the teachers implementing the activities with first grade students (age 15-16) at Masarykova secondary school of chemistry. Therefore, we want to present some results coming from observation during eight laboratory courses and emerged from discussions with colleague also implementing the activities in four laboratory courses with first grade students.

Regarding students, they got used to work with probeware easily, as they are used to work with notebooks, tablets or smartphones. However, the teacher's help with the software was still needed at the beginning. For about half of the students the concept of the activity was problematic. Despite, it is guided inquiry, the instructions were too vague for somebody and some students did not know how to design the experiment without the teacher's help in a way that would bring reasonable results. Another problem was drawing conclusions: students were rarely able to formulate the conclusions on a paper from comparing the graphs, although when asked by teacher they understood the meaning of the graphs. And when they had to communicate the results, some of them perceive it as useless that could be seen in the level of finally-written letter/e-mail. The context of the activity was well accepted, but rather by younger students than by older ones (comparing with the preliminary teachers' notes from Třinec testing and from last year testing at Masarykova school). Older students seem to prefer shorter introduction because they want to focus on experimenting – this observation needs more research. The design of worksheets was acceptable for students, although it was unusual at the first laboratory. They were able to answer the prediction parts, especially graphs, but mostly with poor verbal description. Their description of the procedure was usually very weak, as it was not reproducible. As sometimes the rewritten results/graphs were not schematic, they were inapplicable for further analysis.

Microcomputer-based laboratory places demands also on teachers. They have to master complex competences: not just soft skills, such as IBSE, facilitating students, managing work without direct instructions, being ready to improvise a lot, but also hard skills such as using the probeware, which means sensors and cooperating software. Furthermore, the teachers have to be ready to solve unexpected technical problems (sensor does not want to connect automatically, the software crashes, etc.). These problems represent an element of uncertainty for teacher that can discourage him/her from MBL usage. On the other hand, it is satisfactory when a teacher sees how students can work independently on precise instructions, how they plan their own work, design the experiment in various ways and develop different competencies than in instructional laboratories. Inquiry approach in MBL also brings opportunity for weaker students, who can for example handle the computer or they surprisingly come with elegant solution of given problem. In all cases, a teacher has to be instantly ready for help and new student's ideas, which is a perfect way for him/her to stay open-minded to scientific thinking.

Conclusion

Six biology activities using IBSE in MBL have been prepared within the project COMBLAB. Despite the subject biology, the issues are exploitable also in other science subjects (or in physical education) that can be supported by the fact that testing of these activities were done by chemistry teachers in lessons of chemistry laboratory with no students objections. At the beginning of implementing inquiry based MBL, there is the obstacle of time: students have to be used to inquiry from previous experiences and they should be able to handle the probeware and software. Solution to this is performing short demonstrational MBL experiments by teacher in the science subjects, when the graph is projected on screen – students get passively familiar with the software interface. More difficult is an acceptance of MBL by the teachers: the initial output takes a lot of teacher's time and energy and the effectivity is not seen at the beginning. Moreover, some technical problems and results that sometimes differ from expected ones bring the element of uncertainty to teaching process that meets teacher's resistance. According to our experience, these factors mostly cause the teachers rejection of using MBL in science. Authors see MBL as an important connection between school and real laboratory work. Therefore, one of the solutions can be preparing teachers for using MBL during their study in pre-service teaching. Another important aspect of using MBL is the context of experiment, as in real laboratory the instrumental devices are used to solve given problem. If the context of experiment will also make sense to students, their learning becomes meaningful.

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