MAKING MATHEMATICS MORE ATTRACTIVE USING NEW TECHNOLOGY FOR EXPERIMENTS IN CROSS-CURRICULUM PROJECTS

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In the Austrian school system mathematics is obligatory for all pupils from primary school up to secondary higher level and grammar school classes. Even during final exams all pupils at the age of 18 have to pass a written test in mathematics in order to get the permission to go to university. Therefore the need to learn mathematics is accepted by almost all pupils, however mathematics is not the favorite subject for most of them.

Experiments carried out by pupils using new technology are possibilities and efforts to make mathematics and natural sciences more attractive. We will report about our experiences made during science classes where pupils were working at several topics integrating math to biology, chemistry and physics experiments.

Introduction

In the Austrian school system mathematics is obligatory for all pupils from primary school up to secondary higher level and grammar school classes. Even during final exams all pupils at the age of 18 have to pass a written test in mathematics in order to get the permission to go to university. Therefore the need to learn mathematics is accepted by almost all pupils, however mathematics is not the favorite subject for most of them.

Austrian pupils took part at the Third International Mathematics and Science Study (TIMSS) which was organized by International Association for the Evaluation of Educational Achievement (IEA) and examining about half a million pupils in 45 countries. Within the first population of primary school pupils at the age of 9 Austrian pupils ended up on rank 7 out of 26 concerning mathematical skills and even on rank 4 concerning knowledge about natural sciences. For the second population of pupils at the age of 14 from secondary lower level schools the Austrian pupils ended up on rank 12 in mathematics and rank 8 in natural sciences out of 41 participating countries. All these

results were quite well. However for the third population of pupils at the age of 18 from secondary upper level schools or gymnasiums the Austrian pupils ended up within the lower middle of the field of participating countries (according to [GÖTZ, REICHEL 1998]).

In response of these results especially the bad ranking of population 3 the Austrian government installed a project "Innovations in Mathematics, Science and Technology Teaching" ($IMST^2$) promoting projects at gymnasiums and technical or commercial schools (see [KRAINER et al. 2002]). In these projects new technologies should be integrated into math and science course fostering the interdisciplinary working and reasoning. The ministry of education is also planning a platform for math and natural sciences in order to make these subjects more attractive for pupils and to encourage them to study natural sciences.

Cross curriculum courses

Several projects have been carried out at the Bundesrealgymnasium (BRG) Landwiedstrasse, which is an Austrian grammar school in Linz, integrating new technology and mathematics to science classes. The school is not a technical school, however, the students are interested in natural sciences.

The first experiments started in 1999. In 6 groups 61 students performed some physical and chemical experiments during regular science classes using the data collection systems CBL, CBR and the graphic pocket calculator TI-92 for analysis and graphical representation of experimental data (see [ASPETSBERGER 1999]). Most of the experiments carried out during these classes could be found in [HOLMQUIST, RANDALL, VOLZ 1998]. These courses had the character of repetition courses. The primary goal was not to introduce new mathematical concepts as e.g. in [LAUGHBAUM 2000], instead of this the students should refresh and re-activate knowledge from natural science classes and apply well known functions from traditional math classes for modelling data obtained during the experiments (see [ASPETSBERGER 2000]). However it was new for the students to combine knowledge from different fields like mathematics, biology, chemistry and physics.

The understanding and applying of laws and principles of physics, chemistry and biology as well as the ability of describing processes and interdependencies by mathematical functions and expressions are very important goals in modern science education. Some attempts and suggestions for cross curricular reasoning in math and science courses are described in [ASPETSBERGER 2001].

Being familiar with the handling of CBL and TI-92 students analysed the quality of freshwater (see [JOHNSON, HOMAN, HOLMQUIST 1999]) by using ion selective electrodes of Vernier in laboratory and field studies. An intensive and very accurate calibrating of the probes was absolutely necessary for obtaining good results. This was completely new for the students. On the other hand having good calibration values it was really easy to measure the concentration of several ions in freshwater. Having only single point

measurements the mathematical analysis was restricted to statistical methods. It was much more interesting to interpret the results and to compare them with official limits. Furthermore the students learned about the methods of how to analyse freshwater and the need of saving and protecting it. Visiting a local institution for freshwater control the pupils learned that in principle the same methods are used at the institution for controlling the quality of freshwater as the pupils applied during their experiments [ASPETSBERGER 2002].

Since 2002 the BRG Landwiedstrasse is cooperating with schools from Belgium, Finland and Greece within a Comenius project, which is ongoing until 2004. Within this project students analyse the quality of freshwater quantitatively and qualitatively, think about possibilities for saving and protecting freshwater and do some investigations concerning water quality and health in general. Results, experiences and reports about activities are documented in a common web magazine http://cce.peda.net/magazines/art .

In parallel four high ability courses (since 1999) groups of 10 to 12 students were experimenting with CBL/CBR and TI-92. They carried out experiments almost without help of the teachers. According to their feedback they enjoyed working with new technology. They designed new experiments or found new solutions for given ones.

Students' opinions

The following opinions of the students were obtained by several questionnaires which had to be filled out by the pupils, by interviews, discussions and verbal feedback form the pupils. Evaluation was done according to the action research method of [ALTRICHTER, POSCH 1998]. Since the population of pupils was small we cannot give statistical significant results. Instead of this we present a selection of typical answers.

Do you think that math and science classes become more interesting when experimenting with CBL, CBR and TI-92?

Almost all students are of the opinion that natural science classes become more attractive if they can carry out experiments by themselves. They feel that the classes become more colourful and vivid and closer to reality. They also think that it is important to learn about the use of new technology. Especially they enjoyed to do the experiments by themselves. See for instance the following answer of a pupil: "Experimenting is much more vivid and interesting than writing, writing, writing..." One pupil summarized excellent the essence of the project: "It was important to obtain accurate quantitative experimental data which have to be documented and interpreted by the pupils according to a chemical background."

Do you like cross curriculum working?

About two third of the pupils agree to the importance of cross curriculum teaching. They feel to get better insights to interconnectivities and to get a wider knowledge if different

fields are combined. They find lessons with cross curriculum topics more vivid and flexible.

Give some suggestions for grading

With some exceptions all pupils agree to a grading of the experiments being carried out by the pupils. Most of them suggest a grading based on the protocols being written by the students presenting the background and the results of the experiments. Some of them also wish to be observed during experimenting continuously. However they do not like to write tests.

Do you get a better insight in laws and mathematical concepts

Again almost all pupils feel to get a better understanding of laws of natural sciences and of mathematical concepts if they do experiments by themselves. "It is easier for me to understand something if I do it by myself. It is much clearer than before." (Probably it is meant clearer than in traditional lessons presented by teachers.) Especially graphical visualisations of data obtained from the experiments using graphic pocket calculators help to understand what had happen.

What are the advantages/disadvantages of using data collection systems?

Concerning the advantage some of the pupils refer to the special data collection system CBL and think that it is easy to handle and allows to obtain accurate data. Another group of pupils refer to the use of data collection systems in principle and mention especially working in a team as an advantage.

Technical problems with link cables connecting calculators and data collection systems and the fault intolerant operating program CHEMBIO of the data collection system CBL forcing the students to return to start and to repeat the experiment if problems occur are amongst the most mentioned disadvantages.

If you could skip subjects which one would you cancel first?

Number one of the most unpopular subjects is physics followed by chemistry, religion or ethics, drawing, physical training (especially girls) and psychology. The pupils think that these subjects are not necessary for later life. They are uninteresting, going too much into details and are too complicated, especially physics.

However there was only one pupil out of 37 who would cancel mathematics. The pupils accept the necessity of learning maths but they would prefer also cross curriculum teaching with natural sciences and the possibility of independent working and learning during math lessons. That means that they would like to do experiments also in math, which is too theoretical for the pupils.

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