TECHNOLOGY IN PRE- AND IN-SERVICE MATH AND SCIENCE TEACHER TRAINING EMPHASISING CROSS CURRICULUM TEACHING

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Cross curricular teaching, the use of technology and learning by experimenting are important objectives for future math & science courses. However in order to be successful in school, many teachers themselves first have to learn more about interesting topics and possibilities of cross curricular thinking and the use of technology.

This report is on pre- and in-service teacher training courses for math and science teachers. The main objectives of these courses are to present ideas, examples, techniques, hints and experiences concerning cross curriculum teaching in math and science lessons. The participating teachers learn to use the Voyage 200 and TI-92 plus as well as data collection devices such as CBL 2 and CBR by Texas Instruments.

In this presentation, we also report about experiences made during several pre-service and in-service teacher training courses. When performing the experiments in these hands-on courses many of the teachers are faced with almost the same problems as the high school students do in science and math classes.

Introduction

Interdisciplinary teaching and thinking is a central idea and a fundamental didactical principle in Austrian curricula culminating in final exams where students are encouraged to emphasise interdisciplinary aspects. Furthermore, new information and communication technology should be used in regular lessons starting with pupils at the age of 11. However, for many teachers it is a huge challenge to use new technology: the main reasons are: lack of suitable ideas and experiments as well as projects for interdisciplinary courses in combination with their own subjects.

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]. Experiments carried out by students are very motivating for them and lead to a better understanding of principles and process in sciences. Furthermore, these experiments foster various practical as well as mathematical skills among the students.

Graphic pocket calculators like TI83 Plus or CAS handhelds like the TI-92Plus or V-200 help to visualise data, to plot graphs and to execute tedious and complicated calculations like determining regression curves. Experimental data can be investigated and visualised quite comfortably by using these machines.

The CBL2 by Texas Instruments is a Calculator Based Laboratory which allows collecting data during physical and chemical experiments. Data are stored directly to a calculator e.g. the TI-92 for graphical visualisation and further manipulation. CBR from Texas Instruments is a motion detector which allows gathering a large amount of data points of moving objects.

Analysing data obtained from experiments in chemistry and physics requires some specific mathematical skills and methods especially in statistics as well as the ability of finding the appropriate functions which model or simulate the measurements. Some ideas and experiences about functional modelling of experimental data can be found in [ASPETSBERGER 2000]. Especially the treatment of real data is quite unfamiliar for students and in a similar way also for teachers.

Being familiar with the technology used, e.g. graphical calculators from math courses and CBL from science courses, there are several possibilities for doing some investigations in other subjects, such as analysing the quality of freshwater in biology courses [JOHNSON, HOMAN, HOLMQUIST 1999].

Teacher training courses

The courses described below were designed for in-service and pre-service teacher training. In both types introduction, handling and integration into the classroom of new technologies were main objectives of the courses. However in-service teachers were more interested in our actual experiences and pedagogical aspects of the courses we taught at school and how to use the technology and experiments in their own courses.

We report about experiences made concerning pre-service courses for high school teachers during their education at the State College for Teacher Education at Linz, about pre-service courses for teachers for gymnasiums during a pedagogical year at schools having graduated from university and about in-service courses for teachers at gymnasiums.

The experiments in in-service and pre-service teacher training courses corresponded to some of the main topics of traditional science courses as well as to available probes of the

CBL system. As a third dimension mathematical, statistical and functional aspects were taken into consideration.

From the field of caloric science we treated endothermic and exothermic reactions, freezing and melting temperature of water, the heat of fusion of ice and cooling processes using the temperature probe. Mathematically we needed some interval arithmetic for the heat of fusion of ice and exponential functions of the type $A \cdot b^x + C$ for modelling the cooling process.

Using CBR from Texas Instruments it was quite easy to investigate various processes of motion. It was really fascinating to see how exact the graphs of these processes could be matched by mathematical functions. For describing the motion of rolling or bouncing balls quadratic functions of the types $A\,x^2 + B\,x + C$ or $A\,(x - B)^2 + C$ were suitable fitting functions. The motion of pendulums could be described by trigonometric functions in combination with exponential functions if friction and air was taken into consideration.

From the field of gas kinematics we treated the Laws of Boyle and Gay-Lyssac using the gas pressure sensor from Vernier. These processes were typical for inverse and direct relationships of gas pressure versus volume or temperature respectively and could be modelled mathematically by rational or linear functions.

Unloading a capacitor using a voltage probe was a typical application for exponential functions of type $A \cdot b^x$.

In the following examples from chemistry linear functions were used for modelling: determining the concentration of a solution according to Beer's Law using colorimeters and measuring the conductivity of salty solutions depending on their concentration using conductivity probes. Most of the experiments could be found in [HOLMQUIST, RANDALL, VOLZ 1998].

Participating teachers preferred hands-on courses instead of pure demonstrations. On the other hand they had also learn some basic handling of the data collection system CBL and the graphic calculators e.g. TI-92. So we started with the simple experiment of endo- and exothermic processes demonstrating how to collect data during experiments. In the next experiment concerning Boyle's Law we demonstrated how to visualise and manipulate data obtained from the experiment using the graphic calculator TI-92. All participants did these two experiments together. One trainer was demonstrating the experiments and the second one was helping those participants who had problems. All former experiments were done by the participants in groups of two.

Real data reasoning

Working with real data obtained from the experiments was a new experience for pre-service teachers as well as for in-service teachers. They were not used to deal with errors. Several types of errors occurred during experimenting

Investigating Boyle's Law the participants had to determine an interdependency between the volume and the pressure of a confined gas within a syringe (see figure 1).

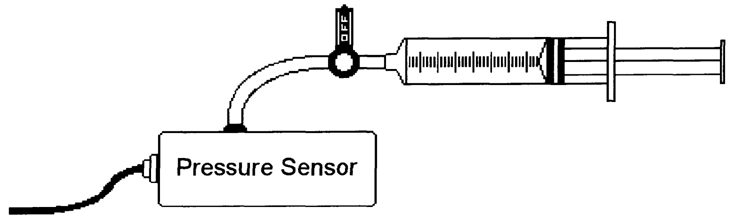

Figure 1: pressure sensor and syringe for investigating Boyle's Law (from [HOLMQUIST, RANDALL, VOLZ 1998])

When the volume V of the syringe was changed by moving the piston the participants got pressures p which did not fit exactly to the expected relation $p \cdot V$ = constant. The reason for this was a systematic error, because the participants had always neglected the volume of the small tube connecting the syringe with the pressure sensor.

Even if the participants have avoided all systematic errors minor deviations always occurred for real data from experiments. At these moments we introduced statistical methods like mean, standard deviation etc. for determining single value measurements.

The situation was more complicated if the expected result was not a single value but a relation between two quantities which should be expressed by a mathematical function. For determining fitting functions two methods were used by the participants. The first method was to compute a regression function which was well accepted for linear functions. The second method was to find suitable parameters within functional expressions to obtain functions fitting the data points. This method was preferred for e.g. quadratic or trigonometric functions.

There was also a third type of error which could occur during experimenting. For instance when determining the freezing point of water the participants did not obtain the expected value of 0°C / 32 F. They were really surprised because they did not obtain minor deviations like 0.15°C or -0.21°C but very distinct ones like 3.242°C or -4.145°C. The students and even the teachers had to learn to calibrate the probes before doing some measurements and second to be careful with significant digits in results. This was especially important when testing water quality using ion selective probes.

Experiences

It was very important not to expect too much of the teachers. In new technology courses emphasizing interdisciplinary aspects the teachers are confronted with technical and very often also with some specialized knowledge of their own and some other subjects.

Participating teachers were interested in simple standard experiments using new technology which could be introduced to their own courses without major changes. They did not like tricky, too complicated and long experiments. On the other hand they appreciated to learn about concepts and hints for everyday work in school and to discuss about our experiences.

In contrast to students teachers were very unsure of themselves when they were using new technology. Sometimes they tried to hide their mistakes. They even did not like to work according to instructions in English. We had to translate all the hand-outs into German.

It was necessary to coach the teachers and play all the tricks by Pawlov and Co. They needed a lot of praise and attention for increasing their motivation. It was difficult to encourage them if their results were not the expected ones.

In one course we had problems using the CBR after running the DATAMATE programme. One group of teachers found out that it was necessary to make a complete reset of the TI-calculators or at least to clear some variables. Of course they were very proud about solving the problem.

The audience of in-service teacher courses was very in-homogenous. They differed from experts to newcomers. However, patience and motivation of experienced participants decreased remarkably when newcomers had problems with the technology and blocked the whole course. Both (!) trainers were necessary to run the courses. In the demonstration phase at the beginning of the courses one trainer was presenting the experiments while the other one was helping inexperienced participants. During the course when the participants were working in groups of two persons separately - according to their further experiences and interests - two trainers were necessary to cover the wide field of four subjects (math, physics, chemistry and biology).

References

[ASPETSBERGER 2000]
Aspetsberger B., Aspetsberger K.: *Functional Modelling of Experimental Data in Science Courses*. ICTCM, International Conference on Technology in Collegiate Mathematics, Atlanta, November 16-19, 2000

[ASPETSBERGER 2001]
Aspetsberger B., Aspetsberger K.: *Cross Curriculum Teaching and Experimenting in Math & Science Courses Using New Technology*. ICTMT5, The Fifth International Conference on Technology in Mathematics Teaching, Klagenfurt, Austria, August 6-10, 2001

[HOLMQUIST, RANDALL, VOLZ 1998]
Holmquist D.D., Randall J., Volz D.L.: *Chemistry with CBL™. Chemistry Experiments Using Vernier Sensors with TI Graphing Calculators and the CBL System*. Vernier Software, 8565 S.W. Beaverton-Hillsdale Hwy., Portland, Oregon.

[JOHNSON, HOMAN, HOLMQUIST 1999]
Johnson R.L., Holman S., Holmquist D.D.: *Water Quality with CBL*. Vernier Software, 8565 S.W. Beaverton-Hillsdale Hwy., Portland, Oregon.