Experience with Inquiry Activities and their Assessment at a Lower Secondary School in Slovakia

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The education in science at lower secondary schools in Slovakia has changed a lot in last few years. The number of compulsory lessons has been reduced, however the emphasize is put on active learning of pupils. The textbooks are based on this approach and inspite of the shortage of lessons teachers are trying to guide the lessons in an interactive way implementing elements of inquiry. Under the running system of continuous teachers´ education many enthusiastic teachers take part at teacher training courses in order to educate themselves in this field. Teachers usually implement or adapt inquiry activities that are already prepared or they even develop their own ideas into the activity according to the needs of their class. The contribution presents examples of inquiry activities designed by a physics teacher of one of the Slovak lower secondary schools. Activities are developed for the use in the class or within a study visit of a research institute emphasizing an authentic scientific experience. The examples of activities involve: How chocolate melts, Human and horse hairs are, How crystals grow, How noisy is our school, Heat, heat conduction, Which objects conduct electric current. There are different elements of inquiry to follow and also assessment tools recommended for the activities to evaluate.

INTRODUCTION

Teaching physics at lower secondary schools has changed a lot since 2009 in Slovakia when the educational reform started to be implemented across all the schools in the country. The reform implies a two-level model of Slovak schools control. The state curriculum defines the basic principles and goals of education based on the general Slovak educational policy while the school curriculum gives schools an opportunity to fit the interests of the particular school and its pupils. The spiral way of building knowledge and skills has been replaced by teaching blocks of topics that are strongly supported by activities aimed at developing experimental skills of pupils, in 6th and 7th grade, in particular. The physical laws and abstract physical formulas are introduced in 8th and 9th grade only, since at this level students get known about how to solve equations in mathematics.

There were a number of new textbooks developed. They are full of different experimental activities with a lot of inquiry elements involved to carry out at schools as well as at home that helps a lot to increase pupils´ interest and motivate them towards science. The activities result in developing theoretical knowledge about the phenomena that pupils

gradually get familiar with as well as inquiry skills connected with the way how to get to the target. The education in physics at this level is based on:

- Observation of everyday phenomena (school or home observations) and their explanation,
- Predictions what can happen and what happens next when exploring phenomena, objects and their properties,
- Experimentation, evaluation of experiments,
- Exploring other relationships and applications of phenomena
- Drawing conclusions.

HOW WE IMPLEMENT AND ASSESS IBSE AT LOWER SECONDARY LEVEL

In order to follow the goals of the reform the Basic school Kežmarská, Košice tries to carry out activities that support the ideas of IBSE. Except from the textbook inquiry activities we have adapted, developed and successfully carried out a lot of additional activities in cooperation with science institutions as well as pupils own project work and moreover, we have arranged special science events, e.g. science open day for parents, science lesson for elementary school pupils, science conference at school or at science institution (Slovak academy of Science and University). The assessment of pupils work within these activities has been based on the following ideas:

- attitude towards the inquiry activity, enthusiasm and drive,
- ability to work in a group: teamwork and cooperation,
- level of knowledge and their skills to plan investigation and gain and process data from the experiment and search for information,
- skills to present information and explain knowledge in front of different audience (class, parents, younger students, scientists from institutions).

EXAMPLES OF INQUIRY ACTIVITIES AND ITS ASSESSMENT

How to melt chocolate

This is an example of home assignment. The goal is to find the best way to melt chocolate and find out the melting point. The designed experiment should have been complemented with the written report involving conclusions. In this case we have decided to make a peer assessment. Pupils that did not know the names of their assessed friends were asked to judge: tools and materials chosen, the designed procedure, explanation, originality with each item assessed with maximum 5 points.

Figure 1: Examples of pupils written reports in chocolate experiment complemented with peer assessment (in yellow circles).

Human and horse hair

This activity has been carried out in cooperation with the Institute of Physics, Slovak Academy of Science. There were 15 7th and 8th grade pupils participating. In the first part the human hair has been investigated. The physicists explained the way how the hair DTA analysis is done when the hair is heated. Pupils were exploring the shape of a human hair and its thickness with the help of a microscope and were measuring its strength, load capacity and elongation under different applied forces. In the second part the horse hair has been explored and its properties compared with those of a human hair. The results of measurements have been elaborated by groups of pupils preparing the final presentation for the science conference. The pupils work on the project was assessed on the basis of pupils´ attitude to work, their interest towards the project and work with the apparatus and measuring tools, cooperation within the group, searching additional information from various sources and the level of presentation and argumentation within the discussion at the science conference.

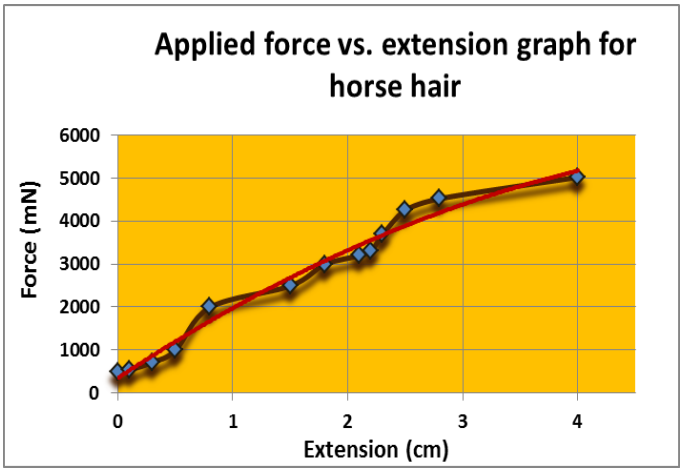


Figure 2: Pupils investigating the hair properties and an example of horse hair measuring results

How crystals grow

This activity has been carried out in cooperation with the Technical University. About 90 6th grade pupils have already participated on this project since 2007. The project usually involves four parts. Its first part is aimed at the study visit of the University mineralogical collection. Secondly, in the school laboratory, pupils create their own different colour crystals made by evaporating saturated water salt solutions (e.g. copper sulphate, potassium ferricyanide, nickel sulphate, sodium chloride). Then they investigate their properties (shape, crystalline structure, colour, etc.) and complement their observations with information gained from different sources. Finally pupils present the results of their work in a form of a presentation at pupils' science conference.

In order to assess pupils work we use teacher assessment. Teacher observes pupils attitudes and their involvement and interest during the study visit that always attract pupils' attention. However, the laboratory activity is not so attractive for pupils and usually just a small group works together in order to mix solutions and observe what happens. However, the last year's pupils were working so enthusiastically that they were awarded by the school trip to Kremnica and Banská Štiavnica. Kremnica is one of the oldest mints in the world. Coins have been still minted there not only for Slovakia but also for other foreign countries. Banská Štiavnica is an old historical mining town with an interesting mineralogical museum and old mining tunnels.

Figure 3: Examples of the crystals´ activities

How noisy is our school

In the years 2011-13 there was a reconstruction of the school performed. Parts of the building were torn down and rebuilt; nevertheless, teaching went still on even in such an annoying and uncomfortable environment. The noise was so unpleasant that it gave reason to investigate its level and its negative effects and additionally, to explore the noise at home created by home appliances, e.g. washing machine, refrigerator, TV or elevator and also the noise in the supermarket, street and means of transport. Different groups of pupils were exploring different places using the sound level meter. Their project work resulted in interesting presentations shared with the audience at the science conference. The project work evaluation was based on the pupils´ creativity, originality in exploring different noise environments, objects, and work with internet resources, tabular and graphical evaluation of the noise level, suggestions on protection against noise and the level of pupils´ presentations.

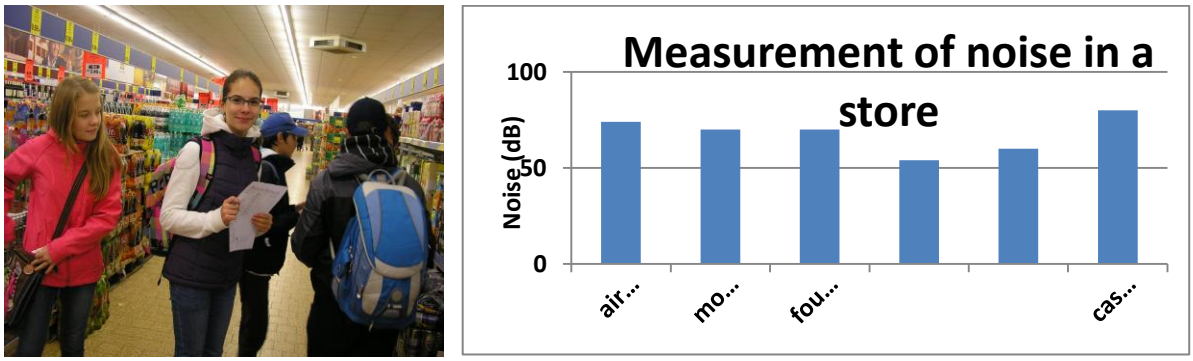


Figure 4: Pupils recording data in the store and examples of measuring results

Heat, heat conduction

This activity has been carried out by the whole class at school. It was aimed at heat exchange between the hot and cold water. Firstly pupils were expected to draw a concept map on the topic of heat in order to think about all the possible concepts connected with heat. Secondly, they designed an experiment in order to investigate the heat exchange between hot and cold water taking into account different conditions and their influence on the experimental results (open or closed vessel, heat dissipation by a vessel, design of the best calorimeter). Based on the plan pupils carried out experiments mixing together same or different amount of water predicting their final temperature and comparing their prediction with the experimental result.

After the activity the written reports were collected and the assessment was done by the teacher using 4-scaled rubrics. In fig. 5 there is an example of a very rich concept map involving many terms like e.g. heat transfer – convection, conduction, radiation, thermal conductors (metal, spoon), thermal insulators (Styrofoam, thermos flask), temperature, thermometer, bimetal, alcohol, mercury thermometer, units, Celsius, Kelvin, Fahrenheit, etc. (4 points). The fig. 6 presents a design of an experiment on heat exchange between hot and cold water. The pupil describes different parameters that should be thought about when carrying out the experiment, e.g. vessel (material, open or closed, insulation, and

best calorimeter), initial water temperatures and masses and where the vessel is situated (on metal, wooden or plastic plate). He also suggests the experimental procedure.

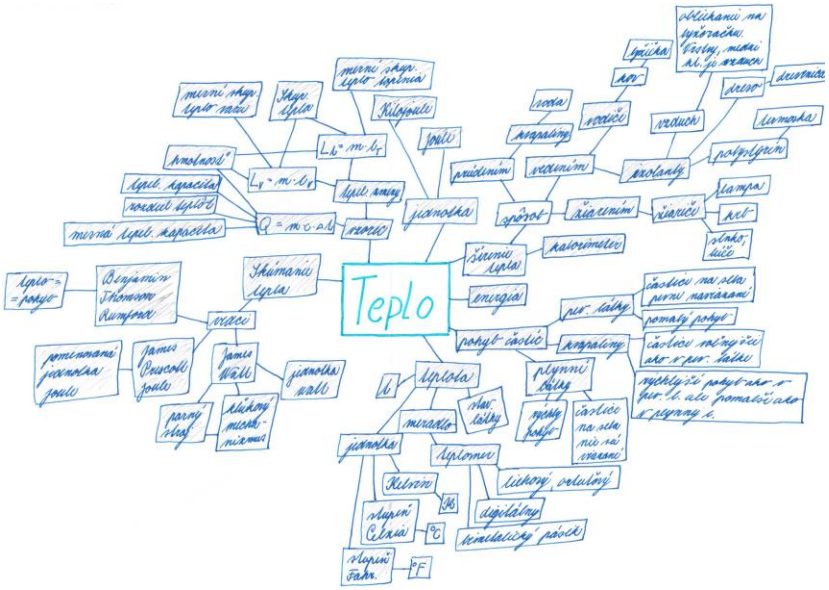
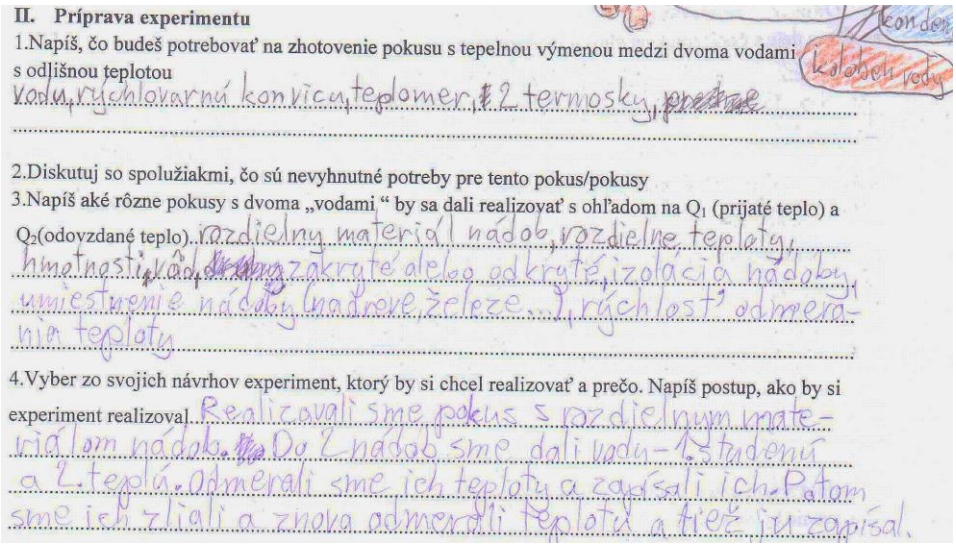


Figure 5: Example of the very rich concept map involving a lot of terms.



II. Príprava experimentu

1.Napíš, čo budeš potrebovať na zhotovenie pokusu s tepelnou výmenou medzi dvoma vodami s odlišnou teplotou

Vodu, rýchlovarnú konvicu, teplomer, 2 termosky, pretože

2.Diskutuj so spolužiakmi, čo sú nevyhnutné potreby pre tento pokus/pokusy

3.Napíš aké rôzne pokusy s dvoma „vodami" by sa dali realizovať s ohľadom na Q_1 (prijaté teplo) a Q_2(odovzdané teplo). rozdielny materiál nádob, rozdielne teploty, hmotnosti vôd, zakryté alebo odkryté, izolácia nádoby, umiestnenie nádoby (hadrové, železe...), rýchlosť odmeriania teploty

4.Vyber zo svojich návrhov experiment, ktorý by si chcel realizovať a prečo. Napíš postup, ako by si experiment realizoval. Realizovali sme pokus s rozdielnym materiálom nádoby. Do 2 nádob sme dali vodu - 1 studenú a 1 teplú. Odmerali sme ich teploty a zapísali ich. Potom sme ich zliali a znova odmerali teplotu a tiež ju zapísal.

Figure 6: The planning of experiment

Which objects conduct electric current

The activity consisted of several stages, i.e. developing a concept map on electricity, designing an experiment on electrical conductivity, selecting available materials, formulating hypotheses on conductivity of different objects, conducting an experiment, drawing conclusions on conductivity and writing an essay on pros and cons of electric current based on searching for information. Based on the written report each part was separately assessed by teacher using 4-scaled rubrics. The examples in fig. 7 involves a

concept map with just a few related concepts (1 point) and hypothesis on conductivity (conducts well, poorly, not at all) of different objects (tea spoon, dice, pen, piece of wood, screw, stone, plastic, scissors, graphite, piece of glass, button, etc.) explored experimentally (4 points).

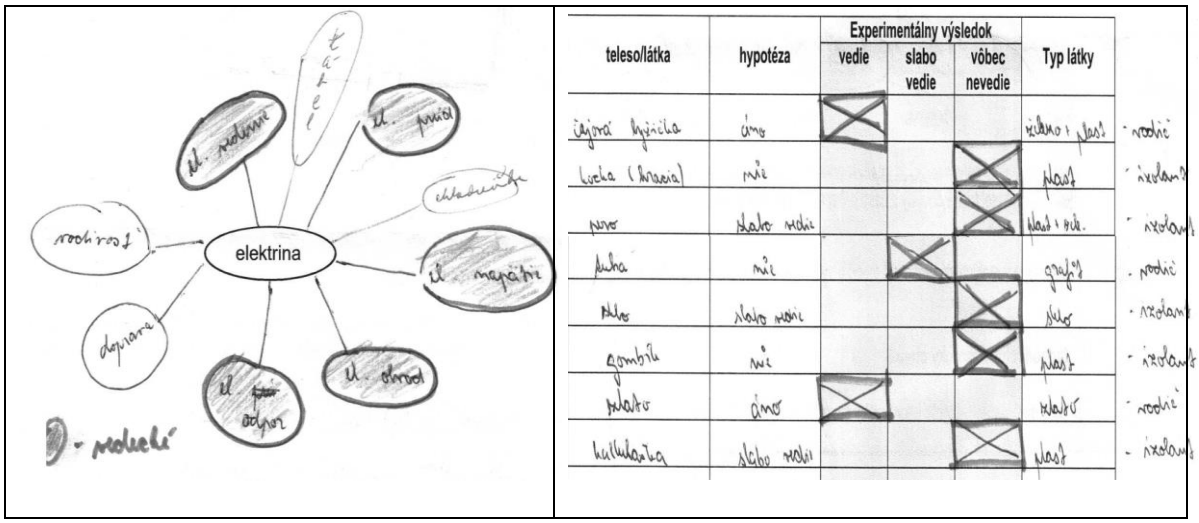


Figure 7: Example of the concept map (left) and hypotheses on conductivity of different objects (right)

CONCLUSION

The IBSE activities are the integrated part of physics education at lower secondary schools in Slovakia. The current curriculum as well as the textbooks is based on this approach. We are trying to carry out and involve pupils into different kinds of inquiry activities that are often enhanced by study visits to research centres, trips and excursions connected with the science topic. At the end we always expect outputs from our pupils presented in different forms (written reports, oral presentations, etc.) However, the evaluation of this kind of activities is usually not straightforward and easy. Our experience is that pupils are expecting and are used mainly to summative assessment with a final grade given by the teacher corresponding to his performance. Gradually, we are trying to implement formative assessment in many forms, not only teacher but also peer and self-assessment. Using the latter ones pupils learn to be critical but fair and respectful. Sometimes these forms of assessment motivate pupils towards the consistent and effective learning even more than traditional summative assessment tools.

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