New approaches in Physics Education, links between formal and non-formal Science Education

The project of non-formal science education SCHOLA LUDUS: THINK, DO AND SHOW

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Why non-formal education

There is great importance on individual activity linked to students' everyday life (OECD, 1996). Parallel with school reforms, non-formal education is also developed. By non-formal education we understand learning not because of certificate but education because of own internal interest and needs. The most popular non-formal education activities are exhibitions, science centres and science festivals. Non-formal education offers unique experimental space for research in public understanding of science with prompt feedback.

My task in the frame of my PhD work was to develop a project supported school science education in non-formal way. My work consists of:

- proposing the theme of the project and their addressees
- creating methodology of the project realisation
- preparing methodological materials
- intrinsic realisation of the project - organisation and evaluation
- preparing and realising the research on children's understanding of chosen physical concepts and utilisation of it for pupils and teachers

The project SCHOLA LUDUS: THINK, DO AND SHOW

The project is build up as a contribution to the Project SCHOLA LUDUS – Slovak Science Centre for All (Teplanova, 1994, 1996). It is intended for children between the ages 10 to 14. The aims are:

- through preparing experiments and demonstrations, encourage children's interest in physics, creativity, invention, handicraft and critical thinking
- through concluding exhibitions of children's demonstrations, develop children's ability to present results of their work, develop communicating abilities, encourage the self-confidence etc.
- support communication mutually between schools, and between schools, parents and community

The name of the project also express its aims and phases of children's work:

THINK - what and why do you want to present, find the problem, build up the questions, make hypotheses, design how you can prove them, interpret the results of your experiment, forecast the result in new conditions

DO - design the demonstration, experiment, change parameters, check the hypotheses, improve the experiment

SHOW - show your results to the others, explain the principles in which your demonstration is working as well as its technical solution, give information about obstacles you had to overcome, give examples from daily life.

The choice of addressee - Cognitive processes between the ages 10 to 14 when they are in a transition from concrete operations to formal operations. This period is characterised by a shift from action (doing) to mental operations which are at first connected with concrete subjects. It sees the beginning of hypothetical-deductive or formal thinking, the development of experimental thinking and thereby the formation of productive thinking.

The project realisation - Children have to prepare their demonstrations at home during the whole school year. The teacher is only a consultant. The child shows their experiments to the class and explains it. Other pupils can ask - not only for an explanation of the phenomena but also for construction, materials, alternatives, ... At the end of the school year children, together with their teacher, prepare an exhibition for other schoolmates and sometimes also for the broader public.

Methodological materials - We prepared a small booklet addressed to teachers. It includes proposals on how to build experiments and how to play with them similarly as in (Teplanova, 1995). Our aim is to support the "notional learning" and "learning through problem solving" instead of "verbal or memory learning". We support it by offering a sufficient amount of opportunities to give various individual experience. Therefore we offer not only description of „ready to run" experiments but also space for creative experimentation. We offer some alternatives on how to build the demonstration. Children have to try and choose themselves what is better according to utility, accessibility, appearance, …

Every theme is completed with some questions. These questions focus on physics and on technical solutions of the prepared „toys". We try to ask in a way which encourages to vary or modify the demonstration. Children must look for answers with their own activity. We consider that this is the way how to change children's way of thinking in order to look for and create optimal reasons in real conditions.

Realisation of the research - Videorecording of children's appearances represent a valuable material of didactical research. Its aim is to discover how children understand selected physical concepts, how they use them in explaining observed phenomena and finally to prepare methodological material which support building of new scientific concepts, respecting children's preconceptions.

Video recording also enable us to compare the approach of children of various ages through analysing children's actions – what they do, how they do it, how they comment and explain it. They speak about things in which they are interested. They are not examined. During the exhibition they answer other children's questions. In this situation children indicate which moments they consider as important and how they understand basic physical concepts, laws and principles.

Evaluation of the previous two years of the project SCHOLA LUDUS: THINK, DO AND SHOW

In first year 1996/97 48 children from 4 schools were involved in the project. Together 102 demonstrations. In second year 1997/98 already 198 pupils from 13 schools (mostly from small towns) were involved and they together had 230 demonstrations. Most demonstrations were focused on the statics and dynamics of fluids (about 50% in the first year and 43% in the second year) and the characteristics of fluids –thermal expansivity, surface tension, capillarity. Other demonstrations were focused on electricity (simple electric circuits, testing of material's conductance), on magnetism (compass, magnetic toys, magnetic pendulum) and on optics (light refraction, inertia of visual perception).

Children showed only one result which they accounted as for the best. Even if they have negotiated some difficulties during the preparation of the demonstration, they did not speak about them. So children did not give all the information, which they had gained through their own work. This is a consequence of values in society. Society only values definitive positive results, not the work and creative searching.

Only in very few cases (15 from 332) the demonstrations fulfilled the requirements of experiments though just this approach is important for developing discussions, to open and solve problems. Many other demonstrations offered the opportunity, at least change the parameters. But children did not took this chance.

Children were challenged to create scientific toys. But only 27 demonstrations can be identified as toys. Only 35 demonstrations were models of technical equipment or would be used in a practical way. This indicates that children do not see the link between school physics and everyday life. They say: ”physics is surely useful but Ican not use it in my everyday life”.

Various explanations - Several times children of various ages presented the same experiment. This fact shows that seemingly very simple demonstrations are interesting and useful for children of various ages, various backgrounds in physics and with various experience. Recording of such demonstrations enable us to observe a shift in children’s thinking and verbalisation.

Concepts without meaning - The youngest children (10-11 years old) still do not feel the necessity to explain observed phenomena. They are fully satisfied by describing a demonstration. They only name parts of the demonstration and describe the result. Rarely explanations were intuitive. Children at this age use simple common language.

Older children (12 - 14 years old) tried to explain observed phenomena. However their presentations outline the absence of their inner necessity to explain, to look for reasons and for causality. Natural curiosity vanishes at children this age. They are satisfied very quickly with formal answers without evaluation. They have no endurance and consistence. They try to use scientific concepts but they use them often in a wrong way. They combine teachers’ words and textbook definitions without any meaning.

Misunderstanding of concepts and causality - Many children confuse concepts (*the amount of air* and *its volume*, *pressure* and *pressing force*), explore deceptive causes (water lens - *water makes things bigger,* no mention about the shape) or do not differ between cause and consequence (*if equal pressure act on the fluid, equal force is created in every point*). These examples testify to inconsistence, superficiality and a lack of critical thinking. Children are not led to independent thinking, to evaluate their own assertions. Mainly it is the teacher who revises children’s assertions, not children themselves.

Room for own explanations - preconceptions - Some very valuable cases of children’s explanations appeared during exhibitions when children tried to explain new phenomena, unknown from school work. In such situations, children used out-of-school explanations combined with their own explanations. (When we blow into the gap between two plastic bottles, they will come together: *It happens because the air turns the bottles around*.) Teachers should use these original children’s ideas and explanations when teaching - start with these preconceptions, warn about their limitations and show better science conceptions. (Nachtigall, 1992, Stork, 1995)

What will we do next year

At present we prepare the third year of the project and the third edition of the booklet and interviews and written questionnaires for children. We are interested how children understand physical concepts presented in their demonstrations which seem to be unclear (pressure, hydrostatic pressure, atmospheric pressure, Pascal’s Law, buoyancy, etc.) and, at the same time, are elaborate in our draft of a new physics course for secondary schools (Teplanová, Biznárová, 1998).

We will focus also to teachers. We prepare a workshop where we would like to exchange experience in teaching and working with children in order to know how teachers use children’s demonstrations. On this basis we would like to open a discussion about children’s understandings.

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