POSSIBLE WAYS OF CHANGING PUPILS' CONCEPTS IN OPTICS

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INTRODUCTION

Non-formal learning approaches developed in the frame of the Project SCHOLA LUDUS are oriented to supporting pupils' curiosity and interest in active cognition. The starting points of pupil's cognitive processes are their current conceptions. These are step-by-step rebuild through active experimentation with everyday things. Cognition is stimulated by using the parallel method with easy–to-made experiments.

"SCHOLA LUDUS: EXPERIMENTARIUM" summer camps are used as one of the experimental basis for the identification of pupils' conceptions and for testing designed learning processes.

Why optics?

The summer camp 2004 was focused on optics. This topic was selected because:

- importance of optics for everyday life – majority of information is received through eyes, but our interpretation of them is not always correct;
- in spite of everyday experiences pupils have many misconceptions;
- optics is used in many modern technologies;
- basic knowledge acquired by investigation of visible light may be generalise to other area of electromagnetic radiation and sound.

Programme of the summer camp

In the aim to create relaxed ambience and awake the curiosity we started from children's natural interest to investigate themselves - their senses. After this - in the context of personal experience - participants of the camp began to investigate basic principles of geometrical optics, information coded in light spectra and basic principles of modelling:

1. *Know your senses* – how can we get information about the world around us? – taste, smell, hearing, touch, sight, the world of weak-eyed and blind people.
2. *Physics of vision* – the function of eye, principles of stereometric vision, eye deficiencies, optical illusions, inertia of eye (creation of animated moving pictures), vision of colours, „after image", complementary colours.
3. *How to produce and direct the light* – light sources, light reflection and refraction, scattering, absorption – Mirror, tell me... (how to create a mirror, what can I see in the mirror, multiple reflection – combination of two or more plane mirrors), The world of uneven mirrors (what can I see in convex and concave mirrors).
4. *Optical phenomena in atmosphere* – why is the sky blue, why is the sun yellow at the noon and red in the early morning, why is the sun oblate in the morning and in the evening, how is the rainbow originated, what is mirage.
5. *Spectrum* – colour as property of light, mixing and decomposition of colours. What colours are in the daylight? How to originate our own "rainbow" (spectrum)? What looks the spectrum of a bulb like, of a fluorescent lamp, of other light sources? Spectrum in non-visible area of electromagnetic radiation, investigation of the universe, distant investigation of the Earth.
6. *Imagining in the medicine (X-rays)* – illumination, shadows [1] (reconstruction of the object from objets' shadows), developing of the photo.
7. *Einsteins' dream and farmers' cows* – explaining of an extraordinary story or Who is right? – the role of the observer, the role of modelling in science, the concept of relativity [2].

DEVELOPMENT OF PUPILS' CONCEPTIONS

In the frame of programme mentioned above we tried out several possibilities how to show children limitation of their current concepts and caused the necessity of reconstruction of these concepts.

Light reflection

Pupils learn about light reflection in the school almost exclusively in the case of mirrors (or in the case of total reflection on the boundary of glass and air). When they try to describe what is going on in the situation showed in Figure 1. after the torch is switched on, they talk about light reflection only in the case of mirror. If paper is used as a screen, pupils talk about light trace on the screen. They do not talk about reflection (they do not see themselves in the screen). [3]

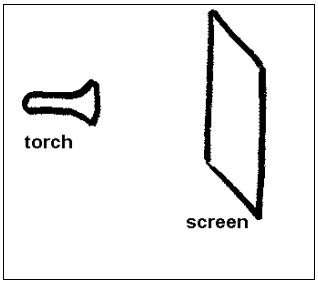

Fig.1. Identification of pupils' conceptions about light reflection.

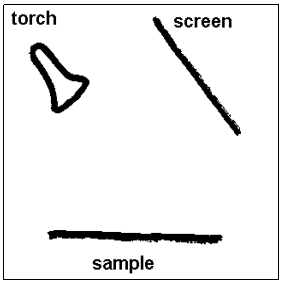

Fig.2. Investigation of light reflection.

Hence the designed learning procedure related to light reflection started from simple qualitative comparison of the intensity of light reflected from different surfaces (different materials with different surfacing: different coloured papers, wood, the face and underside of aluminium foil) - figure 2. The requirement of identical sizes was assigned with stencil made from dead dark paper that we put on investigated samples.

But if every surface reflect incident light, why you cannot see yourself in white paper? The answer is in the microscopic view on the surface structure of the paper and the mirror. (Figure 3.).

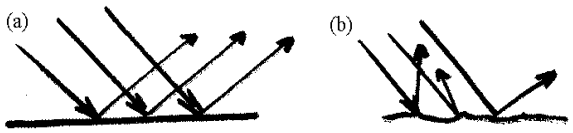

Fig. 3. Light reflection in the case of mirror (a) and paper (b)

Follow-up activities were focused on making one's own mirror, exploring the law of light reflection, investigation of multiple reflection and experimental solving of problem: "How to route the light to the other end of the labyrinth?"

Light refraction

Pupils investigate light refraction in the school almost exclusively with glass lenses. One part of pupils take as necessary condition for light refraction curate boundary (without the influence of angle of incidence). Another part of students take as necessary condition for light refraction fact that light goes through another medium (not air), or that light passes over the interface of two media – again without other influences [4].

Hence we started with exploring light refraction in case of light transition through system of two vessels (outer vessel – small plastic aquarium, inner vessel – a glass) filled with different combination of liquids. (Figure 4.). This simple experiment allows qualitative comparison of refractive indexes of used liquids. We used a laser pointer as a light source. The beam was visualised by adding a drop of milk into the water or yellow food-dye to glycerine.

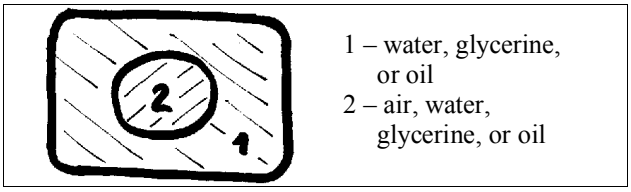

Fig. 4. Investigation of light refraction

Colour as a property of light

Pupils in ages 10-14 understand colour as independent inner property of the object/material [3]. Though several pupils told in the interview that the colour of an object could be "a little bit" different in daylight and in the light of fluorescent lamp, they thought only in terms of colour tone. It was very surprising for them that in certain conditions different coloured objects seem alike (e.g. red and green object illuminated by red light).

The above mentioned phenomena can be introduced in an attractive way by using glasses with optic filters (one part of pupils uses for example red glasses, another part uses green glasses). The task is to read text written partially in one and partially in second of used colours.

Development of pupils' conceptions about the colour and their currency to whole spectrum (behind the visible part) allow to point out information hidden in invisible part of electromagnetic spectrum. Pupils acquainted with infrared imagining used in medicine, satellite imagining of the Earth and using of false colours to code physical information.

Shadows

Most of pupils have experience that the size of shadow depends on the relative position of the object and the light source. But they have problem with explanation of fuzzy shadows. Fuzzy shadows can be caused not only by diffraction. It is usual to ignore real size of light sources – its angular extent – in school practice. A simple experiment: illumination of a pencil by torch in different relative distances shows us dependence of shadow's shape on relative size of object and light source and their mutual distance (figure 5). [5].

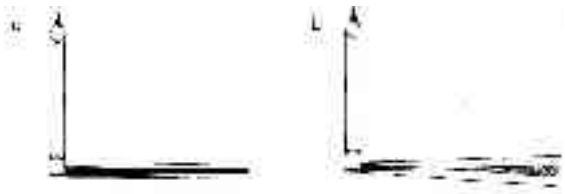

Fig.5. The shadow of pencil illuminated by torch
a) relative distance 2 m b) relative distance 20 cm

Investigation of shadows and reconstruction of the object shape according to its shadows can start the discussion about X-rays and their medical utilisation.

CONCLUSION

Mentioned suggestions and experiences are only a part of SCHOLA LUDUS program focused on research of pupils' conceptions and development of alternative educational approaches in learning basic optics.

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