Experiments “to lay your hands on” at school

Experiment stations make students curious to find out about physics

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The year 2000 has been declared the year of physics. With this decision it is to be emphasised what physics means for the next century. “Physics is the future” assured the DPG with conviction. “Physics is out of touch with real life and difficult”: this is a similarly determined statement by many students. They do not consider physics to be an attractive school subject. Experiment stations in physics at school can help to make the subject of physics more attractive.

There is no denying the fact that the ability to perceive phenomena in our surroundings, to structure and understand them and to store them as a basis of our experience must first be developed. During a long process a young person learns to grasp the meaning of space and time, gradually accepts the independence of an exterior world and learns to differentiate between cause and result. If adolescents are preoccupied with a world of illusions, with “virtual reality” in an exaggerated, one-sided way, they run the risk of not gaining enough confidence in their own perception [1].
Another controversial fact is that a young person can only learn to think objectively in cases which give him or her close access to the objects of discovery and knowledge. Perception with one’s own senses, understanding through concrete actions that can be stopped, repeated an even changed provide the possibility of initiating the structures of rational thinking and of encouraging this process further on. As a result of the basis of reliable items of experience a meaningful view of the world can be formed [2].
Now as ever it is schools that have the fundamental task to help students find a reality that is guided by their own rationality. Schools are expected to contribute to youngsters becoming self-determining adults. Especially physics as a fundamental science offers a lot of possibilities of fulfilling this educational aim.[3].

Physics: a dead foreign language?

Physics as a school subject does not seem to be able to live up to its educational demands. A lot of concepts to be learned are too complicated; all in all, there remains not enough time to learn to think in terms of physics and to practise what has been learned, groups of students are too large, there are not enough practical exercises, and many physics teachers are too much math-oriented in their lessons. These basic conditions have led to the fact that a lot of students primarily learn physical formulae and technical terms without being able to relate this to reality. In many cases, physics as a school subject has lost much of its inherent proximity to nature and the environment. To many pupils physics seems like a dead and difficult foreign language remote and unreal so that they cannot realise what it is all about. It is an undeniable fact that students have growing difficulty measuring influences and different sizes and keeping cause and result apart. Creative solutions to problems in class have thus become impossible.

Experiencing physics with your fingertips

However, experiment stations in physics are meant to heighten and pinpoint the students’ perception! With experiments easily carried out there, natural and technological phenomena can be experienced very closely and directly. There, a truism can be applied: it is easier to grasp the meaning of something that you can grasp and literally put your hands on [4].

In a lot of countries around the world such museums of experience which provide physics you can feel with your own hands have already been brought to life. In Germany there are such institutions too, as for example the German Museum in Munich, the "Phänomenta" in Flensburg, the "Spectrum" in Berlin or also the "Erfahrungsfeld der Sinne" in Nürnberg /Nuremberg which has existed for some years now. Visitors can not only see something there but, more importantly, do something. Physical phenomena to be perceived there encourage interactive learning, surprise and awe, lingering, reflection and an exchange of thoughts when talking to others. Frequently, it is possible to interfere with on-going experiments. Some stations can only be experienced by groups of two or several people. Thus a person's social competence is being promoted. In group discussions recipients can structure their own thoughts, find answers to their own questions; the students undergo a learning process [4].

Experiment stations at school

About six years ago during the 58th conference of physicists in Hamburg I first experienced an impressive selection of close-access experiments which belonged to the "Phänomenta"-Exhibition. I intended to rebuild some of these experiment stations and, as far as feasible, establish them in the corridor in front of our physics rooms.
On two project days at the end of July 1994, the first three stations were being planned and also built together with students and some young teachers of the physics seminar.

To create a "wave mirror" a big, right-angled, flexible and reflective transparency usually used for decorative purposes was shaped into a mirror with a convex and a concave curvature alternately while resting in a wooden structure. The radii of the curvature can be modified with the help of flexible wooden sticks. The results are in part completely distorted, hardly predictable mirror images of one's own body if the distance to and from the mirror is being changed.

The station "stereo reception" enables students to have a very sensitive perception of a small wooden stick having hit a plastic hose on the right, or rather on the left or right in the middle.

The station "turning head" is an interesting example of the fact that our perception is largely shaped by habit. The station consists of two hollow face masks illuminated from behind, one of which shows the viewer the part that is curved towards the outside (convex), the other the concave part (curved towards the inside). From the right distance the concave mask appears convex at the same time. The human brain refuses to look at a "hollow face". Moreover, the hollow face pursues the spectator passing by, which a "normal face" does not.

Reflections about selection

Our decision to establish new stations results from pragmatic rather than profound psychological considerations. The following questions are in the centre of attention: Are the physical phenomena interesting for students? Can the necessary material be provided without difficulties? Does the construction require particular manual skills? Is it possible to establish the stations in cooperation with pupils during two morning sessions? Is the amount of costs for the material within acceptable limits? Are the stations strong enough to be exhibited in a school's corridor without being supervised by a teacher?

Preliminary planning

Some of the experiment stations can be found in almost all science-centres, most objects, however, are at the "Phänomenta" in Flensburg. With the help of publications and photos of our own we have created the individual construction in a way that entails direct access of the human perception to time, forces, distances etc. because they have

assumed appropriate proportions. No precise plans before the construction is an advantage: on the one hand, the participants of different work groups are forced to become creative when dealing with problems without being told to do so. The result in some cases are highly original solutions, which do not only arise from intuition but are sometimes also based on amazingly profound knowledge. On the other hand, it is during the phase of constructing sites that interesting suggestions of changing the original visually presented objects are realised, suggestions which would not have been taken into consideration when meticulously rebuilding a site. In addition, it is essential at this stage of the project to unanimously decide how to proceed. This way, the ability to communicate and to develop social skills are improved. Taking over responsibility for oneself and for the result almost always leads to motivation which inspires strong commitment, that is hard persistent work and perseverance.

The participants of the project

In all science-centres and areas of experience well-qualified experts create exhibits, build them in well-equipped workshops and keep them on stand-by. At a school like the Hardenberg-Gymnasium stations are built by students covering the age-range of ten down to nineteen under the help and guidance of young teachers in our training courses and myself. The number of student groups comprises 10 to 15. On average twice as many boys than girls are committed workers on the stations. Participation in the project is voluntary.

Building the stations

A lot of the stations were established within two days. Therefore the individual steps of the project had to be balanced against each other very well. The groups were subdivided according to various particular tasks which in most cases were pursued in small teams of two. Experience has shown the advantage of working in groups of two down to six under the supervision of a young teacher of the seminar or a teacher trainer, depending on the complexity of the object to be dealt with. Only by dividing the work load is it possible to implement the necessary tasks within a limited amount of time. In the groups team spirit develops as a natural consequence of working together and becomes palpable. Every participant feels that he or she can contribute to the task as a whole. Whenever there are difficulties in one group, the other group is ready to help. When selecting the objects it is absolutely necessary to bear in mind that the chosen task – the creation and exhibition of an experiment station – can really be fulfilled during the period of time at our disposal.

A lot of stations are on permanent display in the corridor in front of our physics rooms, for instance the “mirror of infinity” (fig. 2) and the “stable slanted tower” (fig. 3). Some stations like the “magnetic suspension through induction” (fig. 4) are put on display on special occasions and also used in classroom teaching. Beside every station there is a small board on which the phenomenon in question is briefly described and some tasks to work on are offered. More information can be found on the local school’s homepage: www.hardenberg-gymnasium.de.

Curious students

In contrast to visiting a museum, the students again and again have the chance to make their own experiences with the exhibits in the corridor. The usual times of experimenting are the spare time between lessons, the two breaks of a school morning and the longer noon break.

At the experiment stations that have recently been established the youngsters usually have no special aim in mind when passing by. They stroll along, set the experiment off

and try to find out in a playful mood what possibilities the station has to offer. The hints beside the stations are hardly ever read. However, as the stations are constantly with us, all students including colleagues who teach other subjects are preoccupied more closely and with a special aim in mind with the phenomena and possibilities to change parameters whenever they find time. There are certainly students whose interest is dwindling after being at the stations several times. Some, on a long-term basis, seem to have more fun working on their special "favourite stations" than waiting passively for entering the physics room. Additionally, at some stations special skills which develop only through frequent repetition are required for a successful experiment.

Although stations are not supervised, they have not been destroyed through pure mischief. Repairs were only necessary because they naturally wear down or are obviously misconstructed. Perhaps the reason for this is that most students know that these stations were built with the help of many fellow students.

The behaviour of pupils who do not yet have physics lessons, i.e. pupils from the 5^{th} down to the 7^{th} grade, is especially interesting. First they regard the experiments as toys with which they can change parameters and watch the effects. As the effects at many stations are, on the one hand, so new that pupils cannot explain them themselves, but on the other hand, contain a lot well-known aspects, they react with surprise and "amazement". Through experimenting – playing with the objects with a special aim in mind – they find for themselves elementary pre-formal explanations which can form the basis of a profound understanding and learning later [5].

The effects of pupils being confronted with physical phenomena at the experiment stations on their acceptance of physics as a school subject have so far not been investigated systematically and are probably difficult to prove. The results of opinion polls in several classes have been positive all through. In any case, one can refer to experiences made at the stations in physics lessons while working on material for studying. Observations have proven that at the stations students can receive first-hand experience of the fact that dealing with physical issues can be joy and fun.

Outlook for the future

The omnipresent project "planning, construction and exhibition of experiment stations" undoubtedly contributes to enhancing the quality of school life. Students, participants of the seminar and teachers are committed to a common cause in the form of extracurricular activities. The objects on display can be used without any restrictions by everyone; they are something special at our own school. Perhaps also in future ever new generations of pupils may be encouraged to find interest in becoming aware with their own senses of a small part of the real world of physics at the stations.

Literatur

[1] *L. Fiesser*, Anstiften zum Denken - die Phänomenta, Bericht über ein Forschungsprojekt, Flensburg, 1990

[2] *M. Wagenschein*, Die pädagogische Dimension der Physik, Westermann Verlag, Braunschweig, 1976

[3] *L. Fiesser, H.G. Homfeldt*, Phänomenta - Physik und Technik erleben und begreifen, Sonderdruck aus: Pädagogisches Forum, Heft 2, Schneider Verlag, Hohengehren GmbH, Juni 1992

[4] *M. Kiupel*, Physik lernen im Science-Zentrum? Vor-formales Lernen als Grundlage für den Physikunterricht, Physik in der Schule, **36**, S. 217 (1998)

[5] *L. Fiesser*, Phänomenta - durch Physik denken lernen?, Phys. Bl., Juli/August 1994, S. 678

Fig. 1:
Students cooperate to build a new experiment station to be set up in the school's corridor: when building a bridge with bricks which are shaped like the line of a chain turned upside down, the bridge remains stable even without "glue". At the Hardenberg-Gymnasium the experiments you can touch have become a popular pastime during the breaks.

Fig. 2:
Leaving everyday routine at school behind and taking a glimpse of eternity – all this is possible with the project in physics. Why are the reflections of the chain of lights becoming smaller and darker? Beside every station the experiment is described on a small board, with tasks attached to it.

Fig. 3:
With the given square wooden blocks a “slanted tower”, which is jutting from the edge as far as possible without collapsing, is meant to be built. Its width is being measured and put down on a list.

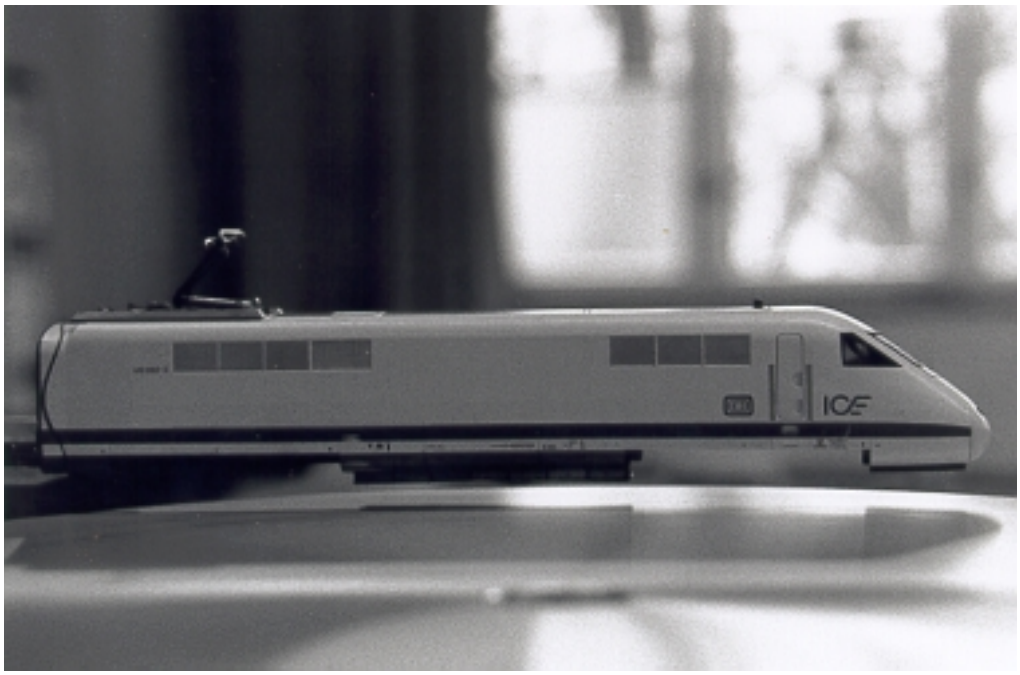

Fig. 4:
So far the stations have been exempt from destruction out of pure mischief. However, some experiments can only be observed in a classroom: “magnetic levitation” results from an aluminium disk above a model vehicle being made to rotate. The magnets at the bottom of the train induce eddy currents in a disk which create a magnetic anti-field. This leads to a lift-force and also a break-force.

Fig. 5:
A young teacher of the seminar also works for the project with strong commitment. Here she is drawing a geometric figure which when moving around slowly appears to be a spatial cone, in whose centre there is an “eye”.

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