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Sparking Pupils' Engineering Interest with Laboratory 'TechLab'*

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The authors claim that the pupils' laboratory TechLab at the Leibniz University Hanover is an answer to pupils' disinterest in technology, the negative image of technology and the insufficient technical education at school. A further aspect for the foundation of the laboratory is the growing demand of engineers, technicians and their educators. The analysis of an engineer's field of activity and the lack of pupils' knowledge is the basis of the concept of the laboratory. For an effective implementation of the concept it is necessary to bring the worlds of school and university together. Thus, the specific characteristic of the laboratory is the teamwork of scientists and teachers on the same level in order to get pupils interested in technology.

Keywords: Sparking interest in technical subjects; pupils' laboratory; collaboration of schools and universities; students supervise pupils

INTRODUCTION

FOR SEVERAL YEARS, technically orientated disciplines, in particular engineering, have internationally faced a dramatic decline in the number of students enrolled. This stands in a disproportionate relationship to the great demand for highly skilled experts and leading executives in the aftermath of economic upsurge in Germany and the rest of Europe. This gap is likely to keep widening in the near future if the general education system does not counterbalance the trend. In particular, the fields of electrical and mechanical engineering have a lack of new blood After a massive collapse in the mid 1990s, the number of first-year students increased in the last five years but remains at a very low level. Surveys of the ZVEI (Zentralverband Elektrotechnik- und Elektronikindustrie e.V.) and studies of the VDI (Verein Deutscher Ingenieure) have revealed that, in the long run, this will not suffice to meet the demand for skilled engineers in Germany. Both organisations call for motivating and appealing to pupils in order to increase the number of students [1].

For pupils to choose to study engineering science they need to get interested in technology on an emotional basis. The TechLab of the Leibniz University of Hanover was mainly founded to achieve this aim. An underlying fascination for technology helps to make pupils realize that a substantial knowledge of science is an important prerequisite for academic studies and for later careers. Consequently, the willingness to gain know-how in these fields can be increased. Teenagers need to break away from wrong ideas about technical fields because they often make career choices without having previously acquainted themselves with the professions.

Jobs in the technical field are, furthermore, often negatively associated with bad experiences in scientific subjects in school (such as being too difficult, too uninspiring).

Traditionally, pupils are educated in the conventional scientific subjects. Yet an intensive cross-linkage to applied subjects, like electrical, mechanical or civil engineering is missing [2, 3]. Pupils do not become aware that the aim is not to accumulate knowledge but rather to be able to respond flexibly to various challenges in later professional life or, at least, to have a basic knowledge of technical requirements. Training pupils to be basic researchers rather than practical workers is the primary aim of schools, in particular grammar schools because teachers are educated in this way. The existing canon of subjects in schools additionally complicates a shift towards a cross-linked perspective of basic research in form of applied subjects. In school, pupils learn the basic laws of physics yet the actual professional life of a technician or an engineer remains unknown and unclear. This is where the pupils' laboratory TechLab of the Leibniz University of Hanover comes in. The occupational field of an engineer is made perceptible by means of practical experiments: Mobile phones, CD-players and bicycles are familiar items for adolescents in their daily life. In the TechLab they can research the operating modes of these commonplace items in independent experiments and thereby grasp the accomplishments of engineering. For example, they can examine rechargeable batteries, dead spots or the actuation of the display of a mobile phone or study the laser

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and the principle of a D/A converter of a CD-player [4].

The TechLab sets itself the target to visualize the engineers' way of thinking and working by putting pupils into the position of an engineer.

JOB PROFILE OF AN ENGINEER

The primary task of an engineer is finding a solution for a technical problem. Suitable procedures have to be examined, costs evaluated and, finally, plans implemented so that a solution to the technical problem can be found. Individual experience and knowledge are the basis for all considerations necessary to find the solution. Quick comprehension and the ability to familiarize oneself with previously unknown topics are also helpful. The engineer has to deal professionally with the problem and develop solutions in a team together with other engineers. This may at first be only a partial solution which then needs to be optimized. Many different people from various fields work together on such projects. Therefore, the ability for teamwork is a crucial competence of an engineer. Apart from the technical perspective economic aspects also need consideration. The engineer identifies with the points of view of those involved in the project and the customers and, consequently, serves as the junction between these people. Tasks like project management, coordination as well as the ability to sum up complex technical issues in an understandable manner further complete the profile of an engineer.

TECHLAB, PROMOTING FUTURE TECHNICAL TALENTS

To provide pupils with insights and details about the profile of an engineer the TechLab uses an activity-orientated approach. The aim is to arouse interest in independently transferring their knowledge from school to real problem-solving in experiments of electrical engineering, mechanical engineering and physics [5]. In each subject area familiar utensils of everyday life are examined. In the case of the electrical engineering laboratory this is a mobile phone, in the laboratory of mechanical engineering a bicycle and in the physics label a CD-Player is the subject. Figure 1 shows an overview of the current experiments. The experiments are designed for pupils ranging from 8^{th} grade to the final classes, with a particular focus on the age group of 14–16 year-olds. The handling time of each experiment is about one hour.

The electrical engineering laboratory currently contains four experiments. In the first one, the rechargeable battery experiment, pupils run a mobile phone by means of a dynamo, watch the variation in current draw in different modes of usage of several phones on an oscilloscope and lift weights using the batteries of the phone (see Figure 2). The second experiment deals more specifically with the construction of the mobile phone, in particular with its display. Specially made models illustrate and explain the development of a display.

A mobile phone can be dissected into its constituting elements which can then be closely analysed. The third experiment in the field of electrical engineering is about the shielding of electromagnetic radiation. Various materials are tested for their suitability. In the fourth experiment, pupils can construct a model city and provide it with a fictitious mobile network. In doing so, the problems of network operators can be made clear.

The physics laboratory analyses a CD-player in five different experiments. The first one initially only deals with the acoustics in a general way (see Figure 3). By using different methods, sounds are made visible as oscillations; a hearing test and an analysis of the frequencies are carried out with a computer. The second experiment compares the surfaces of records, CDs and DVDs. This is done with the help of a magnifying glass, a microscope and a self-made scanning tunnelling microscope. In the third physics experiment the d/a-conversion of a CD-player is in the forefront. The digitalization of oscillations is demonstrated to the pupils.

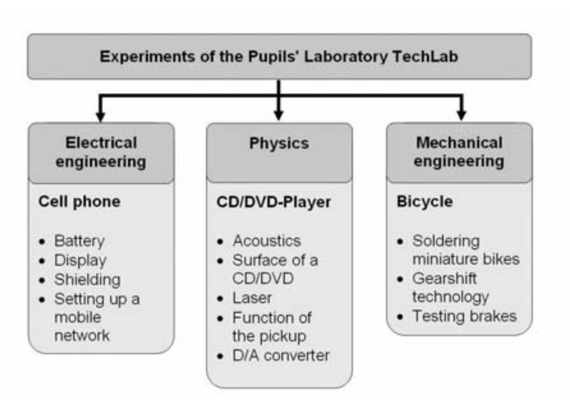

Fig. 1. Overview of current experiments.

Fig. 2. Pupils in the electrical engineering laboratory.

Fig. 3. Pupils in the physics laboratory.

Fig. 4. Pupils in the mechanical engineering laboratory.

In a short and playful introduction the binary number system and the term 'sampling' are explained. The last two experiments deal with the pickup, that is, the laser unit of the CD-player. In the fourth experiment the operation mode of this item is exemplified according to Figure 3 and the fifth experiment deals with the question why the CD-player makes use of lasers at all.

The laboratory 'mechanical engineering' currently contains two experiments with a bicycle. The historical development of a bicycle is reflected in the first experiment. The pupils listen to a radio play in which different types of bicycles are described in their historical context. Subsequently, the pupils can construct their own model of a bicycle according to a guideline by soldering copper wire. The second experiment treats the power input and power output as well as the development of a bicycle. The pupils can measure and evaluate the energy used with the help of an ergometer. In the second part of the experiment, the deconvolution, i.e. the distance covered by one turn of the wheel in different gears, is measured. By means of a computer programme the data are analysed and transferred to the manner of changing gears when riding a bicycle (see Figure 4).

Apart from the independent experimentation, two demonstrative experiments are carried each day. These experiments show the results of former diploma-theses as well as those of ongoing research. This allows for an insight into the research activities of different faculties of the university. If previously arranged, there is also the possibility of attending lectures of the university. The experiments of all three laboratories are continuously developed with two aspects in mind. First, new experiments are planned for the mechanical engineering laboratory to increase its range. More precisely, an experiment is developed in which pupils can learn about the operation mode of a bicycle break. Here, different influencing factors can be investigated with the help of computer enhanced measurement technology. Further experiments about casting, grinding and forming are envisaged to demonstrate these production techniques. Differences in these instructions are made to suit the divergent needs of pupils coming from different types of schools. Pupils coming from the senior classes of grammar schools especially need extensions or enlargements of the experiments to address them on an appropriate level as potential future engineers.

HISTORY AND DEVELOPMENT OF THE TECHLAB

The TechLab came to life in a rather unorthodox way. Unlike following an administrative topdown-principle common in Germany, it originated in the inspiration of a teacher and a university professor following a bottom-up principle. Instead of writing their six-week project paper in school, in 2004, a small group of pupils was given the chance to write it in the Institute of Basics of Electrical Engineering and Measurement Science. The pupils were provided with notebooks which allowed them to evaluate their results easily and include them in their papers. The project was called *The Flying Classroom* alluding to a famous novel of the same name written by Erich Kästner. This first collaboration turned out to be so successful that regular visits of pupils followed. Rather than promoting a few particularly gifted students, the aim was to provide as many as possible with the opportunity to visit the university. Sponsoring the less interested pupils and attaining a widespread effect were paramount. The public image of technical professions, which is not always positive and accurate, was thereby intended to be improved. This idea reflects the basic concepts of the pupils' laboratory TechLab.

A small group of scientists and teachers, as a steering committee, assembled in their leisure time in order to develop a concept for the TechLab. It consists of representatives of different institutes of the Leibniz University of Hanover (Electrical Engineering, Physics, Mechanical Engineering, Didactics of Technology, and Didactics of Physics), the Niedersächsische Kultusministerium (Ministry of Education of Lower Saxony) and the Landesschulbehörde (school board), as well as individual grammar schools in the surroundings of Hanover. About 40 people were on this committee. The steering committee created the necessary framework for the TechLab. An initial achievement of this group was the organization of a permanent location for the pupils' laboratory, including some refurbishment work necessary to install laboratory rooms. The teachers and scientists worked as a team in the steering committee. Their equal collaboration was continued in the operation and further development of the pupils' laboratory. The Ministry of Education of Lower Saxony was asked to delegate some teachers to this team. Currently, the new role of the steering committee consists in supervising and controlling the team.

After setting up the steering committee, networks began to appear which participate in the development of the TechLab in a manner profitable for each side. The project papers of the pupils from the first phase can be mentioned here since they provided numerous impulses for the later experiments. Students pursuing teaching qualification in physics have contributed to the development and evaluation of the experiments of the TechLab by examining it for their final thesis of the state exam. Initial test runs with pupils were carried out in 2005 on the regular premises of the university. These tests were additionally evaluated by the staff of the division Didactics of Physics of the University of Hanover in the light of certain pedagogical aspects [6]. Results of this study are used to improve the didactic concept of the TechLab. Up to November 2005, the number of participants amounted to about 250.

ORGANISATIONAL FRAME OF THE TECHLAB

As mentioned above, the TechLab is a joint project of the Leibniz University of Hanover and Ministry of Education for Lower Saxony. The university provides the premises for the laboratories and the initial set of material for the experiments. It also funds a part-time position of a research associate (graduate engineer) and research assistant for supervision of the pupils. Furthermore, the Niedersächsische Kultusministerium (Ministry of Education of Lower Saxony) and the Landesschulbehörde (school board) delegates three teachers for some of their working hours, coming from the Gymnasium Goetheschule Hannover, Gymnasium Bad Nenndorf and Gymnasium Bismarckschule Hannover, for organisational and supervisory tasks. Six student assistants supervise pupils in the individual rooms of the laboratory each day. They are students of technical subjects, such as electrical or mechanical engineering, as well as of pedagogy or the humanities. Choice and allocation of the student assistants lies in the hands of the leading team and is of crucial importance for the quality of the laboratory. Due to the small age difference between the students and the pupils a relaxed atmosphere immediately arises which serves as the basis for a successful stay at the laboratory.

Assuming that the laboratory is fully utilized and all posts of student assistants are taken, the personnel costs for the student assistants alone amount to almost €15,000 per year. The costs of the leading team (scientists and teachers) are estimated to be €75,000 per year. The acquisition costs for the equipment, tools, etc. cannot be precisely stated since many second-hand instruments are being used. In contrast, the costs for new acquisitions and repairs amounted in 2007 to €10,000. Expenses for rent, electricity, heating, etc, which are hard to estimate are not included in this sum. Summing up all the above mentioned expenses and relating them to the number of visiting pupils, a sum of €50 per pupils can be arrived at. The funding is covered in part by the Leibniz University of Hanover (personnel costs of the student assistants and the scientists, laboratory facilities and acquisition costs) and by the Ministry of Education of Lower Saxony (one teacher). Additional financial support is donated by the Stiftung NiedersachsenMetall, the Verband der Metallindustriellen in Niedersachsen e.V.. Regional industrial enterprises, such as Hüttenes Albertus, Sennheiser, Johnson Controls and VSM AG, support the project in form of donations in kind of experimental setups. In this way, the visit remains free of charge for the pupils.

The TechLab was put into regular operation on 15 November 2005. Since then, approximately 60 pupils have experimented in the TechLab on two days each week. Moreover, advanced training for the teaching staff was realized. In 2006 and 2007, the first two full business years, saw more than 3500 pupils and about 150 teachers visiting the laboratory. The TechLab was booked for more than 87 per cent of the available time. Most of the classes came from the city and greater region of Hanover.

A further organisational aspect is the actual daily routine in the laboratory: after greeting them, the classes are divided into small groups of 2–3 children each. They are allocated to the three laboratories (physics, electrical and mechanical engineering). Each group remains in one room for the whole day and carries out the different experiments. The experimenting phases are livened up by showing a 20-minute film about a research topic, for example, nanotechnology, and demonstration experiments introducing the results of scientific research. Pupils can chill by visiting the neighbouring canteen, which also gives them an insight into student life. Pupils cannot carry out all the experiments they have chosen during the three rounds. But they can exchange their experiences and new knowledge in discussion afterwards. This conversation is moderated by the student assistants who supported the pupils' experimental work during the day.

The fourth phase of the experiment consists in a free session in which the pupils visit the neighbouring rooms in order to see what their classmates have been working on. In the course of the day, the groups have become 'experts' in their own subject area and they can share their knowledge as well as profit from the know-how of the others. Before leaving the TechLab after approximately six hours, a final discussion is held, giving the pupils the opportunity to express their experiences in the presence of the leading team and supervisors.

MARKETING

The TechLab is usually visited by whole classes that have been registered by their teachers in advance. Therefore, teachers of the different types of schools but also parents and pupils are the core group that needs to be addressed as 'customers' by publicity programmes of the TechLab. In order to establish personal contact with this target group, the TechLab exhibits at fairs of different organisations in the areas of schooling and youth. Recent examples of such fairs are *Technik verbindet* (Technology connects) [7], the section *TecToYou* of the Industrial Fair Hanover [8], and the *Ideenexpo* (Idea Expo) [9]. Selected experiments of the TechLab were presented at them all and, as far as possible, workshops for teachers and pupils were organized.

As for print media, for example, in [10], a sufficient number of flyers and posters illustrating the TechLab is available at the fairs and other events to be handed out to interested visitors. Regular annual reports document the management of the TechLab. These reports contain statistics of the utilization of the TechLab, activities outside the Leibniz University of Hanover, collaboration with institutions of higher education, other pupils' laboratories and sponsors. Future developments and expansion of the experiments are furthermore described and, consequently, the prospects for the future of the laboratory are demonstrated. The annual report is provided to institutions to which the TechLab particularly needs to render account. These include:

- the school board, supporting the TechLab in delegating the participating teachers,
- the Leibniz University of Hanover, bearing further costs for personnel and operation,
- sponsors from industry,
- the steering committee of the TechLab,
- individuals giving advice or showing a particular involvement in the future development of the TechLab
- everyone interested in the work of the TechLab.

Apart from collaboration with suitable faculties of the Leibniz University of Hanover, the leading team is eager to establish external networks. The aim is to advance its own development but also to make a contribution to establishing pupils' laboratories more firmly in the German educational system. At the initiative of the foundation NiedersachsenMetall a network of different pupils' laboratories (LabNet) is currently being established in the greater region of Hanover in which the TechLab takes active part.

Additionally, the TechLab is listed in the collection of German pupils' laboratories which is administered by Lernort Labor–Zentrum für Beratung und Qualitätsentwicklung [11]. 234 laboratories are recorded on this list. The laboratories can be found all over Germany; however, they are mostly located in regional capitals, cities with higher education facilities or highly industrialized regions. Among all pupils' laboratories, 35 others claim technology to be their special field of activity. This means that the vast majority of laboratories offer experiments that require some interdisciplinary effort, but they clearly follow the canon of the scientific school subjects, including mathematics, computer science, geosciences, nature protection or rather nature studies. The TechLab is exceptional in this respect since its experiments put a particular emphasis on the field of engineering. The experiments themselves offer the necessary requirements; knowledge of physics is only used as a tool during the experimentation.

In a constant effort for further development, members of the staff attended congresses, such as

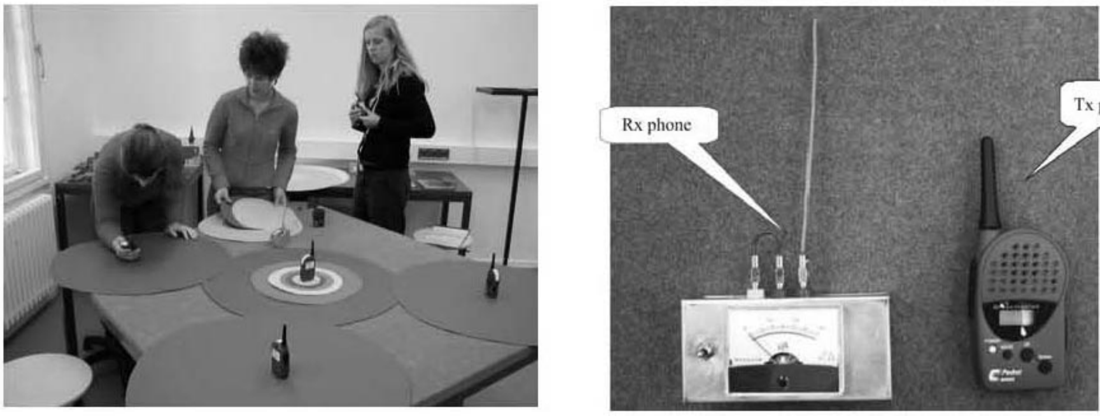

Fig. 5. Examples of an experiment. (a) Receiver and transceiver cell phone (b) Determination of the number of masts of optimal reception.

the International Conference: Meeting the Growing Demand for Engineers and their Educators 2010-2020 of the IEEE in Munich (09.11.07—11.11.07) [12], the nationwide Nat-Working symposia of the Robert Bosch Foundation or meetings of the Deutsche Telekom Foundation [13]. A particular significance is given to the internet web page of the TechLab [14]. Similar to a company, this page is like a business card providing important information about the laboratory, its concept, realization, history and goals. There are individual sections for teachers and pupils describing the laboratory and its experiments. A booking schedule is constantly updated allowing teachers to register their visit online for a designated date. The web presence is rounded off by a photo gallery and a download area.

DETAILS OF TYPICAL EXPERIMENT

The experiments of the TechLab always pose a technical problem from various fields of engineering that the pupils are instructed to resolve independently, thereby drawing parallels with the working life of a real engineer. This principle can be illustrated more precisely via an experiment from the laboratory electrical engineering. The core of the experiment consists in building a fictitious mobile network for a model city which is created by the pupils themselves. As in real life, the initial problem is openly presented. The pupils act as designing engineers and have to resolve the task of positing transmitter masts in such a way that optimal reception is ensured in every area of their city. The first task consists in determining the amount of radiation of a transmitting mast. Walkie-talkies serve as the masts, transmitting at the freely available UHF-frequency 433 MHz (Tx phone). A simple measuring instrument for detecting electrical field strength, constructed by pupils during tutorials, serves as the receiving mobile phone (Rx phone). The gauge is composed of a monopole antenna at the length of $\lambda/4$ of the emitting frequency and a metallic box with a rectifier and an ampere meter. The rectified current can then be displayed by the microampere meter. The sensitivity of the instrument can be regulated by an inbuilt potentiometer (see Figure 5a). Initially, the model city does not exist. A large table coated green is provided for the experiment. Information leaflets, explanatory cards and teaching aids are given to the participants. The lowest level of field strength at which sufficient reception of the mobile network could be guaranteed is defined. To define the emitting behaviour of the transmitting masts circular disks are provided which are to be assigned to individual levels of field strength. This allows for finding out the furthest possible distance of the mobile phone from the mast. In doing so, pupils can arrange the positions of the transmitting masts on an even plane (see Fig. 5b).

After determining the positions of the transmitting masts the city is 'built', which means that model building houses are placed arbitrarily on the table. This is a playful activity which nicely contrasts the theoretical nature of the experiment. Once the city is ready, new measurements are

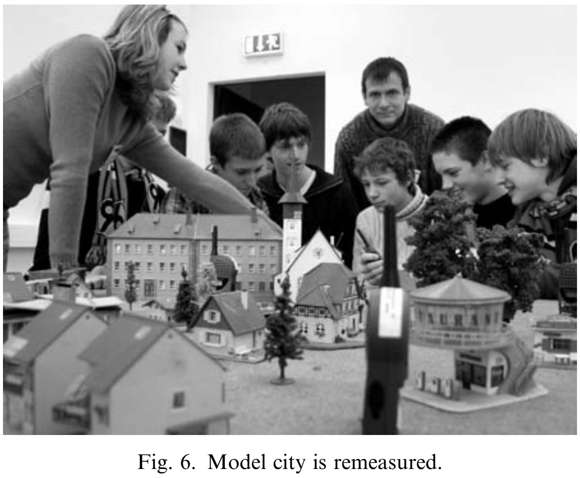

Fig. 6. Model city is remeasured.

carried out with the self-made 'receiver cell phones' (see Figure 6).

Since aluminium foil is attached to the inside of the houses, the shadowing effect arises. Consequently, the positions of the masts have to be rearranged and the field strength between the houses of the city has to be measured anew. Parallel to the approach of a 'real' engineer, the pupils come closer the optimal solution to the problem by repeating measurements. In doing so, they secure a certain level of field strength in the whole model city. If the pupils are interested in more information, they can get additional theoretical knowledge, like the distribution of electromagnetic waves, in explanatory index cards.

Other modules and tasks can be added depending on the age and performance of the pupils. These may include explaining the cell structure of a net (parallel use of several frequencies in one radio network) or the topic of 'electric smog' of transmitting masts. Further exercises are currently being developed for the more advanced pupils of senior classes (Sekundarstufe II). The complex structure of a real mobile network is reduced in this experiment to the basic properties of electromagnetic waves. Pupils showing interests in the properties of a special mobile network can go to information files or speak to the supervisors. Due to the playful component the pupils retain a positive memory of this experiment. All experiments of the TechLab are carried out in groups of 2–3 people. In this manner, working in teams, as is usual for engineers, is achieved.

EVALUATION OF THE LABORATORY

The continuation and development of the laboratory rely indispensably on an evaluation of its work since November 2005. As mentioned earlier, a particular emphasis is laid on a final plenary conversation between the pupils and the laboratory staff at the end of the day. Here, the pupils can share their experiences with the laboratory team. This type of open conversation has proved to be a very effective tool for the evaluation and development of the laboratory. At the early stages of the creation of the experiments, videotapes of test runs with pupils and transcriptions of the pupils' opinions were scientifically evaluated by the Department of Didactics of Physics of the university [6]. Such a comprehensive process was useful during the kick-off phase in order to guarantee a successful start of the pupils' laboratory. Yet the evaluation of questionnaires always depends on the pre-established design and aim of the evaluator. Therefore, it bears the risk of neglecting the impulses of direct feedback from the pupils. The open discussion at the end of each day at the TechLab focuses less on a scientific assessment but rather aims at capturing the pupils' motivational attitudes and considering their self-perception. As a result, we get an impression of the pupils' interests and an opinion of how relevant they find the items studied in the laboratory. They usually pass a positive judgement. Time and again it becomes obvious that the manner and atmosphere of support given to the pupils, besides a skilful and appropriate design of the experiments, constitute a major aspect in the success of the TechLab. The pupils' suggestions help to improve the design of the experiment either by using different materials or learning aids as well to optimize the organisation of the day. Since good supervision is crucial, the leading team of the TechLab initiate an exchange of ideas with the student assistants. All supervisors voice the experiences and observations they made during the day and discuss the criticism of the pupils. Furthermore, seminars take place regularly after certain periods of time. All these measures ensure that the supervising team continuously increases its professional and pedagogical knowledge. Further clues for the quality of the pupils' laboratory can be drawn from the fact that 80 per cent of the teachers visiting the TechLab return with other classes. An additional indicator of success is that several schools in the greater area of Hanover decided to visit the TechLab regularly with all classes of one age-group.

Development of the evaluation-design is not yet finished because the open conversation does not collect all of the pupils' opinions. Therefore, the existing evaluation method will be complemented by a quantifiable form in the future. A questionnaire will inquire about pupils' attitudes towards technological problems before and after their visit to the TechLab. For this purpose, the TechLab aims at cooperating with the Centre for Didactics of Technology of the Leibniz University of Hanover in order to base the evaluation on a scientifically sound background.

CONCLUSION

Representatives from schools and the university work together cooperatively in the TechLab initiative in order to revive pupils' interest in questions of engineering. The pupils experience engineer-like work in experiments from the fields of physics, electrical and mechanical engineering. Here, the focus is more on the solution of the problem rather than on the scientific explanation. On average, about 1800 pupils visit the TechLab in the course of one year. This high degree of utilization justifies the enormous support of institutions and industrial enterprises as sponsors. They make the continuation of the work of the laboratory possible, both on a material and financial basis. The fact that the TechLab worked to almost full capacity during its first year and the positive evaluations prove that this is a promising way to enhance pupil interest in technical matters.

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Holger Thye received the Dipl.-Ing. degree in electrical engineering from the University of Hannover, Germany, in 2004. Since 2005, he has been a research assistant at the Institute of the Basics of Electrical Engineering and Measurement Science at the Leibniz Universität Hannover. His main research interests include electromagnetic compatibility, especially measurements and simulations with transient electromagnetic fields. Since 2006 he has been a member of the IEEE EMC and A&P society. Another focus of his work is the didactic teaching of principles of electrical engineering and organization of the pupils' laboratory TechLab in cooperation with the involved teacher.

Klaus Delto studied mathematics and physical education in Hannover from 1968 until 1973, completed with his state examination in education. From 1973 to 1975 he was a teacher at Hermann-Billung-Gymnasium Celle. In 1975 he joined the Gymnasium Bad Nenndorf. In addition to this he is a member of the TechLab steering. In 2006 he became a senior scientist at the Institute of the Basics of Electrical Engineering and Measurement Science at the Leibniz Universität Hannover. He participated in several conferences concerning pupils' laboritories for technical and nature sciences.

Heyno Garbe got the Dipl.-Ing. (= MS) and Dr.-Ing. (= Ph.D.) from the University of the Federal Armed Forces in 1978 and 1986 respectively. From 1986 to 1991 he was with the Asea Brown Boveri Research Centre in Baden, Switzerland. There he was involved in research activities on EMC related topics. From 1991 to 1992 he was the Research Manager for EMC Baden Ltd., Switzerland. Since 1992 he has been with the Leibniz University of Hannover where he holds a professorship in the faculty of electrical engineering and computer science. In addition to lecturing on basic electrical engineering, measurement technology and EMC, he has developed an active research programme related to electromagnetic field effect modelling, testing and measurement as applied to EMC. He holds the Fellow degree from IEEE and EMP Summa Foundation. He is a member of URSI Com. E, VDE and other national and international professional organizations. He has authored and co-authored more than hundred articles in books, journals or at conferences.