

Success Factors for Extracurricular MINT Talent Support

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Abstract

In the past decade a pronounced and growing lack of engineers, natural scientists, information technology experts, and mathematicians has been noted especially in Europe. Corresponding to the need to attract young people to science and technology, numerous extracurricular science labs ('school labs') have been established, especially in Germany. One of these initiatives is the DLR_School_Lab Oberpfaffenhofen, operated by Germany's national research center for aeronautics and space, DLR, and a typical example of such a school lab. It offers hands-on experiments for regular secondary school classes, advanced teacher trainings and, as its specialty, enrichment courses for gifted students.

In this paper the concept of the DLR_School_Lab is presented. The lab's suitability to offer enrichment projects for talented secondary school students is described, as well as its teacher education concept.

Introduction

In Germany there is presently a lack of more than 60 000 engineers and scientists, and this gap is expected to increase to 425 000 by 2020. The workforce affected by this phenomenon is called "MINT" (mathematics, informatics, natural sciences, and technology). Attracting talented young people to science and technology is a societal task deserving the utmost priority in Europe. The lack of science and engineering students indicates that the existing educational system cannot fulfill this task appropriately: obviously, regular curricula do not provide sufficient information and motivation for students to become involved in science and technology. Because of this lack of information at school, many secondary school students—even at the end of school—are not able to make a decision about their future study or professional goals.

In order to attract young people to MINT and interest them in the respective university disciplines, many extracurricular science labs have been established over the last decade by research centers and universities all over Europe, more than two hundred of them in Germany. In a typical school lab students are enabled to perform high-tech experiments autonomously and on their own responsibility. Studies show

the important role of authentic experimentation as the key success factor of a school lab.

In order to achieve a sustainable impact, the typical one-day-visit to a school lab must be complemented by the mathematics and science teachers in the classroom. They have to interconnect high-tech experiments and research on the one hand, with the standard curriculum and school lessons on the other hand. It requires relevant skill enhancement and advanced teacher training to establish a link between extracurricular activities at the school lab and the standard school curriculum.

The DLR_School_Lab Oberpfaffenhofen – an extracurricular science lab

The German Aerospace Center DLR

DLR is Germany's national research center for aeronautics and space. Its extensive research and development work in aeronautics, space, transportation, and energy is integrated into national and international cooperative ventures. As Germany's space agency, the German federal government has given DLR responsibility for the forward planning and implementation of the German space program and for the international representation of Germany's interests.

Approximately 6 700 people work for DLR at 30 institutes and facilities at 13 locations in Germany. In Oberpfaffenhofen near Munich DLR employs about 1 500 people, making it one of Germany's largest research locations. The main activities of the five institutes in Oberpfaffenhofen are devoted to space missions, climate research, development of earth observation systems and technologies, the European space-based navigation system Galileo, and research in robotics. These activities are complemented by two space operation centers, research flight operations and the German remote sensing data center.

The DLR_School_Lab Oberpfaffenhofen

The German Aerospace Center DLR started its School_Lab program in 2000 and currently operates eight extracurricular science labs, one of which is the DLR_School_Lab Oberpfaffenhofen. This school lab offers to secondary school students high-tech experiments based on the core research areas and technology fields of the DLR institutes in Oberpfaffenhofen as well as the authentic research atmosphere of a large-scale research center. The students experience the fascination of aerospace research and become acquainted with a number of fields as well as with the working methods of high-technology research. The DLR_School_Lab presently offers eleven experiments in which students can become acquainted with infrared, laser, and radar technology, environmental spectroscopy, meteorology, satellite earth observation data, satellite navigation, robotics, virtual mechanics, research flight operation, and mobile rocket research.

In a typical one-day visit to the DLR_School_Lab, each student can perform two of these experiments corresponding to his or her personal scientific interest. Each experiment comprises two hours of intense activities and experimentation in the respective technology field, and by the end of the day the student has gained insight into two research areas and their respective working methodologies.

One key success factor of this extracurricular science lab is the chance to autonomously and responsibly work with advanced and costly high-tech equipment which is unavailable at school. For example, the students are allowed to operate a

reflection spectrometer, an infrared camera, mobile laser and radar systems, or work with sophisticated simulation programs.

The experimenting students are supervised and supported by DLR scientists as well as university students. However, in principle they are stimulated to work independently and regulate themselves in order to gain practical experience of fascinating day-to-day work in interesting fields of applied research, to extend their personal horizons, and to learn basic principles, physical, technical and geoscientific interrelations, and applications for science and technology represented in their chosen experiments. They work in small groups of four to five students which both generate a stimulating working atmosphere and bind them together as a team.

The standard visit to the DLR_School_Lab Oberpfaffenhofen is, in general, complemented by visits to the German Space Operation Center (GSOC) and to the recently opened Galileo Control Center, which provide insights into the control of satellites, the research activities on the international space station ISS, and the operation of Europe's future satellite navigation system.

Since it opened in 2003 more than 12 000 students have experimented in the DLR_School_Lab Oberpfaffenhofen.

Offers for gifted students

One of the key objectives of the DLR_School_Lab Oberpfaffenhofen is to promote specially gifted young people. The lab's experiments, derived from current research activities at the DLR institutes, are particularly adaptable to the potential of highly talented and motivated students since there are no inherent limits to their scientific depth and complexity. In the past years the school lab has developed, conducted and successfully completed about 30 special projects and events for highly talented students.

The scientific and technological research fields of the DLR institutes are very suitable for enrichment projects. A typical example is robotics, which is characterized by its high timeliness and application relevance and its mostly complex scientific issues. Such projects are ideally suited for international MINT talent support projects. The following enrichment project has been completed in the frame of the international project TALNET.

The project TALNET International

The project TALNET International is a series of advanced activities in the frame of the TALNET project that has been aiming to systematically identify and work with gifted youth (13-19 years) since 2003 [1] by using of online educational activities combined with face to face activities in in MINT topics. It is implemented by the Faculty of Math and Physics of Charles University in Prague in cooperation with other faculties, universities and science and research institutes in the Czech Republic.

The TALNET offers a structure of educational and exploring/inquiry activities to children who are recommended by their teachers or psychologists. Activities differ in topic, forms (face to face, blended, online) teaching approach, work load, complexity and applicability. Many gifted children need more and more challenging, e.g. demanding and complex, activities. The level of challenge may be perceived in many different aspects such as subject, problem solving, creativity, production and social aspects etc. The main purpose of this TALNET International projects is to offer to gifted children further advanced opportunities for development of their competencies.

Especially, occasions to work in multi-national teams and communicate in foreign language seemed to be an appropriate instrument and a challenge.

In the spring 2008, we implemented a first run of the project. Talnet, as the main organizer invited partners: the German Kubus project, the Spanish Estrella project and Slovaks from P. J. Šafárik University. The experts from the German DLR (German Aerospace Center in Oberpfaffenhofen) provided us a high-tech professional background.

The educational activities were launched in February 2008 with online activities. The main content of the project itself and of the online phase was a course in robotics accompanied by various discussion clubs about other scientific and European topics such as culture, politics, etc. The objective of the robotic course was to put a robot together and to program it to be able to cope with different tasks.

The culmination of the online activities and the project itself was the face to face meeting. In April 2008, about 10 participants between 13 and 18 years from each country spent a week together in the Czech Republic. Apart from the possibility to work on the robots, there was also an opportunity to experience varied activities such as working with GPS or geo-caching, a conference about the EU, a European quiz, mini language theatre and other team games. A very important part of the face to face meeting was our visit to the DLR in Germany. The purpose of the visit was a professional excursion at the DLR's Institute of Robotics (to see developments of real scientific robots), Satellite Navigation Centre and particularly the possibility to complete the robots and to move forward in programming with the help of DLR's experts. A small race of ASURO robots set up by participants was organized by DLR hosts. The possibility to work on the robots and to take part in the online activities after the face to face meeting remained till the end of May 2008.

While preparing the activities we focused particularly on offering a new challenging and enriching topic and developing communication and cooperation. The course in robotics and the assignments within it headed toward sharing information, advice or successes unlike typical competitions in programming.

At the end of the face to face meeting the participants were supposed to assess the project itself (a multiple choice questionnaire) and to describe their personal benefits (an open ended questionnaire).

From answers from 35 respondents it is evident that most of the respondents actively participated in the robotics course and worked with the ASURO kit and that just a few of them were only assisting the others. For most of them it was a new experience concerning robotics and programming as well.

The excursion to the DLR encouraged 69 % of participants in their interest in the robotics or further work with the ASURO robot. ("I really enjoyed the work on the robots in DLR, it was a great experience". Thomas, 17 years). The visit offered some incentives for their professional development and enrichment by giving an opportunity to work on robots with the DLR's experts and by the possibility to discuss related problems with them. [2]

Teacher Education at the DLR_School_Lab Oberpfaffenhofen

The DLR_School_Lab Oberpfaffenhofen offers advanced training courses for teachers in order to prepare them for the visits of their classes. The main objective of

the teacher training is to help them integrate the extracurricular activities into their standard curricula and, thereby, generate an application-oriented concept for classroom education. The school lab offers special courses for teacher groups from individual schools, for regional teacher groups, and for the advanced training of Bavarian seminar teachers, i.e., the instructors of future teachers.

The key elements of the teacher training are self-contained experiments, where the teacher adopts the role of a student and experiences the same feeling of success when completing an experiment. The experimental work is complemented by didactic as well as scientific background information about the respective experiments and research areas.

Since 2003 about 1,250 teachers have attended advanced teacher training courses at the DLR_School_Lab Oberpfaffenhofen. The general feedback from teachers is positive, especially with respect to independent accomplishment of high-tech experiments, technical advancement, and stimulation for practical classroom teaching. Several of them were motivated to visit the DLR_School_Lab Oberpfaffenhofen with their classes. These requests have led to the situation that this school lab is presently (2010) fully booked for 18 months in advance.

Education of teachers of the gifted

Teachers play a key role in gifted education: especially in type III enrichments the teacher's role changes from that of an educational instructor to that of an initiator, mentor, supervisor, coach, consultant, and assessor of achievement. It is most important to support the independence, motivation, and creativity of gifted students.

The teacher education concept developed at the DLR_School_Lab Oberpfaffenhofen, interconnecting school labs and the school curriculum, including independent experimentation, science background and didactic context, utilizes all of the methodologies described above and is, therefore, especially suitable for teachers of gifted learners. In addition,

- the scientific background of individual experiments can easily be extended to possible problems and questions typical for highly interested and talented students,
- possible combinations of different experiments and technologies are addressed, and
- the didactic background for accelerating experiments, i.e., how to make them feasible and interesting for younger students, is characterized.

Summary

An enrichment concept for gifted students has been developed and successfully realized in numerous projects at the DLR_School_Lab Oberpfaffenhofen. The same holds for the gifted education teacher training concept, which includes especially the scientific and didactic basics for international enrichment projects at the pre-university school level. The key success factors to reach the goal of increasing the interest of talented young people in MINT are hands-on high tech experiments, teachers with practical experience in school labs, the environment of a research center, and ambitious enrichment projects, especially if the latter are embedded in international cooperation.

Final Remark

This text is based on an article which has been submitted for publication in Roeper Review: Hausamann, D. (2010). Science Labs for gifted education. Submitted.

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