Chapter 15

MINT Talent Support in School Labs - New Perspectives for Gifted Youth and for Teachers of the Gifted

Dieter Hausamann

1. Introduction

In the past decade some 300 extracurricular education facilities have been established in Europe, most of them in Germany, Austria, and Switzerland. The majority of these facilities are so-called "school labs", their mission being to increase the awareness for mathematics, informatics, natural sciences, and engineering (MINT) and, correspondingly, attract young people to these faculties. The origin of this development is a pronounced and growing lack of engineers and scientists; the present (2012) engineers' gap in Germany is about 100.000.

Several of these school labs focus on MINT talent support, offering a diversity of special enrichment programs and projects to gifted and motivated students. The DLR_School_Lab Oberpfaffenhofen, operated by Germany's national research center for aeronautics and space, DLR, is a typical example of such a school lab devoted to both objectives of broad education and focused MINT talent support. The lab's expertise has been gained in the past decade with approx. 18,000 secondary school students and about 50 enrichment projects for gifted students.

MINT talent support means, on the one hand, institutions and measures for gifted students. In this paper examples of respective curricular and extracurricular activities will be described, emphasizing the special synergy of the Hector Seminar and the DLR_School_Lab. On the other hand, the role of talent supporters - especially teachers - is crucial in the process of attracting young people to the MINT disciplines. An example of good practice is the inclusion of the DLR_School_Lab in the ECHA advanced teacher education at the ICBF in Münster, which will also be addressed.

2. The MINT Gap

In Germany there was in 2008 a lack of more than 60,000 engineers and scientists, and this gap is expected to increase to close to half a million by 2020. (Stahl, 2009). Similar apprehensions exist with respect to the European science and engineering workforce, as discussed by Osborne and Dillon (2008) and EurActiv (2008).

Different names are used to describe the workforce affected by this phenomenon: in Europe the term most frequently used is "MINT" (mathematics, informatics, natural sciences and technology, which will be used in the remainder of this article); in the U.S. "STEM" (science, technology, engineering and mathematics); Tengelin (2009) calls it "MST" (mathematics, science and technology).

In his analysis of the factors regulating the availability of MINT specialists Tengelin (2009, Fig. 21) shows that the situation in Europe is dominated by the demographic development, as well as by a distinct and growing unpopularity of MINT professions on the part of young people. "*Why don't young people want*

to become engineers?" is the title of a recent publication (Becker, 2010) in which the author concludes that it is necessary to dedicate "*resources to make it possible for students to come into contact with practical work*" (Becker, 2010).

Attracting talented young people to science and technology is a societal task deserving the utmost priority in Europe, as has been stated by the workshop "*Meeting the Needs of Gifted Children and Adolescents: Towards a European Roadmap*" organized by the European strategy organization Cooperation in Science and Technology COST (2007). The major result of this workshop was the resolution, "*Action Plan for the Gifted and Talented - an essential part of the Lisbon Strategy*." This resolution is addressed to the European Commission, one of its main requests being to "*Involve scientists, research facilities and industry in the development of education for our gifted and talented*." In a recent article Wörner (2011) summarizes the effect of the MINT gap from the point of view of a CEO of a large scale European research establishment: He reports on the measures taken by the German Aerospace Center DLR aiming to attract "MINT talents."

In order to interest young people in MINT disciplines, many extracurricular science labs have been established over the last decade by research centers and universities all over Europe; according to the Leibniz-Institute for Science Education (IPN) at the University of Kiel, Germany, close to three hundred of them are in Germany (LeLa, n.d.).

In a typical school lab students are enabled to perform high-tech experiments autonomously and on their own responsibility. The specifics of a typical school lab, as well as the role of experiments and the importance of authentic learning environments as critical factors for up-to-date physics education, have been discussed by Euler (2004). The effectiveness of school labs has recently been demonstrated by Pawek (2009). All of these studies show the important role of authentic experimentation as the key success factor of a school lab. The didactic concept is based on a methodology called "Inquiry-Based Science Education" (IBSE), which has been recommended by the European Commission (2007).

3. The DLR_School_Lab Oberpfaffenhofen and its Major Cooperation Partners Hector Seminar and ICBF

3.1 The DLR_School_Lab Oberpfaffenhofen

DLR (n.d.) is Germany's national research center for aeronautics and space. Its extensive research and development work in Aeronautics, Space, Energy, Transport and Security is integrated into national and international cooperative ventures. As Germany's space agency, DLR has been given responsibility for the forward planning and the implementation of the German space program by the German federal government as well as for the international representation of German interests.

Approximately 7,000 people work for DLR in 35 institutes and facilities at 16 locations in Germany. In Oberpfaffenhofen near Munich (Bavaria) DLR employs about 1,700 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 the German Space Operation Center, the Galileo Control Center, research flight operations, and the German Remote Sensing Data Center.

The DLR_School_Lab program was started in 2000 by the German Aerospace Center and has since been financed by internal funding (approx. 3 million Euro per year). Currently (2012) DLR operates nine extracurricular science labs, one of which is the DLR_School_Lab Oberpfaffenhofen (n.d.). 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 13 experiments in which students can become acquainted with infrared, laser, and radar technology, environmental remote sensing, meteorology, satellite earth observation data, satellite navigation, robotics, telepresence, virtual mechanics, research flight operation, mobile rocket research, and geodesy.

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.

The key success factor of this extracurricular science lab is the authenticity of a real-life laboratory environment, working with real scientists and real university students on real experiments. Experimenting in this school lab means the chance to carry out autonomous work with advanced and costly high-tech equipment which is unavailable at school e.g., to operate a reflection spectrometer, an infrared camera, mobile laser and radar systems, or to work with sophisticated simulation programs.

The experimenting students are, in general, supervised and supported by university students, in principle they are stimulated to work independently and regulate themselves in order to gain practical experience in interesting fields of applied research, to extend their personal horizons, and to learn basic principles, physical, technical and geoscientific interrelationships, as well as applications for the science and technology represented in their chosen experiments. They work in small groups of four to six students, which both generates a stimulating

working atmosphere and binds them together as a team. The teachers escorting their classes to the DLR_School_Lab are requested not to interfere with the experimenting group, but restrict themselves to remotely observe the experiments.

The visit to the DLR_School_Lab Oberpfaffenhofen is usually complemented by a visit to the German Space Operation Center (GSOC) which provide insights into the control of satellites and the research activities on the international space station ISS.

Since it opened in 2003 more than 18,000 students have conducted experiments in the context of DLR_School_Lab Oberpfaffenhofen.

3.2 The Hector Seminar – a scientifically evaluated extracurricular enrichment program

The Hector Seminar is an extracurricular enrichment program which has been implemented in the northern part of Baden-Württemberg (Germany) for promoting the most talented gymnasium (college prep high school) students in the MINT area.

Since 2001 the program has been financed and supported by the Hector Foundation. The Hector Seminar supports especially gifted secondary school students on a long-term basis throughout their school career. The seminar program supplements regular school activities from 6th grade to 12th grade. The projects have an interdisciplinary character; the main objectives are to facilitate a holistic development of personality, to activate and develop cognitive, methodical, personal, and social potentials, and to expand the corresponding competence and capabilities. Each seminar course per cohort comprises 60 students chosen in a two-stage selection process from all 7,500 6th grade students attending secondary schools in the northwestern part of the state of Baden-Wuerttemberg. The cognitive, creative and social capabilities of the selected students are far beyond the secondary school average. The seminars are located in the three cities of Heidelberg, Mannheim, and Karlsruhe; each project is headed by two teachers, and they take place once a week in two-hour sessions. Since 2001 approx. 600 students participated in the Hector Seminar. In general, the Hector Seminar projects are carried out with external research partners e.g., the DLR_School_Lab: Since 2004 five common projects have been completed.

The effectiveness of the Hector Seminar program was thoroughly investigated in the framework of a long-term (8 year) longitudinal evaluation study. The core elements of this study are

- a long-term observation of two Hector Seminar groups throughout their secondary school career (2001–2008);

- a two-stage selection procedure: the first stage selection is a screening process, whereas the second stage selection is based on the Munich High Ability Test Battery developed by Heller and Perleth (2000/2007, 2008);
- an experimental/training/control group design, where the Hector Seminar (training) groups of each cohort consist of the 60 German gymnasium (college prep) students ranking highest (top 1%) in the test score, and the control groups are formed from the 60 students ranking next; i.e., the capabilities of both groups are roughly comparable. For more of the sample and evaluation details see Heller et al. (2010).

The overall result of this study confirms the validity of the search for talent and the efficiency of the Hector Seminar program in all details. The most noticeable effect is the top ranking of both groups in their final school examination; however, the training groups outperformed the control groups considerably. The corresponding study options of, especially, the training groups show strong preferences for the MINT disciplines, i.e., the program fulfills its most important objective.

The DLR_School_Lab Oberpfaffenhofen is one of the key research partners for typical Hector Seminar projects. Since 2004, five such projects have been completed successfully.

3.3 The ICBF and the ECHA teacher education course ‘Specialist in Gifted Education’

The Diploma course "Specialist in Gifted Education" was developed at the University of Nijmegen, the Netherlands, in cooperation with the European Council for High Abilitiy (ECHA), and was further refined by the International Center for the Study of Giftedness, ICBF, for Germany. The objective of this advanced teacher education is to enable teachers to develop didactical concepts and practical school lessons adequate for gifted children and youth.

The advanced teacher training comprises about 500 hours of theoretical and practical work. Current results of ICBF’s giftedness research and promotion are included in the vocational training concept. The trainings are conducted by Prof. Franz J. Mönks and Prof. Christian Fischer and further experts in this field.

The courses comprise three semesters and four two-day block seminars in Münster. In between the block seminars the teachers participate in literature circles and visit schools in small groups for observation of gifted classes. The courses are terminated by a Diploma ceremony.

The theoretical part covers the concepts of giftedness, the identification of specially gifted children, and their promotion in curricular and extracurricular contexts. In the literature circles the obligatory literature is compiled supported by a mentor. The theoretical part is completed by a written examination.

The practical part comprises excursions to giftedness support institutions and, especially, practical exercises with gifted girls and boys. The expertise gained

should be transformed into a giftedness support project at school, which is documented in a diploma thesis. This part is completed by the presentation and discussion of the thesis.

With respect to the MINT disciplines, the DLR_School_Lab is strongly involved in the ECHA concept, by active contribution to the block seminars as well as by providing a location for observation of gifted students.

4. Curricular and extracurricular MINT talent support in Germany

In the past decades the necessity to specially promote gifted children has received increasing attention and is presently reflected by a diversity of public and private measures. The increasing attention is also due to the economic and demographic situation and the urgent need for (especially MINT) experts. Public activities depend strongly on the region, in many areas of giftedness support Bavaria is more advanced than most of the other German federal states.

Apart from numerous school labs described in this paper the most important public and private measures comprise

- the inclusion of gifted education in the policy of the Education and Science Ministries;
- schools with special classes, e.g., the Maria-Theresia-Gymnasium in Munich (n.d.);
- special schools for gifted pupils, e.g., the Christophorusschule in Königswinter (n.d.);
- MINT promotion programs such as the Hector-Seminar (Heller 2009);
- special programs for outstanding school students (e.g., the Maximilianeum Program in Bavaria);
- support networks for excellent university students (e.g., the Elite Network in Bavaria);
- public foundations such as the Studienstiftung des Deutschen Volkes and many other scholarship funds (c.f. BMBF n.d.);
- numerous national and regional private foundations (e.g., the Karg Foundation and the Hector Foundation);
- private associations fostering gifted children and youth, e.g., DGhK, Bildung und Begabung, Mensa;
- international and national MINT competitions (e.g., Science Olympiads or 'Jugend forscht'), as well as other contests initiated by private enterprises (FOCUS journal, Siemens, Intel, etc.);
- the Deutsche Schülerakademie (German Pupils Academy, n.d.) and other science and junior academies.

4.1 Offers to gifted students: Type III enrichment projects at the DLR_School_Lab Oberpfaffenhofen

One of the key objectives of the DLR_School_Lab Oberpfaffenhofen is to promote especially gifted young people (cf. Hausamann, 2011, 2012). Because the lab's experiments are derived from current research activities at the DLR institutes, they are particularly adaptable to the potential of highly talented and motivated students since there are no inherent limits to their scientific depth and complexity. The same holds for the supervising scientists and students, whose personal expertise exceeds by far what is available even at the highest school levels.

In principle, there are two possibilities for such enrichment projects:

1. Regular visits of gifted classes and students, in which the typical one day school lab program is offered to younger students ("acceleration") and/or is extended in scientific depth. These offers are frequently used by special classes for gifted students, e.g., at the Maria-Theresia-Gymnasium in Munich (n.d.).
2. Special projects for groups of gifted: In the past decade 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 extremely suitable for these special activities, so-called type III enrichment projects. Subjects such as satellite navigation or satellite remote sensing are, on the one hand, characterized by their high timeliness and application relevance; on the other hand, the scientific issues are mostly complex and are not covered in standard school curricula.

A typical type III enrichment project initiated by the DLR_School_Lab is characterized by

- a general subject derived from the DLR research fields,
- a more specific project outline defined by the supervising teachers and the DLR_School_Lab,
- a selection process in which the class or group takes a decision in favor of this project (against alternative choices),
- the students' responsibility for the specific tasks and objectives, as well as for the organization and management of the project,
- teachers and scientists in the role of consultants, supporting the students on demand,
- an extension over a period of several months,
- a two- or three-day visit to the DLR_School_Lab Oberpfaffenhofen as an essential project activity,

- and the responsibility of the students for the public presentation of the project results.

Between 2004 and 2012, eight type III enrichment projects were carried out, five of which in close cooperation with the Hector Seminar. The following two examples are typical for all of these enrichment projects.

4.2 The GPS Einstein project

Satellite navigation is one of the rare technical applications which is strongly influenced by Einstein's theory of relativity. The goal of the GPS Einstein project (Hausamann, 2006; Hausamann & Schmitz, 2007) was to quantitatively investigate this influence on the precision of localization. The project involved a 12th grade physics course for gifted students at the Christophorusschule Königswinter and lasted approximately half a year.

In the first phase, the students familiarized themselves with Einstein's theory of relativity and satellite based navigation. The second phase of the project was a three-day excursion to the DLR_School_Lab Oberpfaffenhofen. The program of this visit was tailored to the requirements and abilities of a group of exceptionally gifted students. One important didactic feature was continuous alternation between self-regulated experimental activities and university level science lectures. In the third and final phase of the project the students completed the project: they derived the frequency shift of the GPS satellite clocks and the consequences thereof. The students presented their final results at a National Students' Congress in Munich in December 2005, which was devoted to Albert Einstein's life and research.

4.3 The geophysics project – remote sensing from satellites

The scientific focus of the enrichment project "geophysics – remote sensing from satellites" was on the properties of the solar radiation spectrum and its influence on the geosystem. The goal of this Hector Seminar project was to investigate changes in the participants' home environments by analyzing and comparing remote sensing data from satellites collected over a period of time (Hausamann et al., 2009).

In a one-day workshop in April 2006, the students were introduced to the requisite scientific background, methodologies and technologies. In May 2006 the Hector Seminar students spent three days at the DLR_School_Lab Oberpfaffenhofen focusing on environmental measurement technologies and accessing, processing, and analyzing satellite data. The third project activity was a measurement campaign in Heidelberg. Based on information and results from the measurement campaign the students performed the final task of the project: they classified satellite images and analyzed changes in their home environment between 1989 and 1999 and, finally, produced reports on the

results. In September 2006 the students presented these results at the Hector Seminar Project Workshop in Mannheim.

5. Assessment and Evaluation of Extracurricular Science Labs

Since extracurricular science labs require considerable financial and human resources, it is essential to ascertain their effectiveness in general, and in this case that of the DLR_School_Lab Oberpfaffenhofen in particular. Since school labs have only existed for one decade (the first DLR_School_Lab in Göttingen started operations in 2000), there have been no full evaluation and assessment studies of their effectiveness involving a standard methodology with control groups. However, several initial studies give strong evidence for the effectiveness of this concept. The results of different approaches and methodologies to assess effectiveness are described by Hausamann (2012), including

- an evaluation of four DLR_School_Labs (including the Oberpfaffenhofen lab) to assess their impact on the students' interest and any changes in their self-concept (Pawek, 2009 and 2012);
- a longitudinal evaluation of the Hector Seminar (Heller, 2009; Heller et al., 2010) involving the DLR_School_Lab as one of the external project partners.
- the analysis of more than 9,000 questionnaires - immediate feedback from students after visiting the school lab;
- a qualitative investigation of differences between the reactions of regular and gifted students (Stumpf, Neudecker & Schneider, 2008);
- an analysis of the questionnaires and feedback from 44 participants of type III enrichment projects mentioned above:

Their feedback indicates that

- 95% of the students visited the out-of-school-lab for the first time;
- the expectations of 85% were satisfied;
- 96% agreed with the duration of the visit;
- none of the students criticized the supervision;
- the level of the experiments was well chosen for 98%;
- 65% express that the visit has increased their interest in STEM;
- 93% intend to speak about the visit with parents or friends;
- 81% would like to come again;
- 94% had fun doing the experiments;
- 93% consider the experiments relevant for everyday life;
- 65% plan to take up a STEM career.

In comparison to the evaluation of all the one-day-visits, most answers indicate the same positive feeling by participants. However, there are pronounced differences:

- Obviously, participants in type III projects show an increased interest in continuing their work. In comparison to the regular student group, a remarkably (15%) higher fraction of the gifted students wishes to visit the out-of-school-lab again - which is quite considerable, since all of these students had already spent two or more days in the out-of-school-lab.
- The type III project participants show a much stronger intention to aim at a profession in science or technology. The result was the same as above, a remarkably (15%) higher fraction of the gifted students considers a job in one of the STEM disciplines.

In summary, the written and oral feedback from regular classes is extraordinary positive in nearly all cases. However, the response of the gifted and talented participants involved in the DLR_School_Lab's type III enrichment projects was even more positive.

6. 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 to 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 such a 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, i.e. the teachers also learn how to connect the experiments to the school curriculum.

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 (2012) fully booked for 18 months in advance.

As reported in Hausamann (2012) the feedbacks of 140 teachers show a high (close to 100%) acceptance of the overall concept of the courses, the quality of

presentations and organization, and the competence of the instructors. The usefulness of the courses for school lessons is assessed more critically by about 20% of the teachers. Because the experiments are defined by research topics and not by the school curriculum, the high acceptance of 80% was higher than expected.

6.1 Education of teachers of the gifted

Teachers play a key role in gifted education; their distinguishing characteristics and necessary competence have long ago been summarized by Seeley (1985): 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 (cf. Cropley & Urban, 2002). Pedagogical concepts such as self-regulated learning (Fischer, 2004) are ideally suited for type III enrichment projects.

The teacher education concept developed at the DLR_School_Lab Oberpfaffenhofen (Hausamann, 2008), which interconnects 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. With respect to the content and complexity of individual experiments,

- the scientific background 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.

An example for this good practice is an advanced teacher training for a group of Hector Seminar supervisors at the DLR_School_Lab Oberpfaffenhofen in December 2004 which had been initiated by the Hector Seminar as a consequence of the first common space robotics project in 2004. So far, this workshop has been the nucleus of four follow-up type III enrichment projects: geophysics in 2006, satellite navigation in 2008, robotics in 2010, and again satellite navigation in 2012.

6.2 MINT related offers in the frame of the ECHA teacher trainings

The DLR_School_Lab's extracurricular gifted education concept is also integrated in the ECHA advanced teachers trainings offered by the International Center for the Study of Giftedness at the University of Münster, Germany (ICBF, n.d.) leading to the so-called ECHA Diploma "Specialist in Gifted

Education." Since 2007 the potential of extracurricular science labs - such as the DLR_School_Lab Oberpfaffenhofen - in gifted education has been presented as part of the practical education block, the main focus being the conception of type III enrichment projects, didactical advice for organizing such projects, and recommendations and proposals for exciting subjects. Additionally, the DLR_School_Lab is an official location for observation of gifted student courses; two observation periods are mandatory for each ECHA Diploma applicant.

7. Summary and future prospects

An enrichment concept for gifted students has been developed and successfully realized in numerous projects at the DLR_School_Lab Oberpfaffenhofen, especially in cooperation with the Hector Seminar. The same holds for the gifted education teacher training concept which has been implemented in the ECHA teacher education courses (Diploma "Specialist of Gifted Education") at the ICBF in Münster, addressing especially the scientific and didactic basics for type III enrichment projects at the pre-university school level. MINT talent support will also be included in ICBF's future Bachelor and Master courses.

Existing evaluations and assessment studies indicate that the concept of extracurricular science labs is successful in a way that the students' interest in science and technology is sustainably increased.

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8. References

ASURO (n.d.). Retrieved June 1, 2012 from http://de.wikipedia.org/wiki/ASURO.

Becker, F. S. (2010). Why don't young people want to become engineers? Rational reasons for disappointing decisions. *European journal of engineering education*, *35*, 349–366. [Online]. Available: http://www.sefi.be/wp-content/uploads/Becker%20EJEE%20Why%20dont%20young%20people%20August-2010.pdf [June 1, 2012].

BMBF (n.d.). Retrieved June 1, 2012 from http://www.bmbf.de/pub/begabtenfoerderungswerke_aundz.pdf

Christophorusschule in Königswinter (n.d.). Retrieved June 1, 2012 from http://www.mtg.musin.de/?cat=1&id=50.

COST (2007). *Meeting the Needs of Gifted Children and Adolescents: Towards a European Roadmap*. COST Strategic Workshop, Brussels, Belgium, Nov. 26 and 27. [Online]. Available: http://www.cost.eu/events/node_1384 [June 1, 2012].

Cropley, A. J. & Urban, K. K. (2002). Programs and strategies for nurturing creativity. In K. A. Heller, F. J. Mönks, R. J. Sternberg & R. F. Subotnik (eds.), *International handbook of giftedness and talent* (2nd ed., revised reprint, pp. 485-498). Oxford: Pergamon.

Deutsche Schülerakademie (German Pupils Academy) (n.d.). Retrieved June 1, 2012 from http://www.deutsche-schuelerakademie.de/.

DLR (n.d.). *Deutsches Zentrum für Luft und Raumfahrt – German Aerospace Center.* DLR_School_Lab Oberpfaffenhofen (n.d.). Retrieved June 1, 2012 from http://www.dlr.de/schoollab/en/desktopdefault.aspx/tabid-1738/.

Euler, M. (2004). *Quality development: Challenges to physics education.* Leibniz-Institute for Science Education (IPN) at the University of Kiel, Germany. [Online]. Available: http://www.lernort-labor.de/download/Euler_Udine_03.pdf [June 1, 2012].

EurActiv (2008). *Warning over EU's ageing science workforce.* [Online]. Available: http://www.euractiv.com/en/science/warning-eu-ageing-science-workforce/article-171103 [June 1, 2012].

European Commission (2007*). Science Education NOW: A Renewed Pedagogy for the Future of Europe*. EUR22845. Luxembourg: Office for Official Publications of the European Communities. 22 pages. ISBN 978-92-79-05659-8. [Online]. Available: http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf [June 1, 2012].

Fischer, Ch. (2004). Selbstreguliertes Lernen in der Begabtenförderung [The role of self-regulated learning in gifted education]. In Ch. Fischer, F.J. Mönks & E. Grindel (eds.), *Curriculum und Didaktik der Begabtenförderung* [Curriculum and didactics of gifted education] (pp. 83-95). Münster: LIT.

Hausamann, D. (2006). Hochbegabtenförderung im DLR_School_Lab Oberpfaffenhofen: Das Einstein-GPS Projekt. *Diplomarbeit*. Münster/Nijmegen.

Hausamann, D. & Schmitz, W. (2007). Enrichment at the Doorstep of University - The Einstein GPS Project. In Tirri, Kirsi; Ubani, Martin (eds.), *Policies and programs in gifted education*. Studia paedagogica, *34* (pp. 37 – 46). Helsinki: Yliopistopaino.

Hausamann, D. (2008). Extracurriculare Lehrerbildung: Außerschulische Lernorte für die Begabtenförderung [Extracurricular teacher education: Out-of-school learning

locations for gifted education]. BEGABT – BEGABEND – VERAUSGABT? Begabte(n)förderer im Lichte vielfältiger Herausforderungen. In: 6. Internationaler Kongress zu Fragen der Hochbegabtenförderung. Salzburg, Austria. Nov. 6 – 8.

Hausamann, D., Wilke, G., Taulien, M., Grixa, I. & Locherer, M. (2009). Geophysik – Fernerkundung mittel Satelliten: Ein Kooperationsprojekt des Hector-Seminars (Geophysics and satellite remote sensing – an enrichment project of the Hector Seminar). In K. A. Heller (ed.), *Das Hector Seminar – Ein wissenschaftlich evaluiertes Modell der Begabtenförderung im MINT-Bereich* (Anhang B) (The Hector Seminar – A scientifically evaluated model of gifted education in the area of MINT). Berlin LIT.

Hausamann, D. (2012). Enrichment-Projekte aus der Luft- und Raumfahrt (Enrichment Projects in the Field of Aerospace Technology). In Fischer, C. Fischer-Ontrup, C., Käpnick, F., Mönks, F. -J., Scheerer, H. & Solzbacher, D. (Eds.), *Individuelle Förderung multipler Begabungen* (pp. 216 – 223). Berlin: LIT.

Hausamann, D. (2011). Extra-curricular science labs for gifted students. In Froese Klassen, C. & Polyzoi, E. (eds.), *Investing in gifted and talented learners: An international perspective.* Selected papers from the 18th Biennial World Conference. Vancouver, Canada, August 3 – 7, 2009, pp. 59 – 67.

Hausamann, D. (2012). *Extracurricular science labs for STEM talent support.* Roeper review. Accepted.

Heller, K. A. (ed.). (2009). Das Hector Seminar – Ein wissenschaftlich evaluiertes Modell der Begabtenförderung im MINT-Bereich (The Hector Seminar – A scientifically evaluated model of gifted education in the area of MINT). Berlin: LIT.

Heller, K. A., von Bistram, A., & Collier. A. (2010). The enrichment program "Hector Seminar". A longitudinal evaluation study in MINT (MINT). In K. A. Heller (ed.), *Munich studies of giftedness and talent* (pp. 433-454). Berlin: LIT.

Heller, K. A., & Perleth, Ch. (2000/2007). Münchner Hochbegabungstestbatterie (MHBT) (Munich high ability test battery). Göttingen: Hogrefe.

Heller, K. A., & Perleth, Ch. (2008). The Munich High Ability Test Battery (MHBT): A multidimensional, multimethod approach. *Psychology science quarterly, 50*, 173-188.

ICBF (n.d.). *Internationales Centrum für Begabungsforschung (International Center for the Study of Giftedness*). University of Münster, Germany. Retrieved June 1, 2012 from http://www.icbf.de/

LeLa (n.d.). *Lernort Labor – Center for Consulting and Quality Development*. University of Kiel, Germany. Retrieved June 1, 2012 from http://www.lernort-labor.de

Maria-Theresia-Gymnasium in Munich (n.d.). Retrieved June 1, 2012 from http://www.mtg.musin.de/?cat=1&id=50

Osborne, J., & Dillon, J. (2008). *Science education in Europe: Critical reflections (A Report to the Nuffield Foundation)*. London: King's College. [Online]. Available: http://89.28.209.149/fileLibrary/pdf/Sci_Ed_in_Europe_Report_Final.pdf [June 1, 2012].

Pawek, C. (2009). *Schülerlabore als interessefördernde außerschulische Lernumgebungen für Schülerinnen und Schüler aus der Mittel- und Oberstufe* [Learning laboratories as interest-supporting out-of-school learning environments for secondary school students] (Doctoral dissertation). [Online]. Available: http://eldiss.uni-kiel.de/macau/receive/dissertation_diss_00003669. urn:nbn:de:gbv:8-diss-36693 [June 1, 2012].

Pawek, C. (2012). Schülerlabore als nachhaltig das Interesse fördernde ausserschulische Lernumgebungen (School labs – extracurricular learning environments with sustainable impact on the development of interest). In D. Brovelli, K. Fuchs, R. von Niederhäusern & A. Rempfler (eds.), *Kompetenzentwicklung an ausserschulischen Lernorten (Arbeitstitel)* [Competence development in extracurricular learning facilities (working title)]. Münster, Germany: LIT (accepted).

Piffer, R., & Taulien, M. (2011). Die Begabtenförderung im Hector-Seminar [Talent support in the Hector Seminar]. In D. Hausamann & K. A. Heller (eds.), *MINT-Talentförderung* [MINT talent support]. Journal für Begabtenförderung, 1 (pp. 18-27). Innsbruck-Wien-Bozen: StudienVerlag.

Renzulli, J. S., & Reis, S. M. (2002). The Schoolwide Enrichment Model. In K. A. Heller, F. J. Mönks, R. J. Sternberg & R. F. Subotnik (eds.), *International handbook of giftedness and talent* (2nd ed., rev. reprint, pp. 367-382). Amsterdam: Elsevier / Oxford: Pergamon.

Seeley K. (1985). Facilitators for gifted learners. In J. Feldhusen (ed.), *Toward excellence in gifted education* (pp. 105-133). Denver: Love Publishing Company.

Stahl, M. (2009). Die Entwicklung der MINT-Fachkräftelücke in Deutschland [The development of the gap in MINT specialists in Germany]. Arbeitgeberverband Gesamtmetall. [Online]. Available: http://www.gesamtmetall.de/gesamtmetall/meonline.nsf/id/222Entwicklung_MINT-Fachkraefteluecke/$file/BroschuereMINT-Mangel.pdf [June 1, 2012].

Stumpf, E., Neudecker, E., & Schneider, W. (2008). Teilnehmer-Feedback zum School_Lab Oberpfaffenhofen – eine Pilotstudie zu außerschulischen Enrichmentkursen für Gymnasiasten [Participants' feedback to the School_Lab Oberpfaffenhofen – a pilot study addressing extracurricular enrichment courses for secondary school students]. Würzburg, Germany.

Tengelin, N., (2009). *Corporate investment to increase interest in mathematics, science and technology. A general analysis for the Volvo-group. Master Thesis.* Report No. E 2009:093. Chalmers University Sweden. [Online]. Available: http://www.educationandemployers.org/media/6924/tengelin%20(2009)%20-%20corporate%20investment%20to%20increase%20interest%20in%20maths%20science%20and%20technology.pdf [June 1, 2012].

Wörner, J.- D. (2011). MINT-Talente gesucht – Forschung und Technologie brauchen exzellenten Nachwuchs [Demand for MINT talents – Research and technology need excellent young academics]. In D. Hausamann & K. A. Heller (eds.), *MINT-Talentförderung* [MINT talent support]. Journal für Begabtenförderung, Vol. 1/2011 (pp. 18-27). Innsbruck-Wien-Bozen: Studienverlag.