Providing Creative Environments for Young STEM Talents’ Research Projects

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Innovative research projects are especially suited for supporting talents by bringing them into close contact with state-of-the-art research and development in the area of science, technology, engineering, and mathematics (STEM). A stimulating project with clearly defined objective groups of gifted school students can raise their limits of previous knowledge. By means of self-structured team action they are enabled to conduct targeted research and develop a defined innovative result—A product. This paper presents two practical examples of aerospace-related school student research projects, namely, the “TALNET Robotics-Dart Contest” with Charles University Prague and the Hector Seminar Project “Galileo Simulator,” including their basic conception, organizational conditions, and the essential aspects of planning and implementation. The supporting and stimulating role of teachers, university students and scientists is emphasized, especially by initiating a creative project idea and by structuring the project in an adequate way: Due to the great importance of creativity for all phases of such projects, the basic concepts of creativity and giftedness are addressed. Furthermore, it is demonstrated that project-based learning (PBL) provides a suitable concept for such complex research activities.

Keywords: science, technology, engineering, and mathematics (STEM), gifted and talented students, creativity, teacher education, student research projects, project-based learning, space-education

Creativity & Giftedness at Out-Of-School Labs—The Key Role of Teachers in Initiating Students’ Research Projects

The Basic Concept of Creativity

According to Csikszentmihalyi and Wolfe (2000), creativity can be defined as an act, idea, or product that is original, valuable, and implemented, i.e., that is recognized and adopted by others. Creativity cannot exist in a vacuum: The mental process involved in creativity takes place in a context of previous cultural and social

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achievements, and is inseparable from them (see Figure 1).

Creativity is as much a cultural and social as it is a psychological event. The indispensable environment for creativity has two salient aspects: A cultural or symbolic aspect which is called “domain”; and a social aspect which is called “the field.” This means creativity occurs at the interface of three subsystems: An individual who absorbs information from the culture and changes it in a way that will be selected by the relevant field of gatekeepers for inclusion into the domain, from whence the novelty will be accessible for the next generation: Altogether, creativity can be regarded as the ability to add something new to the culture (see Figure 2).

The individual contribution to creativity consists of three parts:
(a) access to a domain;
(b) personality traits that favor breaking rules;
(c) ability to convince the field.

The importance of intrinsic motivation for creativity is indubitable, as well as the ability to think divergently and be discovery-orientated.

The Different Levels of Creativity

In recent years, an especially useful rubric has been developed that distinguishes between four types, or levels, of creativity: big-C, pro-c, little-c, and mini-c (Kaufman & Beghetto, 2009):

1. Big-C creativity (i.e., creativity considered great in the given field) is associated with celebrated artists, musicians, and scientists;
2. Pro-c levels of creativity are exhibited by professionals who make important (though not necessarily exceptional) progress in their particular areas of expertise;
3. Little-c creativity is everyday creativity. It is related to transformative learning involving personally meaningful interpretations of experiences, actions, and insights. Creative accomplishments at these first three levels rely on the judgment of others;
4. Mini-c creativity, on the other hand, is personally meaningful and is not subject to external assessment; it comprises everyday problem solving and creative expression. Mini-c creativity comes about when the learner filters new information through existing frameworks of understanding to achieve a new level of awareness or knowledge. Clearly, this notion of mini-c creativity is especially relevant to children’s creativity.

School student projects described in this paper are dedicated to produce real innovation—Therefore, they are typical examples for pro-c creativity.

Measurement of Creativity

It is difficult to measure creativity: There are several methods, such as self-assessment, peer nomination, personality correlates, involving tests called “group inventory for finding interests,” divergent thinking tests, and historical recurrence.

Creativity in the technological domain results in technical innovations which are reflected by patents: A patent requires an invention with a sufficient degree of novelty, which is measured by the “inventive step” —Thus, providing an objective indicator for the novelty of a technical product. Therefore, technical creativity can be assessed objectively.

An important indicator of creativity is flow, a situation of most positive experience and the greatest intrinsic motivation, which happens in a situation of high opportunities for action (“challenges”) and a high capacity to act (“skills”).

Creativity and Education

The relationship between creativity and education is complicated, because the education system is by definition conservative or reproductive. Its main objective is to transmit knowledge with as little change as possible: “schools and creativity are inimical” (Csikszentmihalyi & Wolfe, 2000). On the other hand, good teachers are characterized by willing to foster original thinking in their students.

The educational implications at the individual level are:
1. Students’ curiosity and interest are the main sources of potential creativity;
2. Potential creativity is enhanced by intrinsic motivation, and suppressed by excessive reliance on extrinsic rewards;
3. Activities need to be designed with the conditions necessary for flow in mind;
4. Learning to formulate problems should be part of the curriculum;
5. Respecting creative personal traits;
6. Promoting the internalization of learning.

The educational implications at the level of the domain are:
1. How attractive is the information material presented to students?
2. How accessible is the information?
3. How integrated is the information?
4. Are there opportunities for mentorships and apprenticeships?

The educational implications at the level of the field are:
1. The role of funding/resources;
2. How open are teachers to new ideas?
3. Do teachers stimulate students’ curiosity and interest?
4. Can teachers distinguish good new ideas from bad ones?
5. Are there ways of implementing student creativity at school?

The Basic Concept of Giftedness

The three-ring concept of giftedness has been developed by Renzulli and Reis (2000): It comprises three interlocking clusters or traits, including above-average ability, task commitment, and creativity (see Figure 3):

1. Above-average ability includes:
   (a) General ability, i.e., the capacity to process information, integrates experiences that result in appropriate and adaptive responses in new situations, and engage in abstract thinking;
   (b) Specific ability, i.e., the capacity to acquire knowledge and skill in a domain, such as STEM.

2. Task commitment is a focused form of motivation, described by perseverance, endurance, hard work, dedicated practice, self-confidence, and belief in one's own ability.

3. Creativity is an essential component of giftedness. It includes traits, such as novelty, originality, ingenuity, and flow.

![Figure 3. The three-ring concept of giftedness (Source: Renzulli & Reis, 2000).](image-url)
The Schoolwide Enrichment Model—STEM

The Schoolwide Enrichment Model, STEM (Renzulli & Reis, 2018) is a concept devoted to develop the three traits: It provides enriched learning experiences and higher learning standards for all children through three goals:

1. To develop talents in all students;
2. To provide a broad range of advanced-level enrichment experiences for all students;
3. To follow up advanced learning for students on the basis of their interest and motivation.

The core of a STEM program is the enrichment triad model, comprising three types of enrichment:

1. Type I enrichment includes general exploratory experiences to expose students to exciting new topics, issues, and areas of knowledge not ordinarily covered in the regular curriculum;
2. Type II enrichments include instructional methods and materials designed to promote the development of thinking, feeling, research, communication, and methodological processes;
3. Type III enrichment is the most advanced level of enrichment, pursuing advanced or professional level work in an area of the students’ strong interest or passion. The general objective is to develop and create new products and inventions. It involves students in high engagement activities that promote genuine enthusiasm for learning and increased achievement. Especially, important is the interaction in a real-world goal-oriented environment with other like-minded students, in order:
   (a) To produce a product, service, or performance;
   (b) To present their work to intended audiences.

Gifted education according to the STEM serves two purposes: development of students’ abilities, task commitment, and creativity and enabling educators to increase the likelihood that more creative individuals will enhance our society by solving problems and bringing forth new contributions to improve our world.

All school students’ research projects described in this paper are Type III enrichments, going far beyond the school curriculum and resulting in aerospace-related technical products and innovations.
Creativity and Giftedness—Implications for Teachers

The teachers’ role in initiating, organizing, and supporting school students’ research projects changes considerably compared to regular school teaching. Concerning students, the teachers should have a thorough understanding of giftedness and talent and the implications for gifted learning, as well as the ability and expertise to adapt and modify the educational process of teaching appropriately.

Concerning creativity, teachers face three challenges:
(a) fostering creativity of school students (providing organization, help structure, and basic input and support);
(b) stimulating students’ teamwork;
(c) initiating new project ideas.

The latter point is of crucial importance for the success of a school students’ research project, because it creates the initial stimulation and motivation. Furthermore, it requires the teachers to be creative themselves. There are several possibilities for the initiation:

1. Pick up ideas from the school students: This would be considered an optimal process, but the probability for a school student initiative is quite low.
2. Pick up ideas from scientists: In this case, the initiative comes from research and is, therefore, authentic. The teachers’ role is to critically assess such proposals to match the (high, but not infinite) potential of the school students.
3. Creation of project ideas in cooperation with scientists: In this (very realistic) case, the project development is a joint action, considering—and matching—stimulating subjects and the school students’ abilities from the beginning.
4. Teachers’ self-creation of project ideas: This requires the teachers’ extended expertise and personal interest, and guarantees the teachers’ highest possible personal commitment.

All school students’ research projects described in this paper (and many others conducted at our lab) were initiated by the DLR_School_Lab and further developed jointly by teachers and scientists.

Project-Based Learning (PBL)

It has been shown that self-regulated learning is a helpful method especially for gifted youth (e.g., Weinert, 2000; Fischer, Mönks, & Grindel, 2004). In this area, project teaching (or PBL) has been established as an important method and has found its way into many curricula. This method, deduced from educational reformers like Dewey and Kilpatrick (R. Capraro, M. Capraro, & Morgan, 2013), gives learners a high degree of self-determination and self-responsibility for their learning process (Frey, 2012). In a comparative study on current research on PBL, Thomas (2000) found a number of advantages of this method over other, more traditional forms of instruction. In addition to the improvement in results in standardized knowledge tests, PBL also leads to a higher problem-solving ability.

As a further reason for the superiority of PBL over other, less self-regulated forms of learning, a high degree of student activation and engagement is cited (Blumenfeld et al., 1991). In the STEM subjects, PBL is seen as an opportunity to learn viable concepts and a critical, analytical way of thinking (see Capraro & Slough, 2013).

In the remainder of this paper, student research projects will be described as examples of PBL, which on the one hand was perceived as beneficial by the participants but which, on the other hand, resulted most notably in impressive results and an innovative product. The examples also show what the term project-based innovation (PBI) means according to the authors.
Innovative Student Research Projects

The DLR_School_LabOberpfaffenhofen (DSL)

The Oberpfaffenhofen site of the German Aerospace Center DLR has been operating the DLR_School_Lab since 2003—An out-of-school lab that has to date been visited by some 40,000 secondary school students and some 5,000 teachers (see Locherer, Hausamann & Schüttler, 2012; Euler, Schüttler, & Hausamann, 2015).

The experiments as the core content of the DSL’s concept are derived exclusively from the research fields of the institutes at DLR Oberpfaffenhofen, and therefore, have a close connection to space research and development. Due to their high complexity and inter-disciplinarity, aerospace-related topics are particularly attractive for highly talented young people (Hausamann, 2012), which is the reason why there has been a close cooperation with relevant institutions nationwide and even beyond the national borders from the very beginning. The DLR_School_Lab thus also functions as a student research center, i.e., as a place where young people with special gifts can design their own research projects (Plasa, 2013).

The positive effect of a one-day visit to the DLR_School_Lab on the situational interest and self-concept of upper secondary school students was clearly demonstrated (Pawek, 2009). On the other hand, corresponding studies on the support measures as a student research center are currently not sufficiently systematic (see Hausamann, 2012). Over the past 15 years, more than 3,000 highly gifted students have been able to take part in special enrichment activities offered by the DSL. In this context, longer-term student research projects play a special role.

In the following sections, two typical student research activities will be addressed, based on long-term cooperation with the external partners TALNET and Hector Seminar.

Student Research Projects With TALNET

The project TALNET International (Hausamann & Zelenda, 2012; Wikipedia) 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 (aged 13-19) by using online educational activities combined with face-to-face activities in STEM topics. It was 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 and has been running since 2003.

The TALNET offers a structure of educational and exploring/inquiry activities to adolescents, who are recommended by their teachers or psychologists. Activities differ in topic, form of teaching (face-to-face, mixed, and online), workload, complexity, and applicability. Many gifted children need ever more challenging activities, e.g., more demanding and more complex. 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 further advanced opportunities to gifted children for developing their competencies. Especially, the opportunity to work in multi-national teams and communicate in foreign languages seemed to be an appropriate instrument and a challenge.

The cooperation between TALNET and the DLR_School_Lab was initiated in 2008. Starting in 2012, robotics projects have been conducted on a yearly base. They are structured and organized as external learning and development activities, hosted by the Charles University of Prague, the highlight activity being the Robotics Dart Contest in Oberpfaffenhofen.
The TALNET Robotics Projects

Basic Technology: ASURO

The project is based on the DSL’s so called “ASURO Robotics experiment” (Gruber & Grewe, 2004; Wikipedia), in which secondary school students assemble a small robot and learn how to program it. With the assistance of a well-trained tutor at the DSL, this is typically a one-day activity, at the end of which the students have successfully completed the robot as well as developed and tested a simple C++ example program, such as following a black line or stopping at obstacles.

In case of TALNET, the ASURO robot kits are acquired for the project phase in Prague. Connected by the online education platform and supported by the TALNET supervisors, each member of the project team assembles his or her robot at home. Furthermore, all team members are introduced to programming in C++. Finally, the team members learn to design and test programs for their individual ASUROs. Due to the longer timeframe, the exchange within the network, and the support by the supervisors, the TALNET programming activities are far more complex than the programming in the one-day DSL experiment.

The highlight of the TALNET robotics project is a visit to the DLR Research Site in Oberpfaffenhofen. The program of this visit comprises the following:

(a) Introduction to the 10 DLR institutes and their research;
(b) Special visit to the robotics lab of the Robotics and Mechatronics Center;
(c) Special visit to the German Space Operation Center;
(d) Introduction to the DLR_School_Lab;
(e) Dividing the students in pairs for the contest;
(f) Introduction to the contest;
(g) Programming of the ASURO robots;
(h) The contest;
(i) Celebration of the winning team.

The “ASURO Dart Contest” consists of the task to hit the Center of a dart disk printed on a poster on the floor from a starting distance of about three meters: “Try to bring your ASURO as close as possible to the midpoint of the dart disk!”

Figure 5. (a) The ASURO robot; (b) The dart disk for the contest.
All teams have to use the ASURO robots which they have previously assembled at home and their own laptops in order to transmit their programs to the robot. There are two sessions of two hours to develop the program code for the dart program. For each of these sessions, the concentrated atmosphere (“flow”) is typical when the students develop and test their respective programs. Each team receives a dart disk to assess their programs. The teams are supported by the DSL’s robotic expert tutors.

The Robotics Dart Contest first took place in 2012. Despite, the ambitious and difficult programming task, the TALNET supervisors from Charles University in Prague have reported that the participating students were highly excited and deeply satisfied by this project. Therefore, TALNET has offered the robotics project every year since 2012.

Student Research Projects With the Hector Seminar

The Hector Seminar, founded in 2000, is an extra-curricular program in Germany to foster highly gifted secondary school students by providing enrichment activities in the areas of mathematics, informatics, natural sciences, and technology (Heller, 2009). It is financed and supported by the Hector Foundation. The Hector Seminar supervises especially gifted secondary school students on a long-term basis throughout their school career.

The seminar program supplements the regular school activities, from the 6th grade to the end of secondary school at the final grade (i.e., 12th or 13th). The projects are interdisciplinary, the main objective aiming to facilitate a holistic development of personality, the activation and evolvement of cognitive, methodical, personal, and social potential, as well as the development of corresponding competencies and capabilities. Each seminar course comprises 60 students who are chosen in a two-stage selection process from all 7,500 students in 6th grade of the secondary schools in the region of North-Western Baden-Wuerttemberg. The first stage selection is a screening process, whereas the secondary stage selection is based on the Munich High Ability Test Battery (Heller, 2009).

The cognitive, creative, and social capabilities of the students selected are far beyond the secondary school average. The seminars are located in the three cities of Heidelberg, Mannheim, and Karlsruhe. They are headed by two teachers each, and are conducted two afternoon hours per week. Presently, some 500 students in seven courses participate in the Hector Seminar. More than 500 students have successfully completed the Hector Seminar. A long-term evaluation study has shown it is highly effective and successful (Heller, 2009).

Since 2004, eight student research projects have been carried out with Hector Seminar at the DSL, as shown in Table 1.

Table 1
Overview of the Student Research Projects Carried out With the Hector Seminar

| Year | Project name                  | Content                                                                 |
|------|-------------------------------|-------------------------------------------------------------------------|
| 2004 | Space Robotics                | Construction and programming of ASURO robots                              |
| 2006 | Remote Sensing of the Earth  | Geophysics and satellite remote sensing                                  |
| 2008 | Galileo                      | Study on the functioning of global satellite positioning systems         |
| 2010 | Mars Robots                  | Development of a semi-autonomous control for ASURO-robots                |
| 2012 | Galileo Simulator            | Feasibility study for locating with acoustic signals                     |
| 2014 | Ignition Unit Development    | Development of control electronics for the recovery system of a model rocket |
| 2016 | High-Altitude Ballooning     | Development, construction, and launch of a stratospheric probe for atmospheric research and remote sensing of the earth’s surface |
| 2018 | Flying Home from the Lower Stratosphere | Development, construction, and launch of a paraglider returning autonomously from the stratosphere to the launch site |
All of these Hector Seminar student research projects were initiated by the DSL in close cooperation with the Hector Seminar supervising teachers. The projects are based on the fascination of aerospace research: The current research topics of DLR form the starting point for a motivating project idea comprising a problem with an unknown solution (a so-called “research gap”). In cooperation with the teachers of the Hector Seminar, the project is further developed to a student project with complex tasks, a defined project goal, and a concrete product expectation. The overall framework of such a student research project includes the sections:

1. Project announcement and recruiting a group of gifted students;
2. Regular meetings of the student team, organized by the supervising teachers, supported by DSL;
3. Four multi-day stay of the group at DLR: creative product development;
4. Presentation of the product, presentation of the results, and publication.

Steps 1, 2, and 4 are typical and essential components of PBL. The extension to PBI takes place in Step 3, where the knowledge and skills are used creatively to design and realize a novel product. This innovation-creating process takes place within the framework of a stay of several days at the DLR Research Center in Oberpfaffenhofen. It is characterized by the following elements:

1. Stimulating ambience of the research center, insights into current aerospace research (institute visits and guided tours);
2. Structured time management, given daily routine with discussion, planning, working, and reflection phases;
3. Self-organization of the team, autonomous management, i.e., definition of intermediate goals, task allocation, flexible formation of sub-teams, knowledge exchange, critical reflection, and adaptation/change of the project plan;
4. Technical support by scientists and university students;
5. Organizational support from the supervising teachers, as individual contact persons and consultants;
6. Inspiring support program (For example, dinners, excursions, sightseeing flights, space control center, etc.).

**Example Hector Seminar Project “Galileo Simulator”**

The following example describes the student research project “Development of an acoustic Galileo simulator in a LabView/myDAQ environment,” which was conducted in collaboration with the Hector seminar in 2012 (Hausamann et al., 2012). Another example describing the 2006 Hector Seminar Project “Geophysics and satellite remote sensing” can be found in Hausamann, Wilke, Taulien, Grixa, and Locherer (2009).

**Idea**

In the “Satellite Navigation” experiment of DSL, the participants learn, in addition to practical aspects, in particular the functioning and underlying physical and technical principles of global satellite navigation systems. However, since the “real” signals evade direct access, the authors had the idea to reconstruct a satellite positioning system based on perceptible acoustic signals.

**Research Gap**

The question of the feasibility of a positioning system based on digital acoustic signals was at that time still completely open and unexplored. The coding procedures, the main sources of biases, corrective measures and, finally, requirements for suitable hardware, and software were also unclear.
Task Description

The task for the participants of the project was therefore to develop an experimental set-up with which it would be possible to locate a receiver with sufficient precision on the basis of acoustic signals. The only prerequisite was the choice of the data acquisition device and the resulting software.

Group Formation

Three female and eight male students from the Hector seminar applied as volunteers for the project. The basis for their application was a rather openly formulated tender text, which left a lot of scope for the concrete design of the project.

Preparation

The group came together for four three-hour preparatory workshops to learn the basics of LabView programming, satellite navigation in general, and data broadcasting in particular. They were assisted by the instructors. The students received additional help through an on-site course by two DLR employees, who had profound expertise in the respective subject area.

Productive Phase (PBI)

In the next step, the students and their teachers met at DLR Oberpfaffenhofen for a three-day intensive workshop to develop the simulator. They received additional support from DLR staff members of the DSL OP as well as the Institute for Robotics, Communication, and Navigation and the Microwaves and Radar Institute. In addition to intensive work phases, their stay at the DLR was enriched by guided tours and lectures. On the one hand, this helped to create a relaxed atmosphere; on the other hand, it gave the participants the opportunity to gain an insight into the “real” research of DLR. On the last day of the project, the Galileo simulator was presented to an audience of DLR employees and tested for the first time.

Result

The Hector student group was able to realize a one-dimensional location with clock synchronization within the project duration. They achieved position accuracies in the centimeter range. The project was then presented in a festive atmosphere to other students of the Hector seminar who had dealt with other topics, their parents, teachers and the interested public. As a special highlight, the project was invited to be presented at an international symposium. Furthermore, it was successfully submitted to the national STEM competition “Jugendforsch”.

![Student feedback](image)

*Figure 6. Evaluation results: The student responses confirmed the positive impression of the project.*
Evaluation/Assessment

The project was evaluated by means of questionnaires and an intensive round of talks. The participants were satisfied but quite self-critical (see Figure 6). In addition, it became apparent that other affective aspects were also rated positively. The excellent project result allows for indirect conclusions about the acquisition of project-related knowledge and competencies. The highly talented youngsters managed to complete their project successfully despite the high complexity and the real research character. In addition to the appropriate technical qualifications gained, communication and assessment skills were acquired.

Conclusions and Future Perspectives

The projects with TALNET and the Hector seminar have proven to be extraordinary productive and challenging for the young people and at the same time very interesting:

1. In the TALNET project, the school students have proven a deep understanding for assembling and programming robots. The difficult programming tasks resulted in algorithms that were tricky solutions for a difficult problem. In this sense, each of the students created not only a new product, but also showed the ability to develop appropriate software solutions.

2. Concerning the Hector Seminar projects, the output was, in most cases, a new technical solution or concept—an invention which, especially in the “Acoustic Galileo Demonstrator” project could even have been patented, due to the great inventive step.

In both cases, young school students with far above average abilities have developed new products with outstanding creativity on a professional level (“Pro-c”).

Apart from the high ability of the students, their creativity and task commitment as well as teachers play a key role in all of these innovative projects, including:

(a) The necessary paradigm shift in their role as educators;
(b) Their personal interest in fostering highly able youth;
(c) Their supporting role in the projects;
(d) Their willingness to cooperate with scientists;
(e) And finally, their creativity in finding challenging new project ideas, which are adequate for young students.

From a didactic point of view, using PBL to conduct such projects is theoretically well justified, last but not least, they extend PBL’s proven approach to a new level of real innovation (PBI). It seems worthwhile pursuing further respective research. Ideally, this approach could contribute to the development of new teaching concepts that enable young people to effectively and productively use their creative potential.

References

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., and Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. Educational Psychologist, 26(3), 369-398.
Capraro, R. M., Capraro, M. M., & Morgan, J. R. (Eds.). (2013). STEM project-based learning: An integrated science, technology, engineering, and mathematics (STEM) approach. Springer Science & Business Media.
Csikszentmihalyi, M., & Wolfe, R. (2000). New conceptions and research approaches to creativity: Implications of a systems perspective for creativity in education. In K. A. Heller, F. J. Monks, R. J. Sternberg, and R. F. Subotnik (Eds.), International handbook of giftedness and talent (2nd ed., pp. 81-93). Oxford: Pergamon Press.
Euler, M., Schüttler, T., & Hausamann, D. (2015). Schülerlabore: Lernendurch Forschen und Entwickeln (Student laboratories: Learning through research and development). In E. Kircher, R. Girwidz, and P. Häußler (Eds.), Physikdidaktik (pp. 759-782). Springer Berlin Heidelberg.
Fischer, C., Mönks, F. J., & Grindel, E. (Eds.). (2004). Curriculum und Didaktik der Begabtenförderung: Begabungen fördern, Lernen individualisieren (Curriculum and didactics of gifted education: Promoting talents, individualizing learning). LIT Verlag Münster.

Frey, K. (2012). Die projektmethode: Der weg zum bildenden tun (The project method: The way to forming activity). Weinheim: Beltz.

Gruber, R., & Grewe, J. (2004). More fun with ASURO. Publisher, AREXX Intelligence Centre, ARX-BOOK. Retrieved from https://de.farnell.com/arexx/ark-book1gb/book-more-fun-with-asuro-english/dp/1280091

Hausamann, D., Wilke, G., Taulien, M., Grix, 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 STEM). Berlin LIT.

Hausamann, D. (2012). Extracurricular science labs for STEM talent support. Roeper Review, 34(3), 170-182.

Hausamann, D., Schüttler, T., Rommel, T., Taulien, M., Piffer, R., Müller, C., Dallinger, S., & Schubert, J. (2012). Entwicklung eines akustischen GALILEO-Simulators in einer LabView/myDAQ-Umgebung (Development of an acoustic GALILEO simulator in a LabView/myDAQ environment). Retrieved from https://elib.dlr.de/79108

Hausamann, D., & Zelenda, S. (2012). Success factors for extracurricular MINT talent support. Retrieved from https://www.researchgate.net/publication/225006650_Success_Factors_for_Extracurricular_MINT_Talent_Support

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 STEM) (Vol. 5). LIT Verlag Münster.

Kaufman, J. C., & Beghetto, R. A. (2009). Beyond big and little: The four C model of creativity. Review of General Psychology, 13, 1-12.

Locherer, M., Hausamann, D., & Schüttler, T. (2012). Practical science education in remote sensing at the DLR School LabOberpfaffenhofen. In Geoscience and Remote Sensing Symposium (IGARSS), 2012 IEEE International (pp. 7389-7392). IEEE.

Pawek, C. (2009). Schülerlabore als interessefördernde außerschulische Lernumgebungen für Schülerinnen und Schüler aus der Mittel- und Oberstufe (Student laboratories as interest-promoting extracurricular learning environments for middle and high school students). Dissertation. Universität Kiel.

Plasa, T. (2013). Die Wahrnehmung von Schülerlaboren und Schülerforschungszentren (The perception of student laboratories and student research centers) (Vol. 152). Logos Verlag Berlin GmbH.

Renzulli, J. S., & Reis, S. R. (2010). The school wide enrichment model: A focus on student strengths and interests. Gifted Education International, 26(2-3), 140-156.

Renzulli, J. S., & Reis, S. M. (2018). The three-ring concept of giftedness: A developmental approach for promoting creative productivity in young people. In S. I. Pfeiffer, E. Shaunessy-Dedrick, and M. Foley-Nicpon (Eds.), APA handbook of giftedness and talent (pp. 185-199). American Psychological Association.

TALNET International. (n.d.). Retrieved from http://www.talnet.cz/talnet_new/ukazky-z-kurzu

Thomas, J. W. (2000). A review of research on project-based learning. Retrieved from http://www.dl.icdst.org/pdfs/files1/aac48826d9652cb154e2dbf0033376fa.pdf

Weinert, F. E. (2000). Lernens BrückezwischenhoherBegabung und exzellenter Leistung (Learning as a bridge between high talent and excellent performance). Vortrag gehalten anlässlich der zweiten internationalen Salzburger Konferenz zu Begabungsfragen und Begabtenförderung-Salzburg.

Wikipedia. (n.d.). ASURO. Retrieved from https://de.wikipedia.org/wiki/ASURO and http://www.arexx.com/downloads/asuro/asuro_manual_en.pdf

Wikipedia. (n.d.). TALNET. Retrieved from https://en.wikipedia.org/wiki/Talnet