ENRICHMENT – ADDITIONAL LEARNING OPPORTUNITIES FOR TALENTED STUDENTS
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FOR TALENTED STUDENTS

1. Science Competitions: Research on and for Talented Students

2. Characterizing Abilities, Interests, and Beliefs of Participating and Non-Participating Students in Competitions to Support Scientific Talents: The Project Icoon
   2.1 A RIASEC-Based Analysis of Students’ Interests in Science
   2.2 Goal-Orientations and Self-Concepts of Participants in Different School Competitions

3. The Effectiveness of a Project Day to Introduce Sixth-Grade Students to Science Competitions

4. Science Laboratories for Students and Student Teachers

5. Further Research
Curricula for school science education currently set a strong focus on the development of competencies to develop a solid foundation of student scientific literacy. The outlined goal is to enable students as citizens to understand the role and relevance of science for their daily lives, to engage in societal issues involving science, and to make decisions based on scientific knowledge. Like other subjects, school science shall moreover provide a foundation for personal development, on-going learning, and career options. As the number of school science lessons is limited, curricula typically emphasize other goals far less such as providing deeper insights into selected topics of (modern) science or offering interested students further insights into methods and explanations. Hence, many programs have been developed to provide additional learning opportunities as in-school or out-of-school enrichment. These programs include science laboratories, clubs, competitions, and many more. However, this sizable development is not accompanied by similar emphasis on empirical research on outcomes and suitable models of enrichment programs and activities. Until now research has primarily focused on each specific program and generalization to other measures is limited if possible at all. The high investment made in enrichment programs and the relevance of fostering talents in science, technology, engineering, mathematics (STEM) clearly calls for more research in this field.

The IPN has taken this demand into consideration and initiated research projects both focusing on the outreach of science into education and on effects of enrichment programs on students. The projects examine motivation and interest as well as content- and process-related competencies; and the obtained results aim to contribute to a better understanding of the interplay between school and extracurricular programs and to form an empirically sound basis for the further development of such measures.

1 Science Competitions: Research on and for Talented Students

The need to raise interest in STEM fields for more gifted and talented young students has been repeatedly stated. As a consequence, a number of different programs have been developed and implemented to enrich school STEM education. Enrichment can be defined as the provision of in-depth, often multidisciplinary exploration of content beyond that provided in the regular curriculum with the goal to further develop gift-
ed learners. Enrichment can take place inside schools, for example by forming groups of gifted learners to tackling specific issues or projects, or outside schools, such as in student laboratories, summer schools, or science competitions. The development and evaluation of enrichment measures is firmly rooted in the IPN’s research tradition. With respect to in-school settings, the former IPN projects Science in Context still form the foundation for many following projects such as NaWi-aktiv (Science in Action) and the follow-up programs Planspiele Wissenschaft und Beruf (Simulation Games Science and Professions) which offered programs of inquiry-based learning for elective science courses (Wahlpflicht).

Science competitions such as the Science Olympiads can be regarded as enrichment measures as they aim to stimulate students to expand their talents, and to choose a science-related career. The IPN has organized the Science Olympiads – six annual science competitions for students (see Figure 1) – for many decades now.

Subject Olympiads (SI ↔ SII)
*Foster and challenge students’ abilities, offer professional perspectives, stronger differentiation*

BUW (SI & SII ↔ Professional occupation)
*Teamwork, make use of scientific results for society*

IJSO (Elementary ↔ SI)
*Motivation, testing one’s abilities and areas of interest, talent development*

EUSO (SI ↔ SII)
*Interdisciplinary teamwork, merging of subject perspectives*

Figure 1. Orientation and global structure of the Science Olympiads. SI = lower secondary school, SII = upper secondary school. BUW = BundesUmweltWettbewerb; EUSO = European Union Science Olympiad; IJSO = International Junior Science Olympiad.
In the following, we report on three projects the IPN has carried out or is still executing to evaluate enrichment in the scope of the Science Olympiads. The project Individual Concept About Natural Sciences (ICoN) aimed to get a more precise picture about the beliefs, characteristics, and abilities of participants. The project NaWigator in the IJSO investigates activities to motivate and interest more young students to take part in science competitions, in particular in the International Junior Science Olympiad (IJSO). Insights from both projects, ICoN and NaWigator, contributed to the conception of the project Effects of Science Competitions for Students (WinnerS), which focuses specifically on the positive and negative effects of (un)successful participation in science competitions on students’ interest and motivation in science (careers).

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**DURATION //** ongoing  
**COOPERATION //** All competitions are in cooperation with external partners like universities, science centers, and other national organizations. Partners include the Universities of Göttingen and Potsdam; German Aerospace Center (DLR) in Göttingen; Eppendorf in Hamburg; the German National Academic Foundation; the “Deutsche Schülerakademie”; the National Students’ Competition Committee; the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany (KMK). The Olympiads in biology, chemistry, and physics are also supported by associations of former participants, so-called Fördervereine.  
**HOMEPAGE //** [www.scienceolympiaden.de](http://www.scienceolympiaden.de)
2 Characterizing Abilities, Interests, and Beliefs of Participating and Non-Participating Students in Competitions to Support Scientific Talents: The Project IcoN

The research project ICoN focused on participants of science competitions and aimed to reveal differentiated insights into their domain-specific cognitive requirements and motivational variables, such as interest in science, self-concept, and beliefs about science professions and scientists as people. A framework aggregating potentially relevant variables and their interdependencies was developed representing the individual concept about natural science (ICoN). Holland’s RIASEC representation of vocational interests was adopted to serve as a common framework. Different facets of interest but also the constructs nature of science and self-concept as well as students’ knowledge of science were investigated. Research was initiated comparing participating students in different competitions (IJSO; Jugend forscht) with non-participants. Complementary studies concentrating on students from regular schools, focusing, for example, on gender differences were also carried out. The aim was to identify different profiles of learners along the RIASEC dimensions in terms of the different variables of the ICoN constructs. This contributed to the overall knowledge about different groups of students and can also be a starting point for devising adapted supportive measures as a basis for interventional as well as long-term studies. In the following, results regarding two of the four main facets of ICoN will be reported: interest as well as self-concept and goal orientations.

2.1 A RIASEC-Based Analysis of Students’ Interests in Science

Introduction and Objectives

Next to the learning of the basic concepts, students should understand how scientific evidence is generated, how they can apply scientific knowledge to socio-scientific issues of relevance, and how science is communicated. This broader spectrum of science-related activities correlates with the more diverse field of professions based on or related to science.

Thus, there is a need to widen perspectives in science education research beyond the content level as well. With regard to affective variables such as interest, the broad spectrum of activities is usually not represented in a sophisticated manner. The instruments applied do not specifically investigate interest in different contexts and activities with regard to

the whole spectrum of school science, out-of-school science, and science-related professions. Therefore, the goal of the project presented and discussed in this report was to fill this gap, and to develop and test an instrument that offers specific insights into students’ interest with regard to the whole field of current science.

In a first step, the original RIASEC model by Holland had been adapted to characterize typical activities of students in three different learning environments (school, out-of-school, enrichment) to test whether the model was suitable as a framework to assess these kinds of activities of students and participants of a science competition. The second step aimed at adapting the RIASEC+N model to specific science-related activities in the environments school, enrichment, and (prospective) vocation and will be reported here.

**Method**

A questionnaire with a total of 270 items was developed measuring among other things the interest in school activities, science-related school activities, science-related enrichment activities, and science-related vocational activities (see Table 1). For comparing the structures with the original model, the German version of the

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Exemplary item</th>
<th>Environment</th>
<th>α</th>
<th>αoverall</th>
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<tr>
<td>Realistic (12 items)</td>
<td>“I’m interested in conducting experiments according to given instructions.”</td>
<td>School</td>
<td>.65</td>
<td></td>
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<td></td>
<td></td>
<td>Vocation</td>
<td>.79</td>
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<td></td>
<td></td>
<td>Enrichment</td>
<td>.77</td>
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<td>Investigative (12 items)</td>
<td>“I’m interested in investigating the cause of phenomena.”</td>
<td>School</td>
<td>.71</td>
<td>.90</td>
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<td></td>
<td></td>
<td>Vocation</td>
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<td></td>
<td></td>
<td>Enrichment</td>
<td>.81</td>
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<td>Artistic (12 items)</td>
<td>“I’m interested in designing science topics by means of aesthetic criteria.”</td>
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<td></td>
<td></td>
<td>Vocation</td>
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<td></td>
<td>Enrichment</td>
<td>.78</td>
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<tr>
<td>Social (9 items)</td>
<td>“I’m interested in explaining science topics to others.”</td>
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<td>.90</td>
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<td></td>
<td></td>
<td>Vocation</td>
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<td></td>
<td>Enrichment</td>
<td>.81</td>
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<tr>
<td>Enterprising (12 items)</td>
<td>“I’m interested in supervising others in conducting experiments.”</td>
<td>School</td>
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<td></td>
<td></td>
<td>Vocation</td>
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<td></td>
<td></td>
<td>Enrichment</td>
<td>.79</td>
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<tr>
<td>Conventional (12 items)</td>
<td>“I’m interested in sorting and administering the chemicals storage.”</td>
<td>School</td>
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<td></td>
<td></td>
<td>Vocation</td>
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<td></td>
<td>Enrichment</td>
<td>.73</td>
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<td>Networking (12 items)</td>
<td>“I’m interested in comparing thoughts with others about science topics.”</td>
<td>School</td>
<td>.79</td>
<td>.93</td>
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<td></td>
<td></td>
<td>Vocation</td>
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<td>Enrichment</td>
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<td></td>
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<td>School (27 items)</td>
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<td>Vocation (27 items)</td>
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<td></td>
<td></td>
<td>Enrichment (27 Items)</td>
<td>.96</td>
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original RIASEC questionnaire AIST was tested in the same questionnaire as well. The reliabilities were comparable to the ones reported for the standardized instrument, which ranged from .82 to .87. A total number of \( N = 247 \) students from Grades 8 to 12 (age cohorts 12–19 years, \( M = 15.07, SD = 1.21; 59\% \) female) participated in the study. More than 80 percent of them were between 14 and 16 years old. All students came from three different secondary schools with mostly urban catchment in northern Germany. Most of them did not participate in science competitions.

**Results**

Calculated correlations between the original model and our adaptation support the expected characterization along the adapted RIASEC+N model. Relatively large correlations between items from the corresponding dimensions of the original model and the adaptation demonstrate their overall relation. A cross-classified model was calculated to consider the hierarchical structure of the data (Figure 2). The left side depicts the already established seven dimensions of the adapted RIASEC+N model; the right side shows the three environments (school, enrichment, vocation). The middle column shows the questionnaire's scales (for example, R Sch stands for realistic tasks within school). Mplus was used to calculate correlations and goodness-of-fit statistics, which include RMSEA (root mean square error of approximation), SRMR (standardized root mean square residual), CFI (comparative fit index), TLI (Tucker-Lewis index) the value of chi-square and the number of degrees of freedom. The overall fit of the cross-classified model was good considering that the CFI and the TLI reached values above .95. RMSEA and SRMR values under .08 indicated an acceptable fit as well. Alternative models were considered but did not prove to fit the data better. Thus, regarding the overall structure of the model, the learning environments are clearly to be understood as an impacting variable regarding students’ interest. The same applies to the activities actually performed by the learners, respectively their corresponding RIASEC+N dimensions. According to the cross-classified model, the activities are also not sufficient to be solely taken as the variable predicting students’ interest. Both learning environments and activities are necessary for the characterization of students’ interest. Moreover, gender differences were found in that girls’ interest in the artistic dimension was higher than the boys’ interest in school as well as enrichment activities (Figure 3). Likewise, girls’ interest in social – but science-related – school activities was higher than boys’, whereas no significant differences could be observed in the investigative, enterprising, con-
In the realistic dimension, boys showed a significantly higher score in the science-related vocational interest, whereas girls seemed more interested in realistic science-related school activities and enrichment activities.

Figure 2. Cross-classified model describing the structure of interest in science activities.
Discussion

The results give good reason to assume a successful adaption of the instrument to the science domain. The results reveal the syndetic, mutual significance of both, activity and environment, for the precise characterization of students’ interest within the science domain. The practical value of the additional networking dimension, which was found for the first time in a previous study, could be further supported, as the tested “+N”-models proved to be superior regarding goodness-of-fit criteria to RIASEC models. In sum, the adapted RIASEC+N model presents a supplement to a more profound characterization of students’ interests within the science domain by permitting a categorization of students’ interests in specifically science-related activities along the seven dimensions of the adapted model. The positive results of the CFA provide the eligibility for representing the expected structure of students’ interests.

With regard to gender differences, girls showed the anticipated higher interest in activities of the social and artistic dimension in some but not all environments. Thus, these activities still seem to be subject to existing gender stereotypes. The result that the boys’ interest in the realistic dimension is higher only in science-related vocational activities but not in the school and enrichment environments indicate the influence of the environment. Realistic activities such as mechanical craftwork are typically perceived as male professions. In school, on the other hand, it may be that girls often carry out supporting activities in experimental settings without taking the leadership role. This habit might then explain the different results for this dimension, especially in the school vs. vocational activities setting. However this explanation is mostly speculative at this point.
Concerning the future development of enrichment measures, first implications can be stated: Aiming for the most precise support of students by providing enrichment measures and fostering programs with the highest possible congruency to actual interest profiles in science-related activities, the orientation and the target groups of the contests need to be characterized. Based on further analyses of interest profiles of participants of the diverse science contests, matching combinations can be identified. For those interest foci which are not represented by the orientation of any enrichment programs, new matching measures must be developed. Thereby, students can be guided to the corresponding programs more effectively, providing better fostering and enrichment measures in order to stimulate long-term interest in the science domain.

2.2 Goal-Orientations and Self-Concepts of Participants in Different School Competitions

Introduction and Objectives

Goal orientations and self-concept have been highlighted as important variables for motivation and choice in education. However, their influence on participating in different enrichment measures such as competitions is unclear. How do participants of competitions differ from non-participants? The study aimed to investigate goal orientation and self-concept of participants in a science competition in comparison to non-participants. As non-participants, two groups were chosen: non-participating school students and participants of a different, non-cognitive (here: sports) competition. The latter was added to investigate whether the situation of a competition independently of its focus correlates with specific features of motivation and self-concept or whether these might be different only for the cognitive science competition. The following research questions were investigated:

1. How do participants’ and non-participants’ academic self-concepts differ?

2. How do goal orientations of participants of science competitions differ from those of non-participants or participants of another (sports) competition?

3. Which gender effects can be identified?
Method

For the purpose of this study, two vastly different, well-established competitions for students were chosen – the International Junior Science Olympiad (IJSO) and Jugend trainiert für Olympia (JtfO; Young people training for the Olympic Games). The sample of \( N = 574 \) students included participants of the second round of the IJSO from all over Germany \((n = 133)\), participants of JtfO (75\% of them in the last or second-to-last round; \( n = 137 \)), and students of the same age group who neither participated in IJSO nor JtfO (control group; “non-participants”; \( n = 304 \)).

Academic self-concept (school-related) was assessed with 12 items of the standardized Scales for the Assessment of School-Related Competence Beliefs (SESSKO). Six items each were used to ask for social academic self-concept (i.e., self-concept in relation to others) and individual academic self-concept. Internal consistencies were Cronbach’s \( \alpha = .92 \) and \( \alpha = .83 \), respectively.

To assess goal-orientations, the standardized questionnaire Scales for the Assessment of Learning and Performance Goals (SELLMO) was used. Eight items assess learning goals \( (\alpha = .74) \), performance approach goals \( (\alpha = .82) \), and work avoidance \( (\alpha = .83) \), respectively. Seven items assess performance avoidance goals \( (\alpha = .71) \).

Results

Concerning social self-concept, an analysis of variance (ANOVA) showed significant main effects for group (i.e., IJSO vs. JtfO vs. non-participants), \( F(2, 541) = 12.45, p < .001, \eta^2_p = .044 \), as well as for gender, \( F(1, 541) = 15.86, p < .001, \eta^2_p = .028 \). The interaction effect was not significant, \( F < 1 \). Boys had higher self-concepts throughout all groups. Planned contrasts showed that IJSO-participants had higher social self-concepts than either JtfO-participants \( (p < .001, \quad d = 0.44) \) or non-partici-
pants ($p < .001, d = 0.50$), while JtfO-participants and non-participants did not differ significantly ($p = .81$).

Regarding learning goals, a two-way ANOVA showed a significant main effect for group, $F(2, 558) = 17.48, p < .001, \eta^2_p = .059$. Participants of the IJSO had a significantly higher mean value than either JtfO-participants or non-participants, which was confirmed by planned contrasts. Participants of JtfO did not differ from non-participants. An expected main effect for gender (girls superior to boys) was not found, $F(1, 558) = 1.52, p = .218$, in their learning goals.

As for performance approach goals, no significant differences were found at all ($Fs < 2.12$). Regarding performance avoidance goals, a two-way ANOVA yielded a significant main effect for group, $F(2, 558) = 9.18, p < .001, \eta^2_p = .032$; post-hoc contrasts showed the non-participants’ group to be superior to IJSO-participants in that regard ($p < .001, d = 0.42$), but not to JtfO-participants ($p = .06$). Effects for gender and the interaction were not statistically significant.

Lastly, significant differences in work avoidance were found: Boys had significantly higher values on the work avoidance scale than girls, $F(1, 558) = 15.93, p < .001, \eta^2_p = .028$. Likewise, a significant main effect for group indicated work avoidance to be higher for non-participants (contrast test: $p < .001, d = 0.62$) as well as for JtfO-participants ($p < .001, d = 0.52$) than IJSO-participants, $F(2, 558) = 6.99, p < .001, \eta^2_p = .064$. Non-participants and JtfO-participants did not differ on work avoidance ($p = .78$). Although the interaction effect was not significant, $F(2, 558) = 1.55, p = .21$, the descriptive values suggest the gender gap to be non-existent for IJSO-participants.

**Discussion**

In summary, our findings show considerable differences (and also similarities, some of them not expected) between participants of a cognitive science competition, participants of a non-cognitive sports competition, and non-participants. Regarding academic self-concept, as expected, IJSO-participants proved to be superior concerning their social self-concept to both non-participants and JtfO-participants, while there was no difference between the latter groups. That is, IJSO-participants regarded themselves significantly better in terms of school performance than their classmates. As could be seen by their respective grade point average (GPA), this self-belief is also realistic; the effect disappears when GPA is added as a covariate. Therefore, we assume that better GPAs both lead to higher social self-concepts and increase the possibility of participation in a science competition. As to gender differences, generally higher self-concepts of boys were expected as well as found; after controlling
for GPA, the difference became even larger. That is, girls with comparable school achievements to boys have significantly lower self-concepts than boys – seemingly without objective reason. Moreover, it would have been plausible to expect no differences in the IJSO-group, as those girls should have experienced an equality to the boys’ in terms of academic success. However, the results show that even successful girls in the science competition group still seemed to underestimate their abilities and still showed a significantly lower self-concept than comparable boys. The participation in the competition’s first two rounds therefore seemingly did not positively influence the girls’ self-concept significantly. Even though they had been as successful as the boys in getting to the second round, their self-perception was still lower. These results show the need for intervention studies specifically focusing on fostering girls’ self-concept to encourage them to stay in science enrichment programs and competitions and to support their career choices.

As for learning goals, the IJSO participants indeed outperformed non-participants. Apparently, participants of this science competition are more willing to acquire new skills and knowledge and are more intrinsically motivated. Although it is most likely that the IJSO-participants acquired those learning goals beforehand and thus chose to participate, it is also possible that the competition itself enhanced their learning goals even further.
3 The Effectiveness of a Project Day to Introduce Sixth-Grade Students to Science Competitions

Introduction and Objectives

Aiming to motivate more young students to participate in competitions appears to be a good strategy to support overall interest in science and to encourage more talented students to pursue degrees in STEM. To reach this goal it seems necessary to investigate students’ reasons for participation and to find a way to overcome possible obstacles of participation. Thus, our study focused on young students’ reasons for participating in competitions, and examined the effects of a ‘competition day’ which is meant to give students the opportunity to become familiar with competition formats and tasks in a training situation.

Method

The competition day is a project day at school which gives students the opportunity to become familiar with competition formats and tasks in a training situation. The competition day is composed of two main elements. The first one is an oral science quiz in which student teams play against each other by answering theoretical questions and practical science tasks. The second element consists of working stations that give students the opportunity to spend time working on scientific phenomena.

The sample consisted of 474 sixth graders (45 % female; age: $M = 11.20$
years, $SD = 0.42$) from six secondary schools (including one control group school) in five different German states. We formed two intervention groups by randomly assigning half of each school’s participating classes to one of two conditions. A questionnaire study with a pre–post–follow-up design was conducted to evaluate the effectiveness of the competition day. The control group and two intervention groups took part in the first measurement. Both intervention groups attended the competition day between the first and the second measurement. After the second measurement the two intervention groups were treated differently. Since the students are quite young and some had never participated in a science competition, we designed a fictive competition and let the students participate in that during science lessons (Intervention Group A). Intervention Group B worked on the same tasks without any connection to a competition situation, that is, it appeared as typical school situation. The third measurement followed nine weeks later (Figure 4).

We chose and developed 4 point Likert scales regarding students’ individual characteristics (e.g., self-concept, interest in science subjects, learning goals) and attitudes to competition-specific characteristics. The participants were also asked for their willingness to participate in a science competition at all three measurement occasions. In total, 71 items had to be answered.

### Results

As Figure 5 shows, a repeated-measures ANOVA revealed significant changes over time, $F(1.93, 431.30) = 9.19$, $p < .001$, $\eta_p^2 = .039$, as well as significant differences between the groups, $F(2, 224) = 5.13$,
$p = .007, \eta_p^2 = .044$. The interaction effect was significant as well, $F(2, 224) = 12.61, p < .001, \eta_p^2 = .054$. Follow-up analyses of covariance indicated that the competition day increased the willingness to participate in science competitions in both intervention groups but that afterwards, however, Group A as the only group to experience a competitive setting exclusively stayed interested in participating.

**Discussion**

Our goal to design a project day that was suitable to introduce sixth-grade students to science competitions and motivate them to participate in science competitions was successfully attained. The combination of the competition day with a simulated competition (Group A) showed the best results and indicated that this combination could be an option to interest and foster students continuously. Students’ willingness to participate in science competitions in Group B (just the competition day) decreased after the second measurement but stayed significantly higher than the willingness of the control group. The competition day thus seems to be an effective way to implement science competitions at schools. Formats such as our competition day are a practicable way to motivate more young students to participate in science competitions – which can, in turn, be a good option for generating and maintaining student interest and enthusiasm in science and mathematics.
4 Science Laboratories for Students and Student Teachers

In addition to competitive formats, student laboratories have evolved significantly in Germany and are well established nowadays in many universities, industrial plants, and other out-of-school learning environments. The IPN’s research contributes to this development with respect to three perspectives: (a) the educational reconstruction of learning environments based on science and science education research, (b) the investigation of students' perception and understanding of authentic science, and (c) the implementation of student laboratories in teacher education programs.

In the past, the model of educational reconstruction was applied to integrate up-to-date science research, for example, from the Collaborative Research Center (CRC) 677 Function by Switching or the Cluster of Excellence Future Ocean as well as science educational research into out-of-school learning environments like the Kieler Forschungswerkstatt. One example is the student laboratory program klick! with more than 1000 student participants thus far. The developed learning stations cover different fields of applied research from the CRC 677, like specific methods of nanotechnology or switches in daily life. Next to the CRC research, teaching experiments and questionnaire studies form the foundation for the development process. One example is the implementation of modern techniques like atomic force microscopy (AFM). Literature points out that equipment and methods different to school experiments are one important factor fostering the perception of authentic and motivating science in out-of-school learning environments. A second argument for the development of this station was the empirically well investigated difficulty of students to understand the interaction of forces and matter. Hence, in a teaching experiment the prototype was investigated showing the potential of the approach to deal with matter and forces, but also highlighting the students' difficulties with regard to sizes and scales. Consequently, the station was enlarged with another task focusing on sizes and scales and is now implemented in the klick! program. The research was carried out in cooperation with the Weizmann Institute of Science, Israel (Dr. Ron Blonder) and the Bogazici University, Turkey (Dr. Sevil Akaygun).

To also investigate students' perception of authentic science in the klick! laboratory, two questionnaires have been developed. The first investigates students' expectations before and evaluation after a lab visit to analyze goals and the perceived fulfillment of these goals with regard to authentic science aspects like carrying out investigations, cooperating with others, etc. The second questionnaire has adapted Holland’s RIASEC structure (see above) to analyze students' perception of relevant activities of scientists. The studies are still ongoing, however, one result already shows that students' expectations are met on different
levels. While the high expectation of carrying out experiments is well achieved in the klick! laboratory, the perceptions of being in an authentic science environment is not as well met. To enhance this perception (as one factor of motivation), a new project will test the additional use of videos showing real scientists in real laboratories for several stations in addition to the own experimental work of the students. These videos are produced as part of the CRC outreach program and allow insights into authentic laboratories. They will be linked to the student activities in the klick! laboratory, aiming to enlarge the perspectives of and about scientists and their activities and to stimulate a higher degree of authenticity in the student laboratory.

In close cooperation scientists and science educators reflect on new topics with regard to their learning potential. The Leidenfrost reactor is another example of enabling new syntheses of nano particles at school and the discussion of structure–property relations focusing on size and scale. Similar approaches are chosen for the main research areas of Kiel University, such as energy, medicine, or environmental and cultural changes. With a long-term perspective, research will also investigate effects of a preparation at school before and the presentation after a laboratory visit and the long-term effects of different student laboratories (see below).

Out-of-school laboratories not only provide learning opportunities for visiting school-age students but also for students enrolled in teacher education programs at universities. The project Student Labs in Teacher Training Programs aims to connect student laboratories and teacher education at the university. Funded by the German Telekom Foundation, it is set up as a cooperative project of the universities FU Berlin, HU Berlin, Koblenz-Landau, Münster, Oldenburg, and Kiel. In Kiel, the project KiFoLa integrates the student laboratory Kieler Forschungswerkstatt (KiFo), a joint institution of Kiel University and the IPN, into the master program of student teachers in biology, chemistry, and physics. Participating student teachers get the opportunity to apply, intensify, and contextualize their professional knowledge – particularly their content knowledge (CK) and pedagogical content knowledge (PCK) – when teaching and supervising visiting school students. The students also develop new or modify existing learning opportunities (e.g., tasks, experiments), gain experience with school students, and reflect on them with regard to their future profession as school teachers. In order to evaluate the effectiveness of these activities, two approaches are applied: (a) assessing the perceived learning support compared to other formats in teacher education, and (b) characterizing the personal knowledge used in the reflection of teaching experiences. To assess the perceived learning support, we employed an instrument focusing on the six major goals of the seminar: Acquiring and using CK, acquiring and using PCK, diagnosing students’ misconceptions, developing learning oppor-
opportunities, gaining insight into the nature of science research, establishing confidence in being teacher. Student teachers are asked to indicate how the seminar has helped in reaching these goals and how other learning opportunities in teacher education supported them as well. In 2016, the instrument was piloted with \( N = 59 \) pre-service students from several seminars showing sufficient reliability (\( \alpha \) from .62 to .89). The first analyses indicate that student teachers do not reflect different goals of different learning opportunities but believe that school practice helps most in all categories. This indicates a need for more explicit reflections of learning goals and opportunities in teacher education programs. The study will be continued and the approach will be translated to other subjects as part of the cooperation between the IPN and Kiel University in teacher education quality development programs.
5 Further Research

Two large research programs have been derived from studies like those reported above: (a) the project WinnerS and (b) the Kiel Science Outreach Campus KiSOC.

To strengthen and grow the research on fostering talents, the research project WinnerS (Effects of Science Competitions for Students) was started in 2016. The reported studies on characterizing participants, on factors influencing success in participation, and the research-based development and investigation of supporting activities are the foundation for this project, providing instruments as well as a suitable expectancy-value model. Funded by the Leibniz Association and involving all departments of the IPN, the project aims both to investigate which factors determine success or failure in science competitions as well as the influence of success or failure on students' further cognitive and affective development and on their career choices. These questions are investigated longitudinally within all science competitions organized by the IPN. This project will (a) contribute to the theoretical foundations regarding the influence of competitions on participants, and (b) provide practical implications on how to improve existing enrichment measures.
Furthermore, the newly started project IBOint at the IPN initiates, conducts, and coordinates collaborative research studies about different aspects of the IBO. The goals of these research studies are to gain a deeper knowledge about the IBO and to inform further development of the organization.

The Science Outreach Campus KiSOC, funded by the Leibniz Association, the state of Schleswig-Holstein, Kiel University, and the IPN will develop and provide an infrastructure serving as a center for analyzing, categorizing, and developing outreach activities. Ten PhD projects accompanied by an independent junior research group and linked projects will investigate different formats of outreach, such as media or science laboratories, for different audiences, such as school students or science communicators, with regard to different goals, such as fostering interests or a better understanding of the nature of science. Again, former studies carried out in the Kieler Forschungswerkstatt on students' understanding of science and scientists' tasks will be continued as part of the KiSOC research.

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In addition to the partners co-supervising PhD projects, KiSOC has 13 national and international partners establishing a network to promote the research on science outreach. A full list of partners can be found on www.kisoc.de.

**HOMEPAGE //**
- [www.ipn.uni-kiel.de/de/forschung/projekte/winners](http://www.ipn.uni-kiel.de/de/forschung/projekte/winners)
- [www.kisoc.de](http://www.kisoc.de)