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The effectiveness of a project day to introduce sixth grade students to science competitions

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ABSTRACT

Background: Science Olympiads and science fairs are effective instruments to foster interested and talented students. However, at most schools competitions are not systematically integrated into the school mission statement so that students are unaware of these opportunities.

Purpose: The purpose of this study was to investigate the effectiveness of a newly designed competition day in terms of willingness to participate in a science competition and to learn more about students' reasons for a prospective participation.

Programme description: A project day (called 'competition day') for students in sixth grade was designed to encourage and motivate more students to participate in science competitions. The theoretical foundations for the design are self-determination theory and an adapted version of Holland's RIASEC-model.

Sample: The sample consisted of 474 German sixth grade students from six secondary schools.

Design and methods: A pre-post-follow up-study was conducted with two intervention groups; both groups participated in the competition day and either entered a fictive competition or worked on the same tasks in school lessons. One control group not participating in the competition day was also investigated.

Results: The results provide information regarding students' interests, as well as reasons for and against participating in competitions. Furthermore, the effectiveness of the competition day is shown.

Conclusions: The competition day is an effective way to introduce students to competitions and raise their willingness to participate in science contests. Combining the competition day with science competitions showed even better results. This supports the call for continuous fostering strategies.

KEYWORDS
Intervention; science; competition; secondary school

Introduction

Many industrialised countries make great efforts to improve engagement in science, technology, engineering and mathematics (STEM) and to encourage more talented students to

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pursue degrees in the STEM fields. Research suggests that students who decide to and pursue a STEM career do so, among other reasons, because of a positive attitude towards science and mathematics (Osborne, Simon, and Collins 2003; Tai et al. 2006; Wang and Staver 2001). This positive attitude might be expressed by an early interest in a STEM career (Cleaves 2005; DeWitt, Archer, and Osborne 2014; Maltese and Tai 2010, 2011), through the opinion that STEM is useful (Babad 2001; Bøe and Henriksen 2013), or through course enrolment (Burkam and Lee 2003).

In contrast to the countries' efforts, studies have shown that many students lose their interest in or positive attitude towards science in secondary school (Galton 2009; Logan and Skamp 2008; Maltese, Melki, and Wiebke 2014). There are some rare examples that show that the loss of a positive attitude/interest to learn science is not necessarily an inevitable development (e.g. Bennett, Lubben, and Hampden-Thompson 2013). The 'democratic schools' in Israel (Vedder-Weiss and Fortus 2011) are one example. The key to success in these schools seems to be that students are strengthened in their perceived autonomy by the possibility to freely choose their subjects according to their own interests.

To counter the loss of interest in science and maths in the UK, the campaign 'Your Life' supported by the government aims to 'increase the number of students studying maths and physics at A level by 50% within 3 years' (Department for Education 2014).

Similarly, the US government launched the 'Educate to Innovate' campaign. The campaign's aims are 'generating and maintaining student interest and enthusiasm in science and math, reinvigorating the pipeline of ingenuity and innovation essential to America's success that has long been at the core of American economic leadership' (The White House 2009).

Both campaigns try to reach these goals by changing the way of teaching science and the establishment of extracurricular science activities. Likewise, numerous in- and out-of-school interventions have been conducted in several countries to counteract the decline of students' interests. Unfortunately, when systematically supervised, long-term effects of interventions with respect to improving science attitudes were mostly small or even absent (see Stake and Mares 2001 for an overview). This led to growing scepticism about the effectiveness of short one-time interventions (Falk et al. 2012; Fortus 2014) and a tendency towards comprehensive enrichment strategies (Campbell, Wagner, and Walberg 2002; Sahin, Ayar, and Adiguzel 2014; van Rens et al. 2013). One such promising strategy (which is also incorporated in both the 'Educate to Innovate' and the 'Your Life' campaign) includes academic competitions. Academic competitions have the potential to identify, support, and motivate talented students to further engage in STEM activities (Campbell 1996; Sahin 2013; Sahin, Gulacar, and Stuessy 2015). Thus, 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 the STEM fields. To reach this goal, it seems necessary to investigate students' reasons for participating and to find a way to overcome possible hindrances 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.

Theoretical background

Academic competitions as extracurricular activities

Especially in science, academic competitions are effective measures to identify and foster young talents (e.g. Campbell, Wagner, and Walberg 2002; Campbell and Walberg 2011; Goldstein and Wagner 1993; Urhahne et al. 2012). As research shows, participation in science competitions helps students become aware of their potential and contributes to their self-confidence. However, science competitions are not only directed at gifted students but are also suitable to raise interest in science within many different student groups (Sharaabi-Naor, Kesner, and Shwartz 2014; Woolnough 1995). This is especially the case when students can choose from different contest types (e.g. science Olympiads vs. science fairs) and specific topics or domains (self-chosen topics vs. given topics from robotics, science, chemistry, environmental sciences, etc.). Most academic science competitions have several rounds – from local to national events, which is why one could consider them systematic enrichment measures. Students can participate annually. Despite the benefits of academic competitions, many German schools do not include competitions in the school mission statement – which is why most students do not even know of their existence. To change this, the German branch of the International Junior Science Olympiad which is funded by the German Federal Ministry of Education and Research initiated the project 'NaWigator'. The project aims to motivate more students to take part in science competitions as an enrichment strategy. Identifying students' reasons for and against participating in a competition is essential to motivate them to take part in science contests.

Why do students participate in science competitions?

Since most studies addressed older students, varied vastly in sample sizes and research methods (e.g. Czerniak and Lumpe 1996; Dionne et al. 2012), or studied former contestant participants retrospectively (e.g. Feng, Campbell, and Verna 2002; Lengfelder and Heller 2002), little is known about young students' interests in attending science competitions prior to actual participation.

Czerniak and Lumpe (1996) conducted a survey with students ($N = 303$) registered for a science fair to identify predicting factors for students' attitudes regarding participation. Students' most commonly mentioned reasons for participating were the opportunity to learn something new, improve grades, receive prizes, improve presentation skills, and to meet new people. However, the results are somewhat unclear as many students were not participating in the science fair voluntarily. This forced participation turned out to be one of the most predicting reasons for students' participation.

Dionne et al. (2012) identified five factors that explain motivation of science fair participants ($N = 36$). Besides social aspects, gratification, and acquired learning strategies, the two main factors for participation were interest in the science content and self-efficacy.

Abernathy and Vineyard (2001) asked participants of a science fair ($n = 490$) and a science Olympiad ($n = 453$) about rewards they gained by participating. Both groups chose fun and learning new things to be most rewarding, which corresponds with Czerniak and Lumpe's (1996) findings. The participants further mentioned competing against others, learning the scientific process, working with friends and winning prizes as advantages. Gender differences were found only in the science Olympiad group. While female Olympiad participants rated social involvement items like being on a team and meeting students from other schools higher, male participants judged aspects like competing against others and getting one's name in the newspaper as more rewarding.

Usually, studies such as those mentioned above asked only those students for their reasons to participate who actually took part in a science competition, often post hoc. Thus, it remains unclear which of these participants' reasons were the primary factors to take part and which were just post hoc-experienced advantages of participation and therefore negligible.

We asked a group of average sixth graders – as potential participants – about their willingness to take part in a science competition and their reasons. We were thereby able to analyse significant predictors by comparing groups both interested and not interested in participation.

In addition, the essence of the NaWigator project – beside school counselling – is a scientific school project day (called 'competition day') introducing sixth grade students to competition formats and tasks. Focusing on early support we investigated which short-term and long-term influence the competition day had on students' motivation to participate in science competitions.

Aims and research questions of the research study

In order to investigate the effectiveness of the competition day we aimed to answer the following research questions:

(1) What kind of impact did the competition day have on students' willingness to participate in science competitions?
(2) What were the predictors for students' willingness to take part in a science competition?
(3) How did the intervention influence students' decision criteria regarding their willingness to take part in science competitions?

Method and design

Concept of the competition day

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 (Blankenburg et al. 2013). The theoretical foundation are Deci and Ryan's self-determination theory (2000), Palmer's (2009) results for characteristics stimulating students' situational interest, and Dierks, Höffler, and Parchmann's (2014) and Blankenburg, Höffler, and Parchmann's (2016) RIASEC+N model.

The self-determination theory (SDT; Deci 1975; Deci and Ryan 1985, 2000) states that intrinsic motivation is initiated and maintained by satisfying three psychological needs: competence, autonomy and social relatedness. In educational contexts this can be achieved through a combination of letting students make decisions about their learning along with providing challenging tasks and interaction with fellow students. Palmer's (2009) results for situational interest stimulating characteristics show that for students, choice, novelty, social

Table 1. Underlying theories, derived constructs, and conclusions for the competition day.

Theory		Construct	Realisation on competition day
Self-determination theory (Deci and Ryan 2000): characteristics initiating intrinsic motivation		Competence	Adequate task difficulty
		Autonomy	Choose from a range of different topics and activities
		Social relatedness	Play/work in teams
Characteristics stimulating students' situational interest (Palmer 2009)		Choice	Choose from a range of different topics and activities
		Novelty/suspense/surprise	New task formats and activities (quiz)
		Social involvement	Play/work in teams
		Physical activity	Do experiments
RIASEC+N model (Dierks, Höffler, and Parchmann 2014): seven personality dimensions and corresponding interests in science school activities	*Realistic*	Conduct experiments guided by instruction	Activities for all seven personality dimensions (working stations)
	Investigative	Investigate objects more closely	
	Artistic	Draw a picture of an object	
	Social	Explain how to do sth. to other students	
	Enterprising	Lead a student working group	
	Conventional	Search for and organise information about objects	
	Networking	Talk with other students about objects	

involvement and the opportunity for physical activity are also important. Differentiated facets of interest can be analysed and shown by the RIASEC structure (Holland 1997); although it has recently often been used in motivation and interest research since it includes aspects like self-concept and subjective values, this model was originally designed for vocational choices. The model postulates six personality-dimensions with corresponding interests and activities: *realistic*, *investigative*, *artistic*, *social*, *enterprising*, and *conventional*. Dierks, Höffler, and Parchmann (2014) adapted the RIASEC model for science and used it to investigate students' interest in science school activities. They found an additional dimension called networking. Those theories and results were applied to design the programme for the competition day, as described in Table 1.

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. Those can either be multiple choice questions with four answer options (A–D) or open tasks. Just like in the TV game show 'Jeopardy', the teams choose from a range of different categories and difficulties (Figure 1a). This supports participants' confidence according to self-determination theory. Participating in a team and an adequate task difficulty help students to gain confidence and increase intrinsic motivation (which relates to SDT's elements *competence* and *social relatedness*). The playful character of the quiz furthermore can counter unpleasant feelings that might occur in competitive situations (Yasar and Baker 2003). Figure 1b displays the quiz screen and an example task.

Each round starts with one team (consisting of five or six students) choosing a task from the quiz screen. The question is displayed (for example by a projector) for all teams and the audience. A presenter reads the task out loud and the teams get – if necessary for the task – the needed equipment. Then all teams work on the task and try to find an answer. After a given amount of time, all teams give their solution simultaneously. If the question is a multiple choice question, the teams hold up a card with the letter indicating their answer. In an

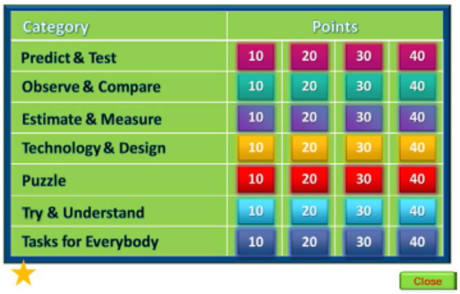

Figure 1a. NaWigator quiz screen.

Figure 1b. Exemplary quiz task (translated; Blankenburg et al. 2013).

open question, the teams write down their solution and hand it to a jury consisting of teachers.

The second element consists of working stations which give students the opportunity to spend more time working on scientific phenomena. This element particularly emphasises the 'autonomy'-aspect of the self-determination theory with thematic choices and no time limits. Students get to know former competition tasks and experiments which represent one or several of the RIASEC+N dimensions (Blankenburg, Höffler, and Parchmann 2016). Students work in teams (SDT: social relatedness) and choose stations according to their interests (SDT: autonomy). One task, for example, is to build a catapult that launches a gummy bear as far as possible (Figure 2). This task combines the *realistic* and the *investigative* but also the artistic RIASEC+N dimensions.

Sample

The competition day as part of the NaWigator project was a strong incentive for the schools to apply for the project. Thus, it was not possible to randomise the students to either the intervention or the control group. The five intervention schools were normal secondary schools chosen for the project because of their motivation to integrate science competitions into their school mission statement in the future. As the target group for the competition day we chose sixth grade students because they had already experienced some science instruction (mainly biology and physics) in secondary school and are generally still interested

Station: Who builds the best gummy bear catapult?

Your mission

Build a catapult that launches a gummi bear as far as possible! First, think about what your catapult might look like. Take a look at the material available and draw a sketch of your catapult. Then build your catapult and try it out.

Available materials:
Pieces of wood, corks, clothes pegs, scoopula, tea-light holder, twine, hot glue gun, glue, elastic bands,...

Catapult information
A catapult is a machine that throws objects. In the Middle Ages catapults were successful long-range weapons. Simple catapults use the energy of a lever and a spring.

Your construction plan (sketch):

Your results:

How far did your catapult launch the gummy bear?

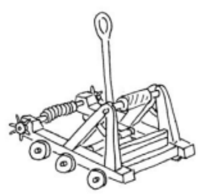

Figure 2. Example of a working station (translated).

in science (Dawson 2000; Krapp and Prenzel 2011). We wanted to use this potential and start the programme before students lose interest in science (Maltese, Melki, and Wiebke 2014).

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 (Group A: $n = 199$; Group B: $n = 161$) by randomly

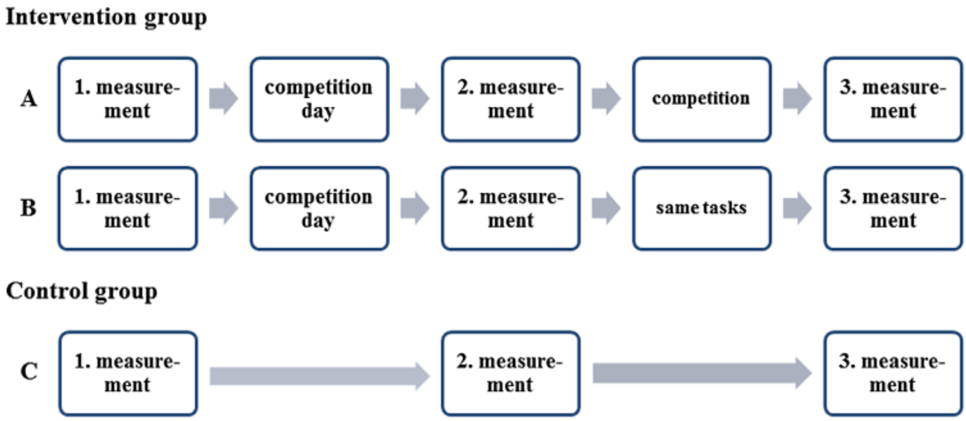

Figure 3. Design of the study.

assigning half of each school's classes to one of two conditions (see Design). One school chose to participate in the competition day with only two of their four classes. These classes formed the control group, together with classes from another school (Group C: $n = 114$).

Design

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 were quite young and some had never participated in a science competition, we designed a fictive competition and let the students participate during science lessons (Intervention Group A). Intervention Group B worked on the same tasks without any connection to a competition situation. The third measurement followed nine weeks later (Figure 3). The study took place from August 2013 through June 2014.

Data pretest and data collection

The first questionnaire version was given to 16 sixth grade students to validate the items' comprehensibility with cognitive pretesting (Karabenick et al. 2007). The students read the items out loud, explained their meaning and declared which answer they would have given and why, using examples from their memories. After minor linguistic changes, the questionnaire was tested in a pilot study with 113 sixth grade students and slightly changed afterwards.

In the main study, reported in this article, the students were asked to fill out 45 min questionnaires during science lessons. We chose scales based on Eccles' expectancy/value model (Eccles 1983; Wigfield and Eccles 2000). The participants were asked for their willingness to participate in a science competition using a dichotomous (yes/no) question at all three measurement points. Additionally, we used scales based on standard instruments to gather students' science self-concept (7 items; Marsh et al. 2005), interest in science subjects

Table 2. Overview of instruments.

Scale	*n* items	Exemplary item (translated)	α_{M1}
Students' individual characteristics			
Academic self-concept	6	I am very good at school	.77
Science self-concept	7	Science seems to be harder for me than for my fellow students	.81
Competition self-concept	4	I won't participate in a science fair/contest because I don't think I'm good enough	.82
Interest in science subjects	4	How interested are you in …?	.78
Utility (science)	3	Science is useful for my future	.86
Learning goals	4	I want to learn something interesting in science class	.72
Performance-approach goals (science)	4	I want others to think that I'm smart in science class	.80
Performance-avoidance goals	4	In science I don't want others to notice when I don't understand things	.81
Work-avoidance goals	4	In science I don't want to work hard	.76
Willingness to participate in a science competition	1	Would you like to take part in a science competition?	–
Student's attitudes to competition-specific characteristics			
Social relatedness	6	I'll participate in a science competition if… … I can get to know other interested students	.75
Team work	3	… I can work together with a team	.80
Individual work	3	… I can work alone	.79
Competence (extrinsic)	5	… I can win a prize for my effort	.86
Competence (intrinsic)	3	… I can learn something new	.75
Autonomy	3	… I can decide how to solve a task on my own	.74
Performance-approach goals (competition)	3	… I can show that I know more than other participants	.74
Utility (competition)	4	… the topic is important for my future	.86
Interest in topic	3	… the topic is interesting	.77

(1 item per science subject), goal orientation (Spinath and Steinmayr 2012; Spinath et al. 2002) and further control variables, such as gender, age, first language, former participation in science competitions with the names of the competitions, and attended science classes.

We also developed eleven scales to assess students' decision criteria for participating in a science competition with respect to learning environments' specific characteristics. These were based on the results of Abernathy and Vineyard (2001) and Dionne et al. (2012) (Table 2).

All rating items were assessed using four-point Likert scales ranging from 'I am not interested at all in doing this/I totally disagree' (1) to 'I am very interested in doing this/I totally agree' (4).

Data analyses

All scales showed acceptable to good reliabilities for all three measurements (Cronbach's alpha .72–86; Table 2) and therefore were used for further analyses.

Data was analysed with inferential statistics of repeated measures analysis of variance (RM-ANOVA) for comparing different groups at three different measurements to investigate the effectiveness of the competition day. ANCOVAs complemented these calculations by considering inequalities between groups at the pre-test.

We calculated logistic regressions with a stepwise backwards and likelihood ratio method to identify predictors for students' willingness to take part in a science competition (dichotomous item). Multilevel analyses were not applicable because of small intraclass correlation coefficients (ICC < .04) and rather small numbers in cells.

Results

The competition day

All participants (as well as headmasters and teachers) gave positive feedback about the competition day at their school. All headmasters stated they would organise the project day on an annual basis. According to the teachers and the first author's own observations at the competition days, the students were highly motivated doing the quiz and working stations. Several schools invited local media (newspaper, TV station) to report about their competition day.

Students' willingness to participate in a science competition

To answer the first research question and to investigate the effect of the competition day, we measured students' willingness to participate in a science competition in each of the three groups, at all three measurement points. As Figure 4 shows, a repeated-measures

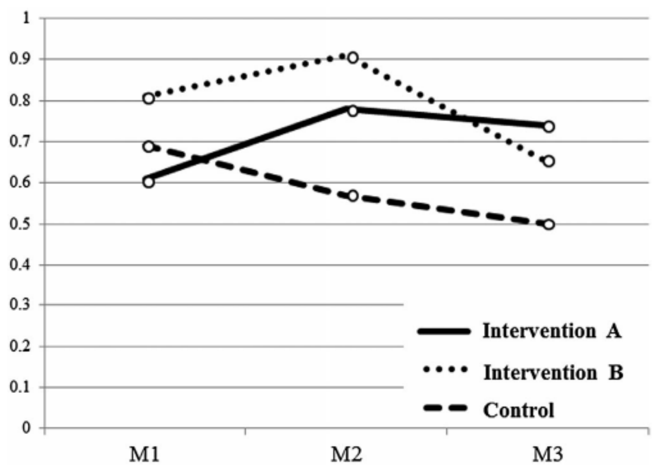

Figure 4. Willingness to participate in science competitions (unadjusted means).

Table 3. Results of the ANCOVAs for the second and third measurement.

Source	*df*	*MS*	*F*	*p*	η_p^2
ANCOVA 2nd measurement					
Willingness to participate (1st measurement; cov.)	1	16.90	127.38	<.001	.255
Treatment effect	2	1.41	10.63	<.001	.054
Interaction effect	2	0.31	2.36	.096	.013
ANCOVA 3rd measurement					
Willingness to participate (1st measurement; cov.)	1	9.26	51.89	<.001	.169
Treatment effect	2	1.42	7.95	<.001	.059
Interaction effect	2	0.20	1.10	.332	.009

ANOVA revealed significant changes over time (F (1.93, 431.30) = 9.19, $p < .001$, $\eta_p^2 = .039$)[1] 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, $p < .001$, $\eta_p^2 = .054$).

As Figure 4 indicates, there were already differences between the groups at the first measurement (pre-test). Indeed, while all students were interested in taking part in a science competition, there were significant differences between the groups (F (2, 455) = 6.09, $p = .002$, $\eta_p^2 = .026$). Therefore, we included the difference at the first measurement as a covariate in subsequent analyses following the significant effects of the repeated measures ANOVA. An ANCOVA (see Table 3) with simple contrasts showed that after the competition day (2nd measurement), students in both intervention groups ($M_A = .75, SD_A = .434; M_B = .85, SD_B = .359$) were more willing to participate in competitions than the control group ($M_C = .57, SD_C = .498$; both $p < .001$, $d = 0.40$ and $d = 0.66$, respectively), while both intervention groups did not differ ($p = .978$). As stated above, the third measurement followed a phase in which intervention Group A took part in a fictive competition, while intervention Group B worked on the same tasks in class in a non-competition setting. The results of another ANCOVA (Table 3) show that at the third measurement intervention Group A continued being interested in competitions ($M_A = .73$, $SD_A = .447$) significantly more than the control group ($M_C = .47$, $SD_C = .502$; $p < .001$, $d = 0.55$) and intervention Group B ($M_B = .67$, $SD_B = .475$; $p_{\text{one-tailed}} = .034$, $d = 0.13$). While Group B followed the downward trend of the control group, Group B was still significantly more willing to participate in competitions than the control group ($p_{\text{one-tailed}} = .029$, $d = 0.41$). Thus, the competition day increased the willingness to participate in science competitions in both intervention groups (Figure 4). Afterwards, however, Group A was the only group to experience a competitive setting and stayed interested in participating.

Predictors for willingness to participate in a science competition

In order to get a detailed understanding about possible reasons for students to be willing to take part in a science competition and to answer the second and the third research questions, we calculated predictors for students' willingness with logistic regressions. The results for the first measurement (Blankenburg, Höffler, and Parchmann 2016) indicated that not competition-specific characteristics (like the opportunity to compete against others or to win prizes) but rather individual characteristics (like interest in science subjects and self-concept) were significant predictors for students' willingness to participate in a science competition. For the first measurement, four predictors had a significant influence: the former participation in a competition, the need for intrinsic competence (take part to learn something new), the science competition self-concept (students' own perception of being able to successfully take part in a science competition), and interest in science subjects (Table 4). All four predictors have *exp b* values higher than 1 which means that an increase in one of these predictors – while keeping the others constant – results in an increased willingness to participate. A student who had already participated in a competition had a 5.12 higher chance to be willing to take part in a science competition than a student who never has taken part in a competition. The students who already participated in a competition (16% of the whole sample) were asked to give the names of these competitions. While some of these students had participated in a science competition (< 5%), the majority had participated in maths competitions.

Table 4. Predictors for students' willingness to participate in a science competition.

Predictor	*B (SE)*	*p*	exp *b*
1st measurement			
Former participation in a competition	1.63 (0.50)	.001	5.12
Competence (intrinsic) (take part to learn sth. new)	1.34 (0.25)	<.001	3.80
Science competition self-concept	0.87 (0.21)	<.001	2.38
Interest in science subjects	0.87 (0.24)	<.001	2.39
R^2 = .30 (Hosmer & Lemeshow), .32 (Cox & Snell), .44 (Nagelkerke)			
Model χ^2 (4) = 110.661, $p < .001$			
2nd measurement			
Willingness to take part in a science competition (1st measurement)	2.28 (0.35)	<.001	9.75
Competition day (intervention, Groups A & B)	1.84 (0.36)	<.001	6.27
Competence (intrinsic) (take part to learn sth. new)	0.70 (0.23)	.002	2.01
Performance-avoidance goals	−0.48 (0.20)	.019	0.62
R^2 = .32 (Hosmer & Lemeshow), .31 (Cox & Snell), .45 (Nagelkerke)			
Model χ^2 (4) = 129.901, $p < .001$			
3rd measurement			
Willingness to take part in a science competition (2nd measurement)	2.72 (0.47)	<.001	15.26
Science competition (intervention, Group A)	1.56 (0.45)	.001	4.76
Interest in science subjects	1.10 (0.29)	<.001	3.01
R^2 = .32 (Hosmer & Lemeshow), .34 (Cox & Snell), .46 (Nagelkerke)			
Model χ^2 (3) = 81.178, $p < .001$			

The second measurement took part after the competition day (for Groups A and B). The logistic regression again revealed four, but different significant predictors for the students' willingness to participate in a science competition: the pre-willingness to take part (1st measurement), the competition day (intervention), the need for intrinsic competence, and performance-avoidance goals (Table 4). The first three predictors have *exp b* values higher than 1. Thus, an increase in one predictor – while keeping the others constant – resulted in an increased willingness to participate. For example, there was a 6.27 greater chance that a student who participated in the competition day (part of the intervention) was willing to take part in a science competition than a student who did not participate in the competition day. The predictor performance-avoidance goals (aim to hide missing competence from others) shows an *exp b* value less than 1 which means that higher values for performance-avoidance goals reduced the chance a student will be willing to take part in a science competition.

After the second measurement, Group A participated in a science competition, Group B worked on the same tasks without a competition situation, and Group C (control group) had no special treatment. The logistic regression for students' willingness to participate in a science competition at the third measurement showed three significant predictors: the willingness to take part at the second measurement, the science competition (intervention), and interest in science subjects (Table 4). All three have *exp b* values higher than 1. Thus, there was a 4.16 greater chance that a student who participated in the science competition (part of the intervention) would be willing to take part in science competitions than a student who did not take part in the science competition.

Discussion

The aim of our study was to investigate the effectiveness of a competition day on sixth grade students.

As the results of the repeated-measures ANOVA indicate, the competition day had a positive impact on students' willingness to participate. Students in both intervention groups (A & B) were significantly more interested in taking part in science contests even after controlling for differences prior to the intervention. These findings were confirmed by the results of the logistic regression. The competition day was a significant predictor for students' willingness to participate at the second measurement. After the second measurement Group A took part in our designed science competition and Group B worked on the same tasks thinking of them as normal school tasks. While students of Group B followed the downward trend of the control group, they were still significantly more willing to participate in competitions than students from the control group. Group A, however, continued being interested in competitions at a high level and was significantly more interested than both other groups. Thus, the competition day is a suitable way to introduce students to science competitions. In combination with participation in real competitions it might be possible to continually interest young students in science.

The results of the logistic regression for the first measurement identified predictors for students' willingness to participate in a science competition. The results showed that students who like to take part in science competitions have already participated in one, are interested in participating in contests because they want to learn new things, are interested in science subjects, and have a positive science competition self-concept which means that they are confident to be good at science competitions (Blankenburg, Höffler, and Parchmann 2016). These findings partly correspond to results of other studies. Abernathy and Vineyard (2001) as well as Czerniak and Lumpe (1996) found intrinsic competence (to learn something new) as well as self-concept or self-efficacy to be important. However, we focused on potential participants in order to gain more information about their motivation to take part in a science competition in the first place. Therefore we were able to directly contrast students who want to take part and students who do not want to participate. Using this comparison we found that extrinsic advantages of competitions (such as winning prizes or getting famous) are not significant predictors for these young students' interest in participation in science competitions. The most important predictor was prior participation in a competition; even if this prior participation was not in a science competition. This shows that competitions as continuous enrichment strategies are a possible way to continually interest young students. However, the predictor competition self-concept indicated that many students might not be confident to enter a science competition in the first place and therefore might not consider participation in competitions.

To investigate the influence of the competition day and predictors for students' willingness to participate in a science competition, we calculated logistic regressions for the second measurement (after the competition day) and the third measurement (after the fictive competition or tasks). The most important predictor for students' willingness to participate in a competition at the second measurement was their willingness to take part in a science competition at the first measurement. This is not surprising since former values for a variable are most often the best predictors for subsequent values. Another significant predictor was the need for intrinsic competence, which was also important for the first measurement.

These repeated findings of intrinsic competence and the absence of any extrinsic competence predictors (e.g. take part to win prizes) demonstrates that those extrinsic reasons are not strong enough for encouraging students to take part, even if other studies – exclusively addressing science competitions participants – suggested this (Abernathy and Vineyard 2001; Czerniak and Lumpe 1996; Dionne et al. 2012).

The logistic regression at the third measurement revealed three significant predictors. The most important predictor was students' willingness to take part in a science competition (2nd measurement). The fact that students' willingness at the second measurement was a significant predictor and not students' willingness at the first measurement indicates that the competition day still had an influence on them. Further significant predictors were participation in our fictive science competition (as part of our intervention) and interest in science subjects.

The results of our study for the first measurement indicate that students who previously participated in a competition like to do so again. This speaks for competitions as continuous strategies to interest and foster students. Students who have not participated in a science competition can be motivated by the competition day to take part in competitions as well. Regular participation in science competitions may be suitable to prevent a reduction of students' interest in science. Additionally, the results of Urhahne et al. (2012) indicate that prior participation is a significant predictor for success in the International Chemistry Olympiad. Hence, students who participate in science competitions are willing to take part repeatedly and become successful through this repetition.

Limitations of the study

The data was collected in those *Gymnasien* (highest track of secondary schools in Germany) that applied for a project to foster student competitions. On the one hand, this leads to a limited generalisability; while on the other hand, we investigated specifically those students who are the target group for academic competitions in Germany. Another concern might be the limited number of participants ($N = 474$) – especially since, unfortunately, one school quitted the participation in the project after the second measurement for organisational reasons. This reduces the results' generalisability somewhat. Since the competition day requires much organisation and the schools are provided with the necessary materials it was not possible to give more schools the opportunity to organise it.

Furthermore, it should be noted that we could only measure students' *theoretical* willingness to participate in a science competition. For the future, it would be very worthwhile to investigate whether the competition day indeed has a direct influence on students' *actual* participation in real science competitions. We certainly hope so, but clear evidence is still amiss.

Conclusions

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 contests was successfully attained. The combination of the competition day with an 'actual' competition showed the best results and indicated that this combination could be a possibility 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 bridge the gap between schools and science competitions. However, in our study we designed a competition day for sixth graders. It would be interesting to investigate whether a competition day could motivate older students as well. This might bridge the gap between school and competitions as a late entrance.

Our results further indicate that former participation in a competition is an important predictor for students' willingness to take part in a competition – even if this former participation was in another domain (here mostly maths). These findings indicate that there is a possibility to introduce students to academic competitions (e.g. in maths) at an early age and to bridge to other domains (e.g. science) or difficulty levels with competition days such as ours.

In any case, it seems obvious that introducing formats such as our competition day are a practicable way to motivate more young students to participate in science competitions – which is, in turn, a good possibility for 'generating and maintaining student interest and enthusiasm in science and math' (The White House 2009).

Note

1. Mauchly's test indicated that the assumption of sphericity had been violated for the main effect of time, $\chi^2(2) = 8.81$, $p = .012$. Therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .96$).

Disclosure statement

No potential conflict of interest was reported by the authors.

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