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"We are sorry to inform you…"—The effects of early elimination on science competition participants' career aspirations

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Abstract
In the past, students' participation in science competitions has been positively associated with their aspirations to pursue a career in science. Previous studies, however, were predominantly focused around successful competitors, overlooking the largest group of participants: those who are faced with early elimination. We therefore aimed to investigate the effects of elimination on the development of biology-related study and career task values and expectancy of success in first-round participants of the German Biology Olympiad ($N = 381$, mean age 16.5 years, 72% female). This study was the first of its kind to use a latent change score model approach to examine the effects of early elimination, with a particular focus on participants who placed great emphasis on succeeding in the competition. We found that, regardless of success or failure, participants' biology-related study and career task value remained stable from the first to the second round of the competition, while their expectancy of success in biology-related studies and career developed positively. Yet, for those participants who placed great importance on advancing in the competition, early elimination interfered with the development of study and career expectations, resulting

Note that Garrecht and Steegh share first authorship of this paper, yet are listed alphabetically here.

in a weaker development. The outcomes of this study suggest that (1) science competitions should re-envision themselves to more directly address participants' values about studies and careers, especially in earlier competition rounds, and (2) science competitions should find innovative ways to provide detailed feedback to students and teachers to improve post-elimination performance. Our findings complement existing expectancy-value research and can serve as a starting point for future studies exploring mechanisms behind early elimination in different science domains and cultural contexts, providing empirical insight into creating an inclusive and supportive environment for all science competition competitors.

KEYWORDS

career aspirations, elimination, expectancy, science competition, value

1 | INTRODUCTION

"There are days that I don't feel like training, but there is no day that I feel like losing."–Serena Williams, American former professional tennis player.

Most people dislike losing, but they do like winning. While winning a competition can bring immense pride and recognition, losing can often result in feelings of disappointment, frustration, and low self-esteem (Buser, 2016; Reeve et al., 1985). As a regular part of most school programs, many young adolescents start gaining experience with winning and losing in cognitive challenges through a variety of academic competitions (Abernathy & Vineyard, 2001; Brustad, 1988). For example, annually, hundreds of thousands of elementary and secondary school students worldwide participate in academic science competitions, prototypical examples of nonformal science programs that aim to raise participating students' interests in science and encourage them to pursue a scientific career (Campbell & Walberg, 2011; Institute of Competition Sciences, 2023a). As such, these structured extracurricular science learning programs are an important addition to formal education as they are particularly suitable for informing and enthusing students about various timely and authentic science topics (Schmidt & Kelter, 2017). This is vital in these present times when science-led approaches play a crucial role in finding solutions to current global challenges such as climate change, food insecurity, energy shortage, and emerging infectious diseases (Alberts, 2022; Tasquier et al., 2022).

In an effort to address these global challenges, numerous local, national, and international science competitions worldwide attract students to promote science-related skills and encourage a career in science (Institute of Competition Sciences, 2023b; Oliver & Venville, 2011). These competitions, such as science fairs and Olympiads, provide students with an opportunity to showcase their skills, knowledge, and creativity, and to gain recognition and exposure in the field (Institute of Competition Sciences, 2023a; Sahin et al., 2015; Smith et al., 2021). Science fairs are generally characterized as project-based competitive events in which participants present a science project of their own choosing, whereas science Olympiads are a collection of test-based competitions in which students compete against each other in hierarchically more difficult selection rounds (Institute of Competition Sciences, 2023a). Most science Olympiads lead up to an international competition in which four to six students represent a participating country. For this purpose, many countries organize a national qualification competition consisting of one or more theoretical and practical selection rounds, from which the best performing participants are selected to compete in the international competition (Petersen & Wulff, 2017; Verna & Feng, 2002).

The positive effects of science competitions have been extensively studied and range from participants attributing their experiences in the competition to the development of 21st century skills (Sahin et al., 2015), a better understanding of scientific inquiry (Schmidt, 2014), a stronger interest in science (Smith et al., 2021) and the development of a science identity (Mitchell et al., 2011). In addition, numerous studies have shown that participation in a science competition had a positive effect on science career aspirations (e.g., Campbell & Walberg, 2011; Dabney et al., 2012; Miller et al., 2018; Sahin, 2013; Sahin et al., 2015; Wu & Chen, 2001). Although the above publications focused primarily on the most successful participants, in the vast majority of competitions, losing and the potentially associated negative consequences are far more likely to occur than winning (Petersen & Wulff, 2017). For example in Germany, with the exception of about thirty to forty winners, all ten thousand students who participate in one of the annual science Olympiads are unsuccessful to a greater or lesser extent (ScienceOlympiaden, 2023). Although losing a competition can have negative psychological effects (Standage et al., 2005) that could potentially affect the majority of science competition participants, we are not aware of any studies specifically examining effects of participation on unsuccessful students. While winning a science competition can bring immense pride and recognition, losing could potentially result in feelings of disappointment, frustration, and low self-esteem. As a result, losing could have long-term consequences, particularly when it comes to a student's motivation and interest in pursuing a science career.

Following Eccles et al.'s (1983) expectancy-value model of achievement motivation, participants with strong science career aspirations may attach particular importance to being successful in science competitions and are therefore at greater risk of experiencing negative effects in the event of early elimination. This is because these students potentially view science competitions as a measure of their ability and potential in the field. With poor performance, this may cause them to question their abilities and lose confidence in their capacity to succeed in the science domain. For this central group of participants, science competitions could therefore unknowingly and unintentionally undermine their own goals of fostering science career aspirations.

In conclusion, losing a student science competition may have significant and far-reaching consequences for a student's future career path in science. To investigate this assumption, this paper aims to shed light on the potential negative impacts of losing a science competition and the importance of addressing these challenges to support students in their pursuit of a successful science career.

1.1 | Literature Review

1.1.1 | Informal and nonformal science learning opportunities

Informal and nonformal science learning opportunities are a large group of diverse science-related offers and activities that take place outside and in addition to the in-school system

(Eshach, 2007). Whether it is a museum visit, a YouTube video, an outdoor activity, or after-school science club, nonformal and informal science learning has the potential to be highly individualized but at the same time mostly depends on voluntary participation (Tisza et al., 2020). Although the terms informal and nonformal science learning describe two distinct approaches to science education with some important differences, they are often used interchangeably (Werquin, 2007).

Informal science learning is characterized by its unstructured, hands-on, experiential approach, and its focus on exploring and discovering science through personal interests and curiosity, regardless of prior knowledge or experience (Dou et al., 2019; National Research Council, 2009; Paños & Ruiz-Gallardo, 2021). It can take place in a variety of settings, including homes, parks, community centers, and museums, and is often self-directed (Adams & Gupta, 2017; Falk & Needham, 2011). Nonformal science learning programs, on the other hand, are structured educational formats and activities with the goal of increasing public understanding and appreciation of science, promoting scientific literacy and identification, and encouraging careers in science and technology (Burke & Navas Iannini, 2021; Werquin, 2007). These type of learning programs are often organized and facilitated by educational institutions, museums, science centers, or community organizations and are designed to be interactive, engaging, and accessible to a wide range of participants (Eshach, 2007). Most nonformal learning opportunities are structured in a co-curricular way with a rather clearly defined alignment of formal school curricula and their learning objectives (Werquin, 2007).

Despite its many benefits, nonformal science learning is not without its challenges. For example, it can be difficult to measure the impact of nonformal science learning on scientific literacy and understanding, as it often takes place outside of formal educational settings (see Bjornavold, 2000). Additionally, facilitating nonformal science learning can be more expensive and resource-intensive than traditional classroom-based education, requiring specialized facilities, equipment, and personnel. Moreover, the formal sector tends to have a greater concentration of highly qualified and well-prepared staff, highlighting the urgent requirement for a more skilled workforce in nonformal education (OECD Education Today, 2022).

1.1.2 | Equity in informal and nonformal science learning

Informal and nonformal environments for learning science are commonly assumed to hold an essential value of being accessible to all. Practically, however, factors such as gender, socioeconomic status, culture, ethnicity, history, and systemic discrimination all play a role in determining the degree of access and opportunities these environments offer learners (Dawson, 2014; Godec et al., 2022). These factors can result in unequal learning experiences, challenges, and risks for development and learning, depending on whether a learner is born into a racial majority group with high social and economic resources or into a historically marginalized group with low levels of these resources (Dawson, 2019; Garibay & Teasdale, 2019).

The difficulties in engaging underrepresented groups in informal and nonformal science learning are reflected in various studies. DeWitt and Archer (2017), for example, found that in general, students who come from more privileged social backgrounds tend to participate more frequently in informal and nonformal science learning activities. Additionally, they found distinct patterns based on ethnicity and gender that varied across different types of science learning activities. Similarly, Godec et al. (2022) found that many young people from minoritized backgrounds who were interested in STEM did not participate in informal and nonformal

STEM learning opportunities, while their socially advantaged counterparts regularly engaged in these programs regardless of their STEM interest. In the case of science competitions, Steegh et al. (2019) published a review stating that particularly science Olympiads in the context of mathematics, chemistry, and physics are generally associated with the male gender due to culturally gendered convictions. The structure of science Olympiads and the types of tasks involved were often found to be more appealing to boys than girls (Feng et al., 2002; Verna & Feng, 2002), with interviews showing that girls tend to prefer cooperative tasks over individualistic competition (Lengfelder & Heller, 2002). Low female participation rates were attributed to cultural gender stereotypes, gender-biased student selection, lack of support from parents and peers, and a lack of female role models in science (Feng et al., 2002; Lengfelder & Heller, 2002).

1.1.3 | Informal and nonformal science learning catering to diverse audiences

Despite the challenges of accessibility and fit, owing to its adaptable and extracurricular nature, informal and nonformal science education has the potential to cater to a diverse audience, including individuals who seek extra challenges on top of formal science education or those who find traditional classroom settings uninviting. Specific programs can be tailored to meet the needs and interests of different audiences showing great potential to counter science learning inequities (Rahm, 2014). Studies exploring the experiences and perspectives of diverse participants, such as the ones by Wade-Jaimes et al. (2022) and Alexandre et al. (2022) have highlighted the need to critically assess STEM learning ecosystems so that equitable learning opportunities can be made accessible and inclusive for all students, particularly those from historically excluded groups.

Although not without obstacles, various programs have now been specifically designed to cater to the needs of underserved learners, connect to other nonscientific personal identities, and steer clear from a deficit approach while instead focusing on changing the culture of science (Archer et al., 2016; Archer et al., 2021; Davis, 2002). The program "I AM STEM" (King & Pringle, 2019), for instance, aimed to bring attention to the experiences and challenges that Black girls face as STEM learners, from their own viewpoint. The program was reported to ignite the girls' curiosity in STEM by offering direct engagement with scientific phenomena and field trips, which resulted in their continued interest in STEM activities throughout the year. Other examples are a girls-only conversation club in an after-school program that facilitated reconceptualizing science beyond cultural formal school science conventions (Gonsalves et al., 2013) and an after-school science club that aided refugee youth navigating their resettlement process (Tan & Faircloth, 2023). In the context of science Olympiads, a growing number of programs have emerged in recent years to support underrepresented groups, particularly girls. These initiatives include events such as the European Girls' Olympiad in Informatics (European Girls' Olympiad in Informatics, 2023), the Pan American Girls Mathematical Olympiad (Pan American Girls' Mathematical Olympiad, 2023), and China Girls' Mathematical Olympiad (Berkeley Math Circle, 2012). Moreover, the organization Science Olympiad, which offers science-based competition programs to millions of students in the United States, has recently started a collaborated with the Million Women Mentor initiative (Science Olympiad, 2023). Additionally, smaller projects, such as an intervention designed for female participants in a German Physics Olympiad, have been successful in boosting physics interest and engagement (Wulff et al., 2018).

1.1.4 | Science Olympiads as nonformal science learning opportunities

Since an early and sustained interest in science has been positively associated with secondary school students' pursuit of a science degree (Dou et al., 2019; Maltese & Tai, 2011) an increasing number of scholars are advocating the provision of fitting and relevant learning opportunities that enhance students' positive interactions with science (e.g., National Research Council, 2009). However, for many students, learning opportunities within the regular school curriculum do not meet their specific needs and interests (e.g., Godec et al., 2022; Subotnik et al., 2011; Todd & Zvoch, 2019). In contrast, appropriate, personally relevant, and adequately challenging out-of-school programs, such as science talks, clubs, camps, and competitions, have been found capable of developing students' science interests and their respective career aspirations (Dabney et al., 2012; e.g., Maiorca et al., 2021; VanMeter-Adams et al., 2014).

To enhance the academic and personal development of specifically high-performing students, a particular collection of nonformal enrichment programs were developed (Farsimadan et al., 2015; Taber, 2007); with science competitions, and particularly science fairs and Olympiads, being one of the best-know examples. Originally, these programs were designed to meet the needs of particularly talented and high-performing students in science (Petersen et al., 2018; Petersen & Wulff, 2017). In recent years, however, many science competitions have redefined their goals and expanded their focus to motivate and encourage interested but not necessarily high-achieving students (Petersen et al., 2018).

1.1.5 | Science Olympiads and the German Biology Olympiad

Worldwide, student science competitions enjoy great popularity: Each year hundreds of thousands of secondary school students from around the world take part in one of the local, national, and international competition programs (Institute of Competition Sciences, 2023a; Microsoft, 2020). Science competitions support a diverse group of interested and talented students in realizing their full potential by facilitating academic experiences outside the regular science classroom (Campbell & Walberg, 2011). While science fairs are project-based competitive events that challenge students to test and present their own research hypotheses, science Olympiads are a collection of test-based competitions that attract interested and potentially high-achieving students (Institute of Competition Sciences, 2023a). Historically, science Olympiads focused primarily on traditional secondary school science subjects, such as biology, chemistry, or physics, but in recent years competitions on nontraditional science topics such as robotics, sustainability, data analysis, and astronomy have been developed additionally (Institute of Competition Sciences, 2023a).

In Germany, thousands of students participate in science Olympiads each year (Arbeitsgemeinschaft bundesweite Schülerwettbewerbe, 2022). For the Biology, Chemistry, and Physics Olympiads, all students between ages 15 and 20 are eligible to enter the first of four national competition rounds (IBO Deutschland, 2023b; IChO Deutschland, 2023; IPhO Deutschland, 2023). After each round, the participants with the highest scores advance to the next and as such, the Olympiads operate through a rigid system of elimination (e.g., Petersen & Wulff, 2017; Verna & Feng, 2002).

The German selection competition for the International Biology Olympiad is a prototypical example of German science Olympiads. We chose to study our research questions in the context of this particular competition for two main reasons. First, the German Biology Olympiad is a well-established and renowned science competition which attracts approximately 2000 participants each year. Second, since this study focuses on early elimination without a specific focus on gender, we aimed to study this phenomenon within the most "gender-neutral" science Olympiad (see review by Steegh et al., 2019). Although efforts have been made, conventional science competitions are still strongly characterized by their male-biased structures, with the Biology Olympiad having the smallest gender gap in participation and achievements (Steegh et al., 2019).

The German Biology Olympiad is structured as follows. Based on the results of the first competition round—an at-home exam paper—, the approximately 500 to 600 best performing participants advance to the second round. After the second round, which entails an at-school exam paper, around 45 students advance to the third round: a week-long seminar camp with lectures, experiments, and theoretical tasks, during which about 10 to 12 students are selected to take part in the fourth and final competition round. During this final seminar camp, four students are selected for the German national team that eventually participates in the annual International Biology Olympiad (IBO Deutschland, 2023a; Opitz & Harms, 2020). Every participant of the German Biology Olympiad receives a certificate of participation. Those who advance to the third competition round receive book vouchers and a chance to do an internship abroad. Reaching the fourth competition round is rewarded with a small cash prize and a nomination for a monthly subsidy toward tuition fees (IBO Deutschland, 2023a). Since the third and fourth competition rounds take place in a distinct competition setting away from home or school and are awarded with additional prizes, qualifying for one or both of these rounds may feel like a win or a success to the participants. Oppositely, participants who are eliminated in the first or second round may therefore feel like they were unsuccessful. In the example of the German Biology Olympiad, this means that of the 2000 students who entered the competition, only the 45 who qualify for the third round—a mere 2%–3%—may feel successful, while the vast majority of participants most likely feel unsuccessful to a greater or lesser extent.

To date, not much light has been shed on the possible negative effects of participating in science competitions, and discussions of potentially negative effects often rely on anecdotal evidence from participants. However, many science competitions have redefined themselves by focusing on encouraging interested but not necessarily high-achieving students, who are often eliminated in the first or second round. Moreover, since it can be assumed that most participants in science competitions have a fundamental interest in science, there is a high probability these participants also have science-related study and career aspirations. A negative experience in the competition may therefore even be counterproductive and thwart the development of a future workforce in science. For these reasons, it is essential the potential negative effects of competitions are laid bare.

1.1.6 | Research on science competitions

To date, by far most studies on students' participation in science competitions have been focused around three general research topics: (1) predictors for participation, (2) variables explaining successful participation, and (3) the effects of (successful) participation on students. Variables predicting students' decisions to participate in science competitions were found to range from social roles and personal values to prior experiences and self-schemata (see Steegh et al., 2019 for a review). In more recent work specifically focusing on the representation and achievements of girls in science Olympiads, the negative role of gender-science stereotypes was closely examined and linked to interest (Ladewig et al., 2020; Steegh, Höffler, Höft, & I., 2021a).

Research on what makes participation successful often revolves around identifying specific characteristics of successful participants, more specifically, those who make it to later rounds. For example, prior studies on student-centered predictors in science Olympiads found that previous competition experience and domain identification were of significant relevance for reaching one of the final competition rounds (Steegh, Höffler, Höft, & Parchmann, 2021b; Urhahne et al., 2012). In addition to individual characteristics, external influences, such as parental support, were also found to be predictive of success (e.g., Verna & Feng, 2002; Wu & Chen, 2001).

So far, research on the effects of participation in science competitions was aimed at the experiences of two groups of participants: participants in general, regardless of their success, and participants who were successful. As for the first group, participation in a science competition was linked to exploring new topics and developing new skills which helped refine their interest in science (Sahin et al., 2015; Smith et al., 2021). Further research on this group revealed that participation promoted science-specific self-beliefs and domain identification (Mitchell et al., 2011) and helped students to inquire scientific methods such as experimentation or decision-making (Garrecht et al., 2020; Paul et al., 2016). With regard to the particular group of successful participants, numerous studies found that participation in a science competition had boosted these students' aspirations to pursue a science-related career and that in many instances successful participation directly facilitated entry to renowned universities worldwide (Campbell & Walberg, 2011; Miller et al., 2018; Sahin et al., 2015; Wu & Chen, 2001).

However, even though all students are welcome to enter the competition, not all have the same experience. By design, since most competitions consist of several selection rounds, and the vast majority of participants are eliminated in the first or second competition round, most likely feel unsuccessful (e.g., Petersen & Wulff, 2017). This raises important questions about the ways in which science competitions impact winners and 'losers' differently.

Success and failure in competitive situations

Although to our knowledge there is no study that has focused on the group of less successful participants in the context of mathematics or science competitions, there is scattered literature that examines the effects of success and failure in the context of sports competitions. Not surprisingly, many of these studies have focused on physical rather than affective explanations and effects among participants (e.g., on stress levels by Chennaoui et al., 2016; on testosterone concentration by Geniole et al., 2017). Only a few studies focused on how athletes dealt with being less successful in a competition on a more psychological level: Gernigon and Delloye (2003), for example, found that track athletes' self-efficacy was related to feedback about their first trial, which then further affected performance in the second trial. A finding which is in line with expectancy-value theory (Eccles et al., 1983), supporting the understanding that success or failure in past experiences can serve as (de)motivators for future ones. Furthermore, a study by Potgier and Steyn (2010) found that participants of competitive sports events on a school or regional level showed more positive reactions to failure than those who competed on national and international levels.

Especially in academic settings, the attribution of success and failure to internal or external factors can influence students' continued involvement in science (Assouline et al., 2006; Guler, 2013; Simpson & Maltese, 2017). Moreover, in the context of the German Physics Olympiad, Treiber (2020) found that participants hold different views about whether or not their results depended on their own effort in the competition–especially in the first competition round. Although findings revealed self-esteem-serving patterns among participants (i.e., successful participants attributed their success particularly to their own abilities while participants who experienced early elimination mostly attributed their failure to external factors such as the difficulty of the competition tasks) little is clear about the exact mechanisms behind these beliefs.

2 | THEORETICAL FRAMEWORK: EXPECTANCY-VALUE THEORY OF ACHIEVEMENT MOTIVATION

For this paper, Eccles et al's (1983) expectancy-value theory of achievement related choices was chosen as the theoretical foundation. This theory has provided the groundwork for research on diverse topics (e.g., occupational choices, gender differences, academic success) aiming to investigate why one achievement-related activity is chosen over another (e.g., Lauermann et al., 2017; Steegh, Höffler, Höft, & I., 2021a). According to expectancy-value theory, the decision whether and to what degree individuals engage in an activity is largely driven by two constructs: first, one's own expectations of success (i.e., the belief about how well one will perform on a task) and, second, the subjective task value ascribed to the activity (Eccles, 2005; Eccles et al., 1983; Wigfield & Eccles, 2000). These activity-related values can fulfill three different personal needs such as enjoyment or pleasure (i.e., interest value), support of reaching future goals (i.e., utility value), and confirmation and expression of individual self-images (i.e., attainment value; Eccles, 2005).

Considerable evidence has underpinned the usefulness of expectancy-value theory for investigating the development of science-related academic and career choices (e.g., Ball et al., 2017; Wang & Degol, 2013). In addition, the theory also provided the developmental groundwork for interventions that sought to strengthen students' engagement with science-related activities (e.g., Hulleman & Harackiewicz, 2009). In the specific context of science competitions, the expectancy-value model has been predominantly used to determine predictors for success, such as the expectancy of success, boredom in school, previous participation in a science competition, gender, stereotypical beliefs, and parental support (e.g., Stang et al., 2014; Steegh, Höffler, Höft, & Parchmann, 2021b; Urhahne et al., 2012). Yet, while the path of successful participation has already been well studied and mapped out in the literature, less is clear about the reversed trajectory: the effect of unsuccessful participation on science career aspirations.

Following Eccles et al.'s (1983) expectancy-value model of achievement motivation, educational and vocational choices are most directly related to students' expectations of success and the importance or value they place on their options. Expectations of success are directly linked to prior achievements, which, in the context of science competitions, could potentially result in early eliminated participants having lower expectations of successful science careers. Adding to this, participants with science career aspirations may attach greater importance to being successful in the competition and are therefore at greater risk of experiencing negative effects in the event of early elimination in the competition. We hypothesize that there are different mechanisms underlying the development of science career aspirations for those who place greater importance on being successful in the competition compared to those who do not feel as strongly about their participation.

2.1 | Studying the effects of early elimination on expectancies and values

For a detailed study of the effects of early elimination on participants in science competitions, we chose to focus on three factors representing participants' expectancies, values, and goals within the psychological component of the expectancy-value theory. In doing so, we were able to study the potentially negative effects of elimination on the value participants place on pursuing a career in a science-related field and their expectation of a successful science career, in particular for those participants who placed great importance on being successful in the competition.

Both among secondary school students and participants of a national chemistry Olympiad *expectancy of success* was found to be a predictor for success (Stang et al., 2014; Trautwein et al., 2012). Moreover, a study by Lauermann et al. (2017) in the context of mathematics confirmed that associations between expectancy and subjective task value beliefs predicted actual adult careers. These prior findings, combined with the fact that we studied unsuccessful scenarios in a competitive setting, make expectancy of success a particularly suitable construct.

With regard to the value component of the expectancy-value model, we focused on *Biology study and career related task value*. In general, task value is connected to a specific task or activity, and describes its perceived interest, usefulness, importance, and cost. In previous studies, task value related beliefs were found predictive for students' science-related course enrollment, engagement, and career aspirations (Eccles, 2009; Wang & Eccles, 2013; Wigfield & Eccles, 2002), which is why we selected this particular value construct for our study.

Short-term achievement goals describe the value participants place on advancing to the next competition round. As such it shows considerable overlap with attainment value, which was conceptualized by Eccles (2009, 2011) as the needs, personal values, and explicit motives fulfilled by a specific activity. Attainment value and other task values were found to be substantial predictors of course-taking decisions in secondary and tertiary mathematics and science education (Dabney et al., 2012; Eccles et al., 1999; Nagy et al., 2006; Taskinen et al., 2013; Uitto, 2014), specifically among high achievers (Andersen & Ward, 2014). Moreover, higher attainment value was found to boost performance even if students had a low expectancy of success (Putwain et al., 2019).

Several extracurricular student science programs were found to have (long-lasting) positive effects on students' science career trajectories (Blustein et al., 2013; Hiller & Kitsantas, 2014; Kitchen et al., 2018). Yet, conversely, can competitive science programs such as the science Olympiads also have lasting negative effects on participants' science careers? Participants in science Olympiads with ambitions for a career in science may place greater importance on success in the competition, and failure may therefore have a disproportionately negative effect on the study and career plans of these participants. So the question remains to what degree enrichment programs such as science Olympiads meet their goals, particularly when a heterogeneous group of students are invited to participate in a competitive environment (Stake & Mares, 2001).

3 | THE PRESENT STUDY

In this paper we focus on the largest and least successful group of participants of the German Biology Olympiad, namely those who are eliminated after the first of four national selection rounds. We aimed to explore the effects of elimination on participants' biology-related study and career task value and expectancy. To determine whether and how students' career aspirations develop after facing early elimination, we collected data from students who participated in the first round of the competition before *and* right after they received feedback regarding their qualification for the second round. The objective of this study was to evaluate the data utilizing the latent change score model approach to address the following research questions:

1. How does elimination in the first competition round affect participants' development of biology-related career task value and expectancy?
   Based on the positive link between winning in a science competition and students' task value and expectancy, we expected to find a non-positive relationship between early elimination and task value and expectancy.
2. How does early elimination in the first competition round particularly affect those participants who place high value on advancement in the competition?
   We expected that participants who placed high importance on advancing in the competition but faced early elimination to be more prawn to a decrease in biology-related study and career value and expectancy compared to participants who placed low importance on competition advancement.

4 | METHODS

4.1 | Research context

The current article is part of the WinnerS-project, which aimed to examine the impact of factors determining success and failure in German science competitions. Our data are derived from students who participated in the first round of the German Biology Olympiad in 2017. The competition proceeded as follows: From June to September, participants individually answered a paper-pencil test which assessed their biology knowledge. This test entailed four theoretical tasks divided into sub-tasks spanning a wide range of biological topics such as botany, genetics, and molecular biology. After students submitted the completed test to their teachers for review, they were invited to participate in our online survey. This survey contained questions about age, gender, grade, and several variables capturing participants' biology-related self-schemata, values, and expectancies about advancement in the competition and in biology-related studies and career. Until the end of September, teachers reviewed students' work and transmitted the results to a state representative. Immediately after receiving feedback on their scores, participants were asked to complete our second online survey–regardless of their result. Hence, we have data of the participants before *and* after they received feedback about their achievements (i.e., qualification for the second competition round or elimination) in the first round of the German Biology Olympiad.

4.2 | Data basis

From the 1913 participants (67% female) of the German Biology Olympiad, 381 participants (72% female) completed our initial online survey (i.e., before receiving feedback). On average, participants were 16.5 years old (*SD* = 1.10 years) and attended 7th to 13th grade at German secondary schools (see Figure 1). Although there is a common framework for biology education in Germany (KMK, 2005, 2020), responsibility for its implementation lies with the 16 independent German federal states. In addition, there are different school tracks in each state with varying emphasis on science education. As participants of the German Biology Olympiad come from all over Germany, they will have different experiences with how biology is taught depending on the available school tracks in their federal state. The majority of the participants (95%) attended academic track schools (*Gymnasium*, i.e., a specific type of secondary school preparing students for higher academic education), 3% attended mixed-track schools, and 2% did not state their school type. Furthermore, as an indicator of ethnicity and culture, native language was measured and 92% of the participants spoke German as their first language. The number of books at home was used as an indicator of socioeconomic status (as is the case with large-scale international assessments of student performance such as TIMSS; see Broer et al., 2019) and 73% of our participants reported to have more than 100 books at home (on a scale from 0: "0 books" to 5: "more than 100 books" (see Heppt et al., 2022).

Of the 381 participants from our initial study, 64% qualified for the second round of the competition. After the announcement of the first round's results, all 381 participants who had participated in our first survey were asked, regardless of their result, to participate in our second online survey. In our second survey, 242 participants took part. Of these 242 participants, 72% had qualified for the second round of the competition.

4.3 | Instruments

Participants were asked to rate different Likert-type items ranging from 1: "I completely disagree" to 4: "I completely agree." We chose an even number response scale to avoid a potential mid-point bias and to prevent participants from responding in a socially acceptable way (see Cao & Drasgow, 2019).

4.3.1 | Biology study and career related task value

Items measuring participants' biology study and career related value had been adapted from existing instruments by Eccles and Wigfield (1995) and the value items by Lykkegaard and Ulriksen (2016). Our online surveys featured four items (full list of items in Table S1 in the supplementary material) and showed acceptable reliabilities in both surveys (Cronbach's $\alpha_1 = 0.74$, Cronbach's $\alpha_2 = 0.63$).

4.3.2 | Expectancy of success in biology study and career

Participants' expectancy of success in relation to a possible biology study and career was measured using four items (full list of items in Table S2 in the supplementary material). All items were adapted from existing instruments by Eccles and Wigfield (1995) and Lykkegaard and Ulriksen (2016) and showed acceptable reliabilities in both surveys (Cronbach's $\alpha_1 = 0.67$, Cronbach's $\alpha_2 = 0.63$).

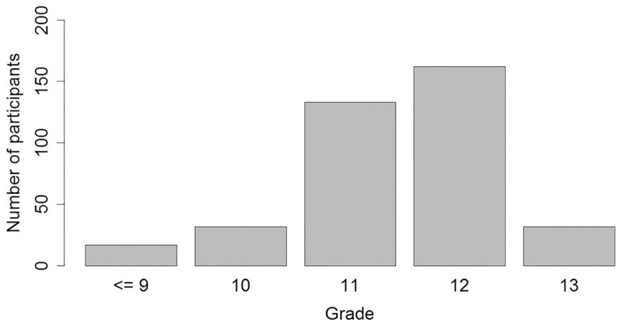

FIGURE 1 Distribution of grade levels attended by participants in German secondary schools based on $N = 381$ participants.

4.3.3 | Short-term achievement goals: Advancing to the next competition round

To determine the value participants placed on advancement in the competition, we asked them in the initial survey how important it was to them personally to qualify (i.e., to be successful) for the second round of the competition. To this end, we provided three items in our first online survey that were adapted from an existing instrument by Urhahne et al. (2012) (full list of items in Table S3 in the supplementary material). Cronbach's α indicated an acceptable reliability (Cronbach's $\alpha = 0.78$).

4.4 | Data analyses

4.4.1 | Longitudinal analyses

We analyzed our data in *R* (R Core Team, 2021) using the package *lavaan* (Rosseel, 2012). For model development in participants' biology-related career task value and expectancy, we followed the latent change score model (LCSM) approach (McArdle, 2009). Key feature of the LCSM is that it captures an average change in a variable as well as the variation in this change across individuals (Ferrer & McArdle, 2003). We applied a univariate common-factor LCSM, as displayed in Figure 2. Manifest variables M1 to M4 on two time points (i.e., the two online surveys) each reflect the underlying construct that is modeled as latent variable (LV). By defining a latent change score variable (ΔLV) as the part of LV[2] which is not corresponding with LV [1] (McArdle, 2009), we were able to capture the change between both scores. Since the latent factors LV[1] and LV[2] are considered to be free of measurement error, the latent change ΔLV between them is also measured without error (Little et al., 2006).

Another advantage of the LCSM is that paired t-tests and repeated measures ANOVA can be considered as special cases of LCSM (e.g., Voelkle, 2007). By specifying a correlation instead of a regression between LV[1] and ΔLV, LCSM enables testing the significance of the mean of ΔLV, which is identical to a paired t-test between two time points (Coman et al., 2013).

A requirement for LCSM is that both latent factors (i.e., LV[1] and LV[2]) are measured equally at each time of measurement (e.g., Ferrer et al., 2008). We therefore established measurement invariance by constraining equal loadings, intercepts, and error terms of manifest

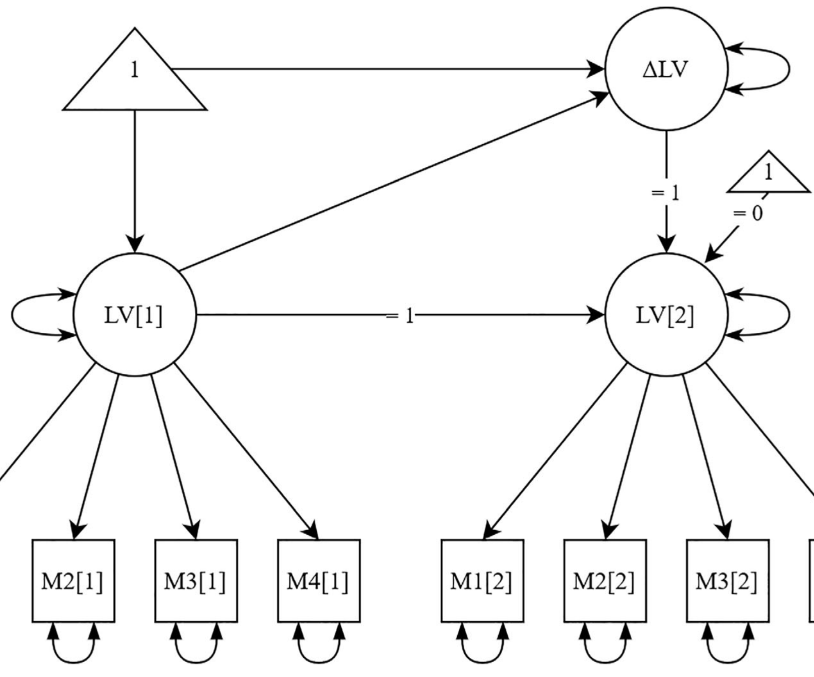

FIGURE 2 Applied univariate common-factor LCSM. Model assumed measurement invariance and correlated residual errors over time which are omitted for visual clarity. Auxiliary variables are not displayed. "=" indicated fixed values. LV, latent variable; M, manifest variable.

variables across the two online surveys. In addition, we applied the effect-coding method for intercepts and factor loading of manifest variables (Little et al., 2007). As a result, the latent variable parameters were estimated in the original metric of the manifest variables. Furthermore, we allowed correlated residual errors over time. The *R*-syntax is available as supplementary material accompanying the online article.

4.4.2 | Missing data

In total, 139 of all 381 participants did not attend the second online survey (of which 69 participants had qualified for the second round and 70 were eliminated after the first round), hence, data of these participants are missing. Moreover, missing data also accrued in some answers of the remaining participants who attended the second online survey: four of the 242 participants did not answer items about their biology study and career related task value and seven of the 242 participants did not answered items about their expectancy of success in biology study and career.

To make full use of the data from all 381 participants, we therefore used full information maximum likelihood (FIML) estimation implemented in *lavaan* to handle the missing data. Research has shown that FIML parameters are relatively unbiased under the missing-at-random (MAR) condition (Arbuckle, 1996; Enders & Bandalos, 2001; Wothke, 2000). Data are MAR "when the probability of missing data on a variable *Y* is related to some other measured variable (or variables) in the analysis model but not to the values of *Y* itself"

(Enders, 2010, p. 6). The MAR condition is difficult to test since the required information is missing (van Buuren, 2012), however, indications can be obtained by testing whether the missing data on Y in the second round is unrelated to the variable Y in the first round after partialling out other variables (Enders, 2010). Results from logistic regressions showed that the missingness of the variables "task value" and "expectancy of success" in the second round were unrelated to their initial values (for task value: $p = 0.81$; for expectancy of success: $p = 0.35$). Therefore, we assumed MAR condition for both variables. We included auxiliary variables (gender, age, participants' grade, fluid intelligence, as well as biology-related interest, self-concept, self-efficacy, and career motivation) in the FIML procedures as saturated-correlates (Graham, 2003). By doing so, observed covariances were used to inform the missing information. This approach is, in comparison to listwise deletion, less biased and enables analyses without the reduction of statistical power (e.g., Enders, 2008).

5 | RESULTS

5.1 | Descriptive results

Table 1 shows the descriptive results of the study variables. Participants' average biology study and career related task value was generally similar in magnitude across both online surveys ($M_1 = 3.40$, $SD_1 = 0.50$; $M_2 = 3.40$, $SD_2 = 0.45$), whereas their average expectancy of success in a biology study and career slightly increased between both surveys ($M_1 = 2.90$, $SD_1 = 0.53$; $M_2 = 3.02$, $SD_2 = 0.48$). We conducted t-tests to examine all variables for gender differences. We have not found any gender differences in study and career related task value in both surveys ($t(175.8) = -0.41$, $p = 0.68$; $t(94.7) = -0.55$, $p = 0.50$), expectancy of success in both surveys ($t(163.9) = 1.17$, $p = 0.24$; $t(114.5) = 0.68$, $p = 0.24$), elimination in the first competition round ($t(179.3) = 1.21$, $p = 0.23$) and short-term achievement goals ($t(159.7) = 0.77$, $p = 0.44$). The data showed that, between both surveys, participants' average task value ($r = 0.51$, $p < 0.001$) and average expectancy of success ($r = 0.63$, $p < 0.001$) correlated significantly. Furthermore, participants' elimination in the first competition round correlated only with their expectancy of success ($\rho_1 = -0.12$, $p = 0.022$; $\rho_2 = -0.15$, $p = 0.021$). These results could be related to the potential influence of elimination on participants' development of expectancy of success, which is analyzed in the next section.

5.2 | Participants' development of biology-related career task value and expectancy of success

To verify a development of both constructs over time, we first computed two univariate common-factor LCSM and specified a correlation between LV[1] and ΔLV. Results of the LCSM referring to participants' biology study and career related task value and expectancy of success in a biology study and career are displayed in Table 2. Both LCSM provided a good fit (Model 1a: CFI = 0.948, RMSEA = 0.056, SRMR = 0.027; Model 1b: CFI = 0.938, RMSEA = 0.063, SRMR = 0.029). In both models, the variance of the latent change was significant (Model 1a: 0.05, $p < 0.001$; Model 1b: 0.04, $p < 0.001$), indicating inter-individual differences in change. Furthermore, the latent mean of participants' change in biology-related career task value did not significantly differ from zero (−0.03, $p = 0.225$). However, the latent mean of change in

TABLE 1 Descriptive statistics and correlations of study variables based on $N = 381$ participants.

	M	*SD*	NA	(1)	(2)	(3)	(4)	(5)	(6)
(1) Biology study and career related task value [1]	3.40	0.50	0.05	—					
(2) Biology study and career related task value [2]	3.40	0.45	0.38	0.51***	—				
(3) Expectancy of success in biology study and career [1]	2.90	0.53	0.06	0.46***	0.33***	—			
(4) Expectancy of success in biology study and career [2]	3.02	0.48	0.39	0.28***	0.38***	0.63***	—		
(5) Short-term achievement goals [1]	2.75	0.80	0.07	0.42***	0.28***	0.28***	0.11[b]	—	
(6) Elimination in the first competition round[a]	—	—	0.00	−0.04[b]	−0.05[b]	−0.12*	−0.15*	−0.06[b]	—

Note: The variables (1)–(5) represent the average of relevant item scores. [1] and [2] indicate the result of the first and second online survey, respectively. *M*, *SD*, and NA are used to represent mean, standard deviation, and the proportion of missing data, respectively.
[a]Since the elimination is represented by a dichotomous variable (0: no, 1: yes), Spearman's rank correlations are used.
[b]Not statistically significant.
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

TABLE 2 Numerical results for LCSM of participants' biology study and career related task value and expectancy of success.

	Model 1a: Value			Model 1b: Expectancies of success		
Parameters	**ML**	**STD**	***p***	**ML**	**STD**	***p***
Fixed parameters						
Intercept LV[2]	0.00	0.00		0.00	0.00	
LV[1] → LV[2]	1.00	1.11		1.00	1.06	
ΔLV → LV[2]	1.00	0.59		1.00	0.47	
Freely estimated parameters						
Intercept LV[1]	3.40	7.94	0.000	2.89	6.59	0.000
Mean ΔLV	−0.03	−0.15	0.225	0.08	0.43	0.002
Covariance LV[1] and ΔLV	−0.07	−0.71	0.000	−0.05	−0.57	0.001
Variance LV[1]	0.18	1.00	0.000	1.93	1.00	0.000
Residual variance LV[2]	0.05	0.35	0.000	0.04	0.22	0.000
Variance ΔLV	0.05	1.00	0.000	0.04	1.00	0.000

Note: Intercepts, factor loadings, and error terms of manifest variables are forced to be equal over time, but these are not displayed. Correlated residual errors of manifest variables and auxiliary variables are not displayed.
Abbreviations: LV, latent variable; ML, maximum likelihood estimate; STD, standardized estimate.

expectancy of success was statistically significant (0.08, $p = 0.002$). It can be assumed that participants' biology-related career task value did not change whereas their expectancy of success between both time points did. In the following, we therefore focused on participants' development of expectancy of success.

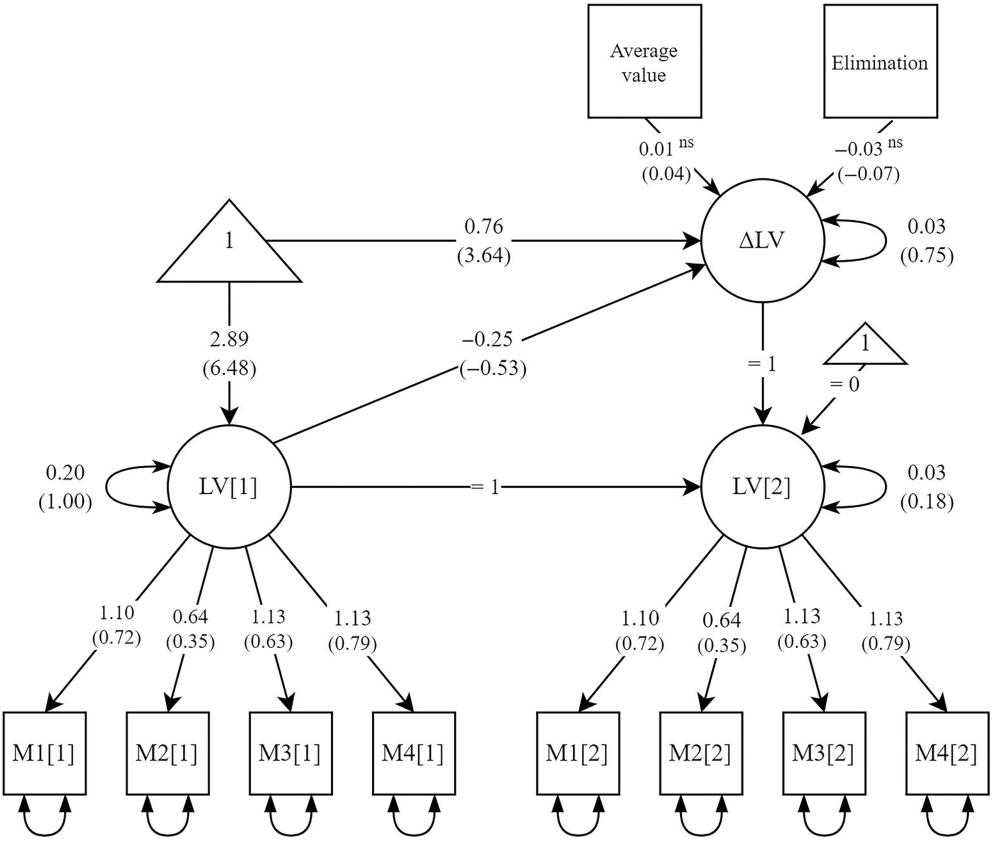

FIGURE 3 Univariate common-factor LCSM of participants' expectancies of success. Values are maximum likelihood estimates with standardized estimates in parentheses. For intercepts and factor loadings of manifest variables effect-coding method was applied. Model assumed measurement invariance and correlated residual errors over time. Manifest variable intercepts and residual error terms are omitted for visual clarity. Auxiliary variables are not displayed. "="indicated fixed values. LV, latent variable; M, manifest variable; ns, nonsignificant estimate.

In order to analyze the impact of early elimination in the first competition round on participants' development of expectancy of success, we expanded the common-factor LCSM by including an indicator for elimination as predictor for ΔLV (i.e., latent change in expectancy of success; see Figure 3). Furthermore, we adjusted for participants' average biology-related career task value. Our model provided an acceptable fit (CFI = 0.910, RMSEA = 0.075, SRMR = 0.039). Participants' initial expectancy of success (i.e., LV[1]) is highly predictive for the development of their expectancy ($\beta = -0.529$, $p = 0.004$), indicating a general lag in the increase of expectancy of success: The increase in expectancy of success was greater in participants with low initial expectancy. Furthermore, participants' elimination did not impact ΔLV ($\beta = -0.067$, $p = 0.591$). Across all participants, we can therefore assume that an early elimination in the first competition round of the German Biology Olympiad did not hinder participants' development of biology-related career expectancy.

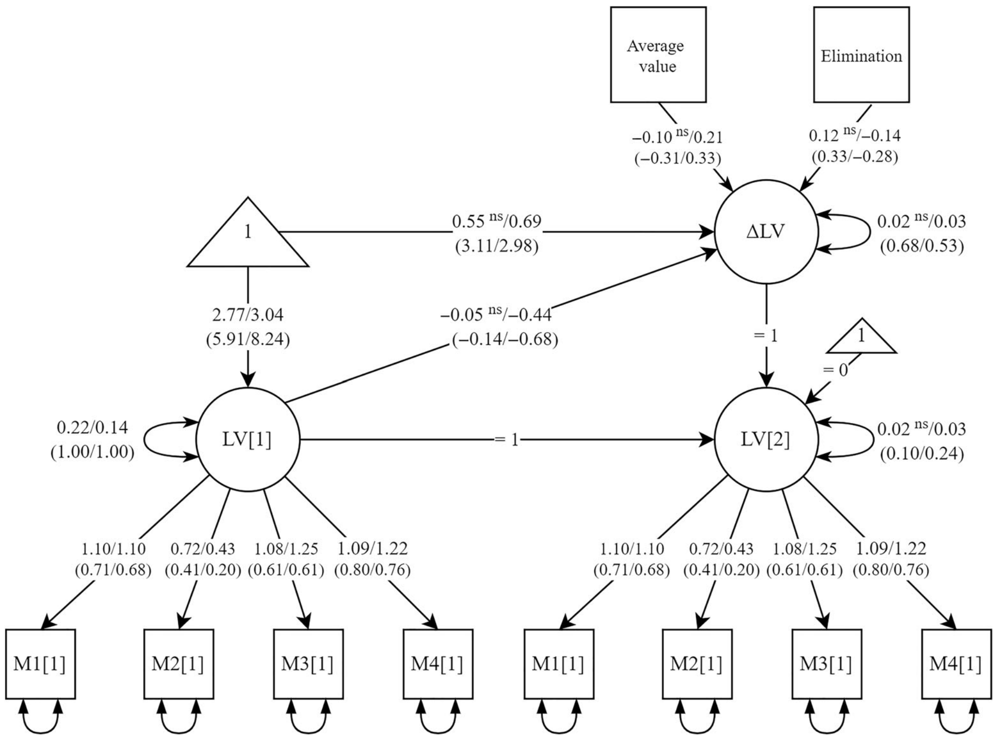

FIGURE 4 Univariate common-factor LCSM of expectancies of success for participants with low and high importance. Values are maximum likelihood estimates with standardized estimates in parentheses for the low importance and high importance group. For intercepts and factor loadings of manifest variables effect-coding method was applied. Model assumed measurement invariance and correlated residual errors over time. Manifest variable intercepts and residual error terms are omitted for visual clarity. Auxiliary variables are not displayed. "=" indicated fixed values. LV, latent variable; M, manifest variable; ns, nonsignificant estimate.

5.3 | How do short-term achievement goals for advancement to the next round impact expectancy of success?

To investigate how early elimination in the first competition round particularly affects those who placed high value on advancement in the competition, we performed a median split of our sample. We specified two groups according to participants' average value on advancement. The first group (*low importance*, $N = 183$) comprised participants with an average value on advancement lower or equal to 2.67, the second group (*high importance*, $N = 173$) included those with an average value on advancement greater than 2.67. For both groups, we computed the common-factor LCSM like in Figure 3 simultaneously. The resulting model (see Figure 4) showed acceptable fit indices (CFI = 0.905, RMSEA = 0.080, SRMR = 0.050). For the low importance group, the model showed no significant influence of participants' initial expectancy of success ($\beta = -0.143$, $p = 0.687$), average biology-related career task value ($\beta = -0.308$, $p = 0.282$), and elimination after the first round ($\beta = 0.329$, $p = 0.154$) on a change in expectancy of success. In addition, no increase (0.550, $p = 0.110$) and variance (0.021, $p = 0.098$) in the development of expectancy of success was detected. For the high importance group, participants' development of expectancy of success was significantly related to their initial expectancy of success ($\beta = -0.679$, $p < 0.001$) and their average biology-related career task value ($\beta = 0.326$, $p = 0.032$). Moreover, for participants who placed high value on advancement, early elimination in the first competition round negatively influenced the development of their expectancy of success ($\beta = -0.283$, $p = 0.029$).

6 | DISCUSSION

The current study examined the effects of early elimination in a science competition on participants' career aspirations. We first tracked the impact of elimination in the first competition round on participants' development of career task value and expectancy of success and did not find effects on participants' study and career values but participants' expectancy of success developed positively from the first to the second competition round. We then zoomed in at the group of participants who placed particularly high value on advancement in the competition and found that among those participants, early elimination interfered with the development of study and career expectations.

6.1 | Participants' biology-related study and career values remained stable from the first to the second round of competition

Contrary to expectations, this study did not find significant effects of early elimination on participants' study and career values. In other words, whether participants were successful or not, had no effect on how they valued a possible future study or a career in biology. These findings are likely related to the stable nature of values in general (see Eccles & Wigfield, 2002), which are possibly less affected by a one-time event such as a science competition. Students may not make a direct connection between their personal experiences in the competition and their values. In other words, even though they did not perform well in this competition, it did not change their belief that biology is interesting and that a career in biology would mean a lot to them.

The principle of valuing effort is extended by the effort paradox (Inzlicht et al., 2018), which suggests that while many students tend to avoid exerting effort, the opposite can also be true, and effort can be perceived as valuable. This concept potentially also applies to the German Biology Olympiad, where participants who face early elimination may continue to view a career in biology as valuable because of the effort required to attain this goal.

Moreover, since the participants in our study expressed overall notably high study and career related task value ($M_1 = 3.40$; $M_2 = 3.40$ on a 4-point Likert scale), participants of science competitions may generally have high overall science-related task value compared to the average secondary student. The outcomes of prior studies on task value among typical students may therefore not be immediately applicable to our distinct cohort of competitors.

6.2 | Expectancy of success in biology-related study and career developed positively from the first to the second round of competition

In contrast to study and career related task value, we found that overall, participants' expectancy of success in biology-related studies and career developed positively from the first to the second competition round. In comparison to task values, participants' expectancy of success therefore seems to be more directly influenced by their experiences in a science competition. In particular, participants with the lowest success expectations at the beginning of the competition experienced the greatest development after the first competition round. These participants may have believed that their participation in this biology competition could be indicative of their potential for a successful career in biology.

When zooming in on the effects of early elimination, we found that participants' expectancy of success developed positively and that elimination after the first round did not affect this development. This finding was contrary to our hypothesis and also contrary to a previous study from Chang and Lin (2017) which suggested that participants' academic self-concept (which we consider closely connected to expectancy of success) in an international earth science Olympiad was significantly related to their achievements in the competition. Moreover, numerous studies in the context of secondary school education found similar linear relationships between self-concept and science achievement (e.g., Jansen et al., 2015; Liou, 2017; Nagengast & Marsh, 2012).

A possible explanation for our divergent finding could be that individuals frequently disengage from negative feedback for hedonic reasons (i.e., to avoid feeling bad). As described by cognitive dissonance theory, this coping behavior is particularly used when the feedback does not correspond to one's own expectations (Eskreis-Winkler & Fishbach, 2019; Grundmann et al., 2021). To avoid cognitive dissonance between expectations of success and the reality of early elimination, participants may simply deny and disregard the negative feedback, thereby reducing its effects.

6.3 | Early elimination interfered with the development of certain participants' expectancy of success in biology-related study and career

As stated in the previous section, overall, the results of this study suggest that elimination after the first round of competition did not interfere with the development of participants' expectancy of success in biology-related study and career. However, among participants who placed great importance on being successful in the competition, early elimination interfered with the development of study and career expectations.

As a whole, we were able to distinguish three different groups of participants: (1) those who placed little importance on succeeding in the competition and had stable levels of expectancy of success over the two competition rounds, (2) those who placed great importance on the competition, qualified for the second round and experienced a positive development of their expectancy of success, and (3) those who placed great importance on the competition, were eliminated after the first round and experienced a positive, but weaker development of their expectation of success. In short, within the group of participants who placed high importance on the competition, elimination did not negatively affect the development of study and career success expectations, but it did interfere with the positive development. We therefore argue that students who ascribed great importance to their participation may not have been able to attribute their elimination along the lines of cognitive dissonance theory: Rather than disengaging from the negative feedback, the importance of the competition may have caused them to face their elimination and downgrade the development of their future expectations about an academic career (see Ilies & Judge, 2005; Krenn et al., 2013). In other words, these participants may have experienced a "reality-check."

6.4 | Limitations

Overall, it should be noted that the performances of our statistical analyses are limited to the pattern of the missing data. About two-thirds of the original 381 participants took part in the second study, however, among those who were eliminated, only half took part a second time. These patterns limited the generalizability of our results. Although FIML "appears to be the method of choice" (Enders, 2001, p. 367) for these missing data conditions (see Schafer & Graham, 2002), our results must be interpreted with caution. They do, however, provide initial insights into the effects of early elimination in science competitions. A second main limitation of our study is that the data we used were limited to participants' expectations about the first round of competition and the effects of elimination versus qualification after this round had taken place. We are therefore not in a position to determine the extent to which elimination affected participants' career aspirations in later rounds or how permanent these effects might be. Third, the model specified in Figure 4 does not seem to apply to the low importance group, resulting in nonsignificant model parameters. Therefore, conclusions concerning participants who ascribed little importance to their forthcoming in the competition need to be interpreted with caution. Additional studies will be needed to develop a full picture of how career aspirations are affected for this group. Fourth, our findings relate specifically to participants in the German Biology Olympiad and may not apply to participants in other science competitions in or outside of Germany. Although the interfering effect of early elimination on participants' expectancy development may not be specific for German biology competitions, we suggest that further studies considering different science domains and cultural contexts should be undertaken. Finally, our LCSM did not detect a significant change in participants' career task value. At this point, it remains unclear whether career task value can indeed be assumed as stable or if changes in career task values were mainly undetectable due to ceiling effects of our test instrument.

6.5 | General recommendations for nonformal science learning opportunities

In this study, participants' biology-related study and career values did not develop from the first to the second competition round; neither for those who successfully reached the second round nor for those who faced early elimination. This suggests that nonformal learning opportunities may need to provide more sustained engagement if they aim to have a positive impact on students' career aspirations. A study by Rende et al. (2023), for example, showed that students who participated in a multi-year volunteer program at a science museum chose to pursue a science career at higher rates than the national average. Another avenue for sustained engagement might be to encourage students' repeated participation in nonformal science learning opportunities, as recursive participation in, for example, science competitions has been shown to play an important role in the development of students' interest in pursuing a science-related career (Dabney et al., 2012). In addition, nonformal science learning opportunities that allow participants to explore topics of their own choosing (rather than topics chosen for them, as it is typical in science Olympiads) might help shape their science-related study and career values, as issues of personal or societal importance are linked to the relevance of choosing a science-related career (e.g., Cerinsek et al., 2013).

Since participating in the Biology Olympiad involved authentic science activities (e.g., laboratory work), it likely provided students with opportunities to raise their expectations for success in biology-related studies and careers. However, a weaker development was recorded among those participants who had placed greater importance on reaching the next round of competition but had faced early elimination. Two conclusions can be drawn from this: First, participation in a science Olympiad or any other competitive and inquiry-based nonformal learning opportunity may enhance students' understanding of the skills required in science professions, which can be a valuable complement to other career-based scenarios used in formal education (see Drymiotou et al., 2021). However, our second conclusion is that students participate on different bases and do not all benefit equally from participation. Other nonformal science learning opportunities, such as student science clubs, can facilitate a similarly authentic engagement with science, but are also less competitive, making them a potentially more positive experience for a broader audience.

7 | CONCLUSIONS AND IMPLICATIONS

Although a positive relationship has been found between participation in science competitions and the development of participants' career aspirations, little research has been conducted on the effects of early elimination on participants' study and career values and success expectations. Our study challenges this by being the first to link participants' study and career task value and expectancy depending on competition goals and their success and failure in the competition.

This study has yielded three major findings. First, we found that participants' study and career task values remained stable from the first to the second round of competition, independent of success or failure. Second, expectancy of success in study and career developed positively from the first to the second round of competition. Third, we established that early elimination interfered with the development of the expectancy of success in studies and career paths of participants who placed great importance on being successful in the competition. From these findings we were able to draw two major conclusions. First, science competitions can be programs for fostering students in STEM pathways, assuming they are further developed to provide participants in the earlier competition rounds with explicit activities for the development of values, expectations, and peer networking. Second, failure in science competitions can become an acknowledged part of learning by providing participants with individualized feedback and integrated task orientation and growth mindset exercises. We will further elaborate on these conclusions in the next two sections.

7.1 | Science competitions as programs for fostering students in STEM pathways

Our first finding shows no connection between participation in a science competition (independent of success or failure) and the development of study and career task value, which we found discouraging. In recent years, science competitions have developed themselves to expand their focus on motivating and encouraging interested but not necessarily high-achieving students to pursue a science career. Since values and expectancies are positively linked to study and career aspirations (Eccles, 2009; Lauermann et al., 2017; Wang & Eccles, 2013; Wigfield & Eccles, 2002), a development of those values and expectancies is believed to positively influence study and career aspirations. Although our findings show that task value was not negatively affected by participation in the competition (independent of success or failure), there was no positive development either. Therefore, we appeal to science competition managements to reflect on their measures and to think about ways to more directly address participants' study and career values, especially in earlier competition rounds. Finding ways to incorporate value interventions such as the one designed by Rozek et al. (2017) into science competitions could be an effective and enriching way to encourage participants' career pursuits independent of success or failure. Another great potential for science competitions to expand their horizons beyond "simply being a competition" is to integrate values affirmation exercises such as the one developed by Turetsky et al. (2020), which was found to strengthen social peer networks and thus stimulate science persistence.

Even though our second finding regarding the positive development of expectancy of success implies the positive impact of science competitions on participating students, we still view this finding critically. Since we also found that eliminated participants who had placed high importance on the competition had less benefits (in the form of expectancy-development) compared to successful participants and those who were eliminated but considered the competition less important, we do wonder about the effects of elimination throughout the entire competition. This finding amounts to the fact that in the first round alone we found an interference with expectancy-development in half of the eliminated participants. In other words, those participants' study and career expectancies were boosted, but not to the same extent as for the rest of the participants. In fact, our finding lays bare how science competitions (unconsciously and presumably unintentionally) discriminate against less successful participants: the group of participants who presumably needs the biggest push. Again, we suggest an expansion of the program so that science competitions can be truly inclusive and achieve their overarching goals for each participant independent of their success. A combined expectancy-value intervention as created by Hecht et al. (2019) could be an excellent approach to achieve these goals, since this intervention combines success expectations at the start of the program with sustainable long-term science persistence.

We do not know in what way success or failure in the competition affects the career aspirations of participants after the second round of competition. We do know however, that at the end of each national science Olympiad, only four to six participants are selected for the national team, and are thus considered winners (although they will advance to an international competition in which they may still experience failure). This means that of the 1913 students who took part in the German Biology Olympiad in 2017, 1909 did not win. As participants progress through a competition, we expect them to develop a greater importance for the competition. Extending this thought would mean that elimination in later rounds could have a more negative effect on expectations than at the beginning of the competition. We therefore propose further (quantitative) research to better understand the development of expectancy in the higher rounds of competition. Furthermore, we suggest additional research studying the effects on students participating in more than one science competition, and thus experiencing multiple successes and failures, as well as the effects of success and failure in other science competitions besides the Biology Olympiad and in other countries besides Germany.

7.2 | The role of feedback in science competitions

In a study by Simpson and Maltese (2017), specific support received after an unsuccessful event was shown to be critical in shaping subsequent academic and career paths. Regarding the after-care for participants in out-of-school programs such as science competitions, our study points toward the crucial role of feedback and support, especially for those who place great importance on their participation. Instead of the potential negative effects, as indicated by our findings, science competitions have the potential to be the fostering experiences they aim to be by incorporating social support and encouragement from teachers and parents to positively influence students' science career expectations (e.g., Perry et al., 2010; Vedder-Weiss & Fortus, 2013).

Generally, in terms of education, both success and failure are acknowledged parts of learning. Such a realistic attitude may be particularly important in view of a future career in science, in which professional scientists often employ the method of trial and error in their search for scientific knowledge. The results of a study among STEM professionals by Simpson and Maltese (2017), for example, showed that experiences of failure shaped participants' views of failure in general (e.g., framing it as possibility). By extension, these experiences also constituted participants' trajectory within STEM and provided additional skills, which lead to the conclusion that participants "attributed at least part of their success as a STEM professional to their experiences with failures" (p. 233). Nonetheless, as suggested by Ellis et al. (2006), in case of both successful and failed events, it is central that some kind of performance feedback is issued to enable performance improvements. In the context of science Olympiads, however, there is neither a possibility to review one's work nor is it understood as an iterative process. Participating in the first round of such competition does therefore not provide an opportunity for "productive failure" (Kapur, 2008) and the learning and developmental effects might be very limited. As more and more science competitions transition to online procedures (accelerated by the COVID-19 pandemic), providing ways for personalized online feedback to students and their teachers may be within reach. Moreover, as understood from competitive sport contexts, task orientation and a growth mindset strongly relate to more positive reactions to success and failure (Potgier & Steyn, 2010). We therefore also see increasing potential in integrating online task orientation and growth mindset exercises (Law et al., 2021; Lee et al., 2021) as part of the competition. These suggestions may provide science Olympiads and other competitive science programs with the tools to create an inclusive and supportive environment for both winners and "losers," so that in the future, participating truly becomes more important than winning.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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