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Academic self-concept of gifted and nongifted biology students: indications for domain-specific gifted education

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Structured Abstract

Background: It has been commonly accepted that gifted students show a high academic self-concept due to their high academic performance in school without considering the exact kind or domain of giftedness. Most existing studies in this field focus on global conceptions of intellectual giftedness, which disregard the variability of different gifts and talents. Furthermore, it is questionable to what extend we can adopt existing findings on the self-concept development in science subjects (Jansen et al., 2014) on gifted students and use it for their fostering.

Purpose: The aim of this study was to investigate the academic and subject-related self-concept of gifted students in the subject biology to fill the gaps in self-concept research on domain-specific gifted students and draw conclusions regarding their education and preparation for their professional life. Enrichment programmes could benefit from this study and design their teaching concepts according to the results.

Sample/Setting: A total of N = 418 students from German elementary and secondary schools participated (4th to 7th grade; mean age = 10.68 years; 40.0% female). The selection process of the experimental group was part of an enrichment program to foster gifted students in biology and was based on two phases. At first, teachers from 83 cooperating schools nominated potential gifted biology students to participate in the program. In the second step, the nominated students completed a numeric and figurative thinking skills test (KFT-12-R; Heller & Perleth, 2000). The final experimental group consisted of n_1 = 209 students. The control group was composed from the remaining, not-nominated students from the selection process (n_2 = 209).

Design and Methods: In a quantitative cross-sectional study, the academic self-concepts referring to different reference norms (ASC) and school subjects (SRSC) were investigated to compare gifted and non-gifted students in biology using the Academic Self-Concept-Scales (SESSKO; Schöne et al, 2012) and the German Differential Scholastic Self-Concept Grid (DISK-Grid; Rost et al., 2007). Both of these instruments showed good to excellent reliability estimates across all subscales. The data was analyzed using a multivariate analysis of variance (MANOVA) in the first step, followed by a descriptive discriminant analysis (DDA).

Results: Results showed gifted students to score significantly higher values for ASC and SRSC in every measured subscale. The social reference norm and school subject mathematics contributed highest to given group differences, followed by biology and german. Significant grade level effects on gifted students' ASC were observed. The 4th grade scored significantly higher values in every ASC reference norm and the individual norm contributed most to given group differences.

Conclusions: Gifted education in biology, both inside and outside school, should use appropriate methods regarding the important reference norms for gifted students in biology. Social comparisons are most important to gifted students in this study, so teachers must be aware of that and adapt their style of teaching to offer situations and chances for gifted students to develop a high but realistic self-concept, get in touch with equally performing peers early, and build up coping strategies in these situations to prevent negative effects of a possible big-fish-little-pond effect (BFLPE; Marsh et al., 1986) in their school / professional career. We need further investigation on how important subject-related self-concepts and actual performances in math are for the expression of giftedness in biology. Possible impacts of the transition from primary to secondary schools and changing the curricula for gifted students in biology, should be considered, as well as possible impacts of the attendance to enrichment programs on students' ASC. Subsequent studies should aim to use matched samples and more objective diagnostical test measures, beyond self-assessments, to compare and identify gifted students in biology from different age groups. Applicable instruments and educational methods for teachers, should be developed to improve and objectify nomination processes in gifted education.

Keywords: *gifted education, subject-specific giftedness, giftedness in biology, STEM, academic self-concept, subject-related self-concept.*

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1 Introduction

Research on academic self-concept (ASC) receives a great deal of attention in general educational science and giftedness research (Peperkorn & Wegner, 2020), as it is named as one of the most important motivational factors in educational psychology (Jansen et al., 2014). A high ASC leads to higher effort, attainment, and academic and professional career ambitions (Guay et al., 2004; Nagengast & Marsh, 2012; Wigfield & Eccles, 2000). Based on the works of Shavelson et al. (1976) and Marsh and Shavelson (1985), numerous studies concluded that student academic achievement is positively correlated to self-concept (Guay et al., 2003; Hansford & Hattie, 1982; Marsh & Yeung, 1997). Jansen et al. (2014) showed that subject-specific measures of self-concept are better predictors of the factors mentioned above than general measures of self-concept and point out that students distinguish their perception of abilities between different science subjects. Furthermore, "the self-concepts in biology, chemistry and physics should not only be distinguished in theoretical models of academic self-concept but also behave differently empirically as shown in their subject-specific relations to achievement measures" (Jansen et al., 2014, p. 19). In the course of the classification of the science subjects in the I/E-Model (Marsh, 1986) students' self-concept in biology clearly differs from the self-concepts in chemistry and physics, as it correlates equally with verbal and mathematical achievement, measured by grades and achievement tests (Jansen et al., 2015). Hence, a multidimensional consideration of the self-concepts in different science subjects should be applied (Jansen et al., 2014; Urhahne & Hopf, 2004). Although Plucker and Stocking (2001) confirm for gifted adolescents that academic self-concept correlates with academic achievement in one specific subject, they suggest that educators should view gifted students from a multifaceted perspective. Furthermore, other studies point out the "uniqueness of gifted students" (Chang & Lin, 2017, p. 3996) and show that their self-concept could not be transferred equally to the I/E-Model (Skaalvik & Rankin, 1992). Following that, it is highly questionable, if the multidimensional view on the self-concepts in science subjects (Jansen et al., 2014) can be adopted for the fostering of gifted students. To be able to use the mentioned benefits of self-concept development for gifted students, foster their interest in science domains, and best encourage them to use their talents in scientific professions later on, we need more research on their subject-related self-concepts (SRSC). Additionally, this could add helpful information for the development of domain-specific conceptions of giftedness (iPEGE, 2014; Olszewski-Kubilius & Thompson, 2015) and knowledge about the unique characteristics of gifted students (Van Tassel-Baska, 2005). To date there are no studies examining the specialties in the self-concept of domain-specific gifted students in biology (Peperkorn & Wegner, 2020). Accordingly, in this study, we used widely differentiated test instruments (Schöne et al., 2012; Rost et al., 2007) to examine the global ASC and SRSC in domain-specific gifted biology students. The current state of research about ASC leads us to ask how domain-specific gifted students score in ASC and different SRSCs and what effects different reference norms have. The results may provide insights for the development of special educational concepts and enrichment programmes for gifted students in biology.

2 Research Background

2.1 Academic self-concept and achievement

The multidimensional, hierarchical model developed by Shavelson et al. (1976) states that self-concept describes a person's self-perceptions, which arise through collected experiences and their own interpretation of the environment. The construct describes internal and external comparisons (Marsh, 1986). Marsh and Shavelson (1985) built upon this understanding of self-concept and highlighted the multidimensionality of self-concepts. They stated that a global self-concept (often equated with *self-esteem* (Marsh & Craven, 1996)) is not a strong determinant in relation to specific domain self-concepts. They revised the original model and included verbal and mathematical self-concept, as well as a wider variety of specific academic facets. In ongoing research, it was added that ASC should be examined in specific school subjects, and that a simple investigation of 'global' ASC would ignore the complexity of a student's self-perceptions (Marsh, 1990).

In other words, the self-concept comprises all cognitive representations of one's own abilities in academic performance situations (Schöne et al., 2012). Although these representations have cognitive and affective components (Bong & Clark, 1999), it has been suggested to exclude the affective component as it is a lurking factor that simply describes the emotional outcome of cognitive representations (Arens et al., 2011; Schöne et al., 2012). Furthermore, even though both components correlate with general school competence (Marsh et al., 1999), performance components are better correlated (Helmke, 1992). Various studies demonstrate that self-concept descriptions are either absolute ("I am talented.") or related to a frame of reference ("I am more talented than …"; Möller et al., 2009; Skaalvik, 1997; Skaalvik & Skaalvik, 2002; 2004; but see Bong, 1998). Schöne et al. (2003) identified four different reference norms on which people base their self-concept: absolute, social, individual, and criteria-based. High performance does not ultimately correlate with high self-concept, instead, a person must be able to perceive and evaluate their performance in order to develop a self-concept. The social reference norm describes comparisons with fellow classmates or other relevant persons. It is suspected that students "assimilate their self-perceptions into the context in which they are placed (either basking in glory or suffering from labeling)" (Skaalvik & Skaalvik, 2002). This theory, better known as the "big-fish-little-pond effect" (BFLPE; Marsh et al., 1986; Marsh & Parker, 1984), shows that even in the case of similar individual performance, a higher average performance in a learning group decreases an individual's ASC, because upward comparisons in high-ability groups are more likely than downward ones (Marsh & Hau, 2003). On the other side, a lower school-average achievement increases student's ASC. Furthermore, students compare their current academic achievement to their past one, which is described by the individual reference norm. If they perceive their current achievement as higher than in the past, individual ASC increases (Schöne et al., 2012). Criteria-based reference norms influence how a person evaluates achievements compared to institutional requirements, such as curricular learning goals (Rheinberg, 2014; Schöne et al., 2003).

Many studies assume that academic achievement positively correlates with ASC and vice versa (self-enhancement model / skill-development model, e.g., Guay et al., 2003; Hansford & Hattie, 1982; Marsh & Craven, 1996; Marsh & Yeung, 1997). It has been suggested that both ASC determines performance, and that performance determines ASC (Helmke & van Aken, 1995; Köller et al., 1999). Regarding gifted students, it is important to investigate how self-concept influences and is influenced by their potential academic achievement, as well as its effects on behaviour.

2.2 Positive influences of a high ASC on academic behaviour

The consideration of the ASC offers important insights for the development of educational concepts. ASC has a positive impact on motivational factors such as *interest, performance expectancy, task effort,* and *dealing with failure* (Meyer, 1987; Schöne et al. 2012; Viljaranta et al., 2014). The subjective probability of success is composed of task difficulty, self-concept and intended effort (Meyer, 1980; Reinhard & Dickhäuser, 2009). When confronted with a similar task difficulty, students with a high initial task effort will have higher *performance expectancies,* however, this also depends on their self-concept (Schöne et al., 2012). Furthermore, students with high academic self-concepts are more likely to attribute their success to their high ability, so they tend to self-enhancing attributions that have a positive influence on their motivation and academic achievement (Lohbeck et al., 2017). Eccles et al. (1985) model of achievement choice implies that performance expectancies influence students' electoral behaviour, i.e., what academic profile they choose (e.g., science, languages, or arts). Going along with this, a higher self-concept in specific subjects makes students more likely to choose this subject in their future school career (Dickhäuser & Stiensmeier-Pelster, 2002). If gifted students in biology show a high ASC, this might be a good precondition for them to make use of their talent in their professional life and become a high-quality workforce in the STEM[1] sector.

2.3 Gifted Students' academic self-concept

Following the reciprocal theory of ASC, a high academic performance observed in gifted science students should ensure a high ASC (Hoge & Renzulli, 1993; McCoach & Siegle, 2003; Preckel et al., 2017). However, since the relationship of academic achievement and ASC is complex, there might be a certain "uniqueness of gifted students" (Chang & Lin, 2017, p. 3996). Studies on gifted students could not transfer the internal/external frame of references model to describe this general relationship (Skaalvik & Rankin, 1992). For example, a gifted student with a high ASC in a scientific subject may exhibit a low ASC in a verbal subject. The assumption that gifted students´ ASC is generally high cannot be maintained and associations to certain domains or school subjects are required (Peperkorn & Wegner, 2020; Plucker & Stocking, 2001). Even if a gifted student's ASC is higher than the ASC of a nongifted student, we need more information about important reference norms and how gifted students individually weigh them in self-concept development. Furthermore, there are gender (Gallagher & Kaufman, 2005; Preckel et al., 2008; Stoeger, 2004) and age (Rudasill et al., 2009; Shi et al., 2008) differences in gifted students' ASC. Since there is no consensus about the influences of gender or age, they must be considered in terms of domain-specific giftedness.

2.4 Giftedness in biology

Many studies in the field of gifted education base their research on general intelligence by using standardized measures to test intelligence and form experimental groups. There are understandable reasons as to why general intelligence should be used as a key factor to determine giftedness (Warne, 2016). According to iPEGE, giftedness is generally defined as the overall ability to perform. "More specifically, giftedness refers to the respective individual level of development of performance-related potential, i.e., those prerequisites what, with appropriate disposition and long-term, systematic stimulation, support, and encouragement, enable the individual to act in a meaningful and responsible manner and to perform demanding activities in areas what are considered valuable in the respective culture." (iPEGE, 2009, p. 17).

However, giftedness should not simply be tied to intelligence but other facets, such as the willingness to perform, interest, discipline, self-confidence, self-control abilities, and creativity (iPEGE, 2009; Renzulli, 1999). Abstract analytical cognitive skills measured by standardized tests are completely different from the skillsets needed to succeed in different subject domains (Sternberg, 2018).

To provide a differentiated promotion for gifted students in STEM subjects, we need a domain-specific conception of giftedness in biology that includes knowledge about intellectual abilities, specific academic abilities, task commitment,

[1] Science, technology, engineering, and mathematics.

and creativity (Renzulli & Reis, 2021; Van Tassel-Baska, 2005). Based on previous assumptions, Wegner (2014) developed a differentiated concept for giftedness in biology, which is composed of various aspects such as creativity, work discipline, social competence, self-control, self-confidence, scientific interest and self-concept. These must all be developed to a certain degree to define a student as gifted in biology (Wegner, 2014), but one study about all these aspects would go beyond a reasonable scope. As already mentioned, within giftedness research the investigation of self-concepts offers valuable information for the development of enrichment interventions, as it has high influences on motivation, effort, and career decisions (Guay et al., 2004; Nagengast & Marsh, 2012; Wigfield & Eccles, 2000). To build upon this, Sternberg and Davidson (2005) described that gifted students in STEM are even more variable in their abilities than gifted students in other domains. It appears that gifted students in STEM are extremely competent in identifying and solving problems and have a high interest in natural phenomena (Karnes & Riley, 2005; Olszewski-Kubilius & Thompson, 2015). If this assumption is transferred to biology classes, giftedness can express itself through a quick perception of scientific content, the correct use of technical terms, and/or the early attainment of formal operational thinking (Wegner, 2014). Sternberg (2018) further described that the direct measurement of skills in actual scientific work seems to offer a better way to identify gifted students in STEM than a measured IQ. According to domain-specific giftedness in STEM, he described skills like generating hypotheses, generating experiments, and drawing conclusions (Sternberg, 2018). How cognitive and non-cognitive traits are structured to display these abilities and how these could be implicated in future promotion-based programs has not yet been examined in detail.

To foster giftedness in STEM subjects, experience-based methods with aspects of practical scientific work are promising (Ulger & Çepni, 2020). Exemplary methods are: Inquiry-based learning (Bell et al., 2010), problem-based curricula, and phenomena-orientated working (Wegner et al., 2013). Most existing promotional concepts are structured through the five main phases consisting of: Orientation, conceptualization, investigation, conclusion, and discussion (Pedaste et al., 2015).

The purpose of this study is to shed light on one important aspect of (domain-specific) giftedness, to bridge the research gap in studying domain-specific gifted students' ASC in biology. Therefore, we examined gifted students global ASC in order to record effects of different reference norms in school and SRSC to enable a comprehensive view on gifted students' self-concept, which may help to improve current educational concepts, and further develop the conception of giftedness in biology. As a consequence, we investigated the following two research questions:

RQ1: Are there statistically significant differences in the ASC or SRSC between the experimental and the control group?

RQ2: Do gender and/or grade level have a main effect on ASC and / or SRSC of the experimental group?

3 Methods

3.1 Research model

To examine ASC in gifted biology students we used a cross-sectional quantitative research design with a paper and pencil survey[2]. The experimental group completed the survey during a meeting at Bielefeld University, the control group completed the survey at school during a regular lesson. In both cases trained research assistants were on hand to help with possible comprehension difficulties.

3.2 Participants

The sample was composed of N = 418 students between 4th and 7th grade (mean age = 10.68 years, 40.0% female) from different levels of German schools (38.0% attended elementary schools[3], 1.2% attended Realschule[4], 62.7% attended Gymnasium[5]). The nomination process of the experimental group was part of an enrichment program for gifted students in biology, which has a limited capacity due to institutional requirements. The experimental group was composed of n_1 = 209 (35.9% female, 58.3% attended Gymnasium, 2.4 attended Realschule, 38.8% attended elementary school). In the first step 249 students were identified to participate in the enrichment program by teacher nominations from a total of 83 cooperating schools (42 primary schools; 41 secondary schools), including subject-related performance, as well as student interviews to examine their interests and motivation in biology, and via conversations with their parents. An exact number of total students included in the first nomination step was not recorded. Due to institutional requirements and the limited capacities, in the second step, potential participants were tested for their quantitative numeric skills and figurative thinking, as basic skills of science literacy (Klieme et al., 2000), using the *Kognitiver Fähigkeitstest für 4. bis 12. Klassen* (KFT4-12+R; Heller & Perleth, 2000). The control group (n_2 = 209, 35.9%

[2] The specific instruments are explained later in chapter Data Collection Tools.
[3] Elementary schools in Germany are from 1st to 4th grade. During this time, students prepare themselves to qualify for one of the three secondary school forms in this tripartite educational system.
[4] The Realschule represents the second highest school form in the German tripartite educational system.
[5] The Gymnasium represents the highest school form in the German tripartite educational system. Graduating from this school type and obtaining the Abitur (German high school diploma) enables students to study at university.

female, 56.9% attended Gymnasium, 32.7% attended elementary school) was selected randomly from the not nominated students from the same classes as the experimental group to omit differences in socio-cultural background and school career. Parental consent was obtained from all participants. All students participated voluntarily and could quit the survey whenever they wanted. Data was obtained pseudonymized by using codes. Nominated students who refused to participate in the second-step testing, were excluded from the study.

3.3 Data Collection Tools

3.3.1 Academic self-concept

ASC was measured using several Academic Self-Concept-Scales (SESSKO), developed by Schöne et al. (2012). The instrument consists of 4 different subscales (Cronbach's α = .87 - .93): *social ASC* (comparisons to classmates), *individual ASC* (comparisons to oneself in the past), *criteria-based ASC* (comparisons to institutional requirements), and *absolute ASC* (no reference frame), which allows an explicit measurement of the effects of different reference norms.

3.3.2 Subject-related self-concept

Since ASC must be related to specific school subjects (Marsh, 1990), we used the German Differential Scholastic Self-Concept Grid (DISK-Grid) developed by Rost et al. (2007) to measure students' SRSCs in biology, math and german (Cronbach's α = .90 - .95). The subjects math and german were added to measure a comparable value for verbal and mathematical self-concept (Marsh, 1990), as the self-concept in biology is allocated to both factors (Jansen et al., 2014), but there are no information given to what extent.

3.4 Data Analysis

We computed descriptive statistics (means and standard deviations). To test RQ1 and RQ2, we computed a 2 x 2 x 4 MANOVA[6] (giftedness in biology x sex x grade level) on both the combined subscales of ASC and SRSC. To further interpret the results of the experimental group we conducted post-hoc discriminant analysis on significant outcome variables. Interaction effects of giftedness in biology with gender or grade level were further interpreted by a MANOVA and follow-up discriminant analysis within the experimental group.

4 Results

To answer our research questions, we initially computed means (*M*) and standard deviations (*SD*) for giftedness, gender, and grade level. The mean scores of the experimental group were higher in every ASC subscale and all SRSCs than the mean scores of the control group (Tab. 1). For more detailed descriptive statistics sorted by gender and grade level see Table 1. The MANOVA on ASC showed statistically significant effects for giftedness and grade level. Gender had no effect on ASC (Tab. 2.). Additionally, we observed a significant interaction effect between giftedness and grade level in ASC. No other interaction effects were found (Tab. 2). The MANOVA on SRSC showed statistically significant main effects for every tested variable. We observed no interaction effects in SRSC between any tested variables (Tab. 2). As the design of the study did not focus on gender differences, no further analyses were conducted in this direction. To further investigate the effect of giftedness on ASC and SRSC subscales both conducted MANOVAs were followed up with discriminant function analysis. This method allows us to break down the linear combination of our MANOVA in more detail, using different predictors, and find out what factors really distinguish our different groups (Field, 2018). The discriminant analysis in SRSC revealed a discriminant function, which was statistically significant, Wilk's Λ = .79, χ^2 (3) = 87.55, p < .001, canonical R^2 = .21. The correlations between SRSCs and the discriminant function revealed that math loaded highest on the function (r = .87), followed by biology (r = .75) and german (r = .59).

[6] Multivariate analysis of variance.

Table 1. Means (M) and standard deviations (SD) of ASC and SRSC subscales for giftedness, gender, and grade level (N = 418).

Scales	ASC								SRSC					
	social		individual		criteria-based		absolute		biology		math		german	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
giftedness status														
experimental	4.05	.65	4.03	.68	4.30	.58	4.33	.58	5.05	.90	5.08	1.00	4.65	1.01
control	3.44	.64	3.72	.75	3.79	.67	3.81	.68	4.30	1.03	4.07	1.22	4.04	1.02
gender														
female	3.64	.69	3.82	.69	3.95	.71	4.02	.68	4.43	1.04	4.10	1.32	4.33	1.02
male	3.82	.71	3.91	.76	4.11	.65	4.11	.68	4.79	1.02	4.81	1.09	4.32	1.08
grade level														
4th grade	3.92	.77	4.19	.69	4.16	.76	4.27	.75	4.64	1.05	4.70	1.29	4.55	1.08
5th grade	3.74	.57	3.89	.60	4.14	.52	4.14	.56	4.79	.92	4.44	1.15	4.15	1.06
6th grade	3.80	.68	3.69	.70	4.07	.61	4.07	.60	4.94	.94	4.70	1.13	4.32	.98
7th grade	3.41	.61	3.54	.72	3.75	.61	3.71	.58	4.23	1.11	4.08	1.16	4.01	.99

Note. ASC: Academic self-concept; SRSC: Subject-related self-concept.

Table 2. Multivariate tests for ASC and SRSC (N = 418).

Scales	Effect	Λ	*F*	*df 1*	*df 2*	*p*	η2
ASC	giftedness	.90	10.59	4.00	389.00	< .001	.10
	gender	.98	1.99	4.00	389.00	.095	.02
	grade level	.87	4.51	12.00	1029.49	< .001	.04
	giftedness x gender	.99	.882	4.00	389.00	.475	.01
	giftedness x grade level	.95	1.80	12.00	1029.49	<.05	.02
	gender x grade level	.97	.99	12.00	1029.49	.452	.01
	giftedness x gender x grade level	.02	.75	12.00	1173.00	.700	.01
SRSC	giftedness	.93	9.33	3.00	355.00	< .001	.07
	gender	.92	9.84	3.00	355.00	< .001	.08
	grade level	.92	3.57	9.00	864.13	< .001	.03
	giftedness x gender	.99	1.49	3.00	355.00	.216	.01
	giftedness x grade level	.96	1.46	9.00	864.13	.158	.01
	gender x grade level	.98	1.01	9.00	864.13	.430	.01
	giftedness x gender x grade level	.98	.87	9.00	864.13	.552	.01

Note. ASC: Academic self-concept; SRSC: Subject-related self-concept.

Following that, we conducted discriminant analysis, which revealed three discriminant functions. The first explained 76.4 % of the variance, canonical R^2 = .16, the second explained 18.5 % of the variance, canonical R^2 = .05, and the third explained 5.1 % of the variance, canonical R^2 = .02. In combination these discriminant functions significantly differentiated between grade levels, Wilk's Λ = .79, χ^2 (12) = 48.67, p < .001, but removing the first function indicated that the combined second and third functions, Wilk's Λ = .94, χ^2 (6) = 12.11, p = .059, did not significantly differentiate between grade levels. Removing the first and second function indicated that the third function, Wilk's Λ = .99, χ^2 (2) = 2.65, p = .266, did not significantly differentiate between grade levels as well. We will not further interpret the third function separately, due to its low percentage of explanation. The correlations between ASC subscales and the discriminant functions revealed that individual ASC loaded highest on the first function (r = .87), followed by absolute (r = .80). Criteria-based (r = .58) and social ASC (r = .56) loaded lower on the first function. With regard to the second function social ASC (r = .73) loaded highest, followed by absolute (r = .42), individual (r = -

.29), and criteria-based ASC ($r = .28$). The discriminant function plot (Fig. 1) showed that the first function discriminated the 4th grade from the 5th, 6th, and 7th grade, and the second the 6th grade from the 4th, 5th, and 7th grade.

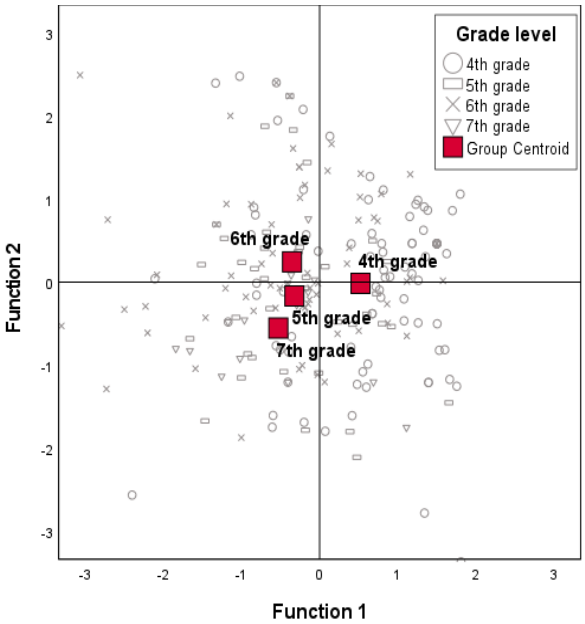

Fig. 1. Discriminant analysis combined groups plot of grade levels within the experimental group.

Note. This graph plots the variate scores for each person, grouped according to the experimental condition to which that person belonged. In addition, the group centroids (unstandardized canonical discriminant functions evaluated at group means) are shown as red squares.

5 Discussions and conclusions

To the best of our knowledge, there are no studies investigating ASC and SRSCs of domain-specific gifted students in biology. Furthermore, existing research was mainly focused on intellectual giftedness and based its conception on measured IQ scores. In this study, we used a twostep identification process with teacher nominations in the first step and a test on quantitative numeric skills and figurative thinking in the second step to identify gifted students in biology.

5.1 Differences in ASC and SRSC between gifted and nongifted students

Our experimental group showed significantly higher values in all ASC subscales than the control group. Gifted students in biology seem to perceive their school performance as higher than that of the control group, going along with previous findings (for a review, see Peperkorn & Wegner, 2020). As we investigated a domain-specific giftedness, it seems reasonable that good performance in biology led to a higher ASC (Plucker & Stocking, 2001). To further investigate what reference norms or subjects lead to the group differences in ASC between the experimental and control group, we conducted discriminant function analysis. The significant discriminant function revealed that social ASC had the highest impact on group differences in giftedness. Comparisons to other students seem to play an important role for a gifted biology student's development of self-concept (Huguet et al., 2009). As we want students to use their gifts and talents meaningfully in later life for the benefit of society (iPEGE, 2009), we must maintain their high self-concept, because this is an important predictor for success and electoral behaviour in later professional life (Judge et al., 1998). When we look at gifted education in STEM, actual scientific work, during which communicative and social coping skills are required and special attention is given to discussions and presentations (Wegner et al., 2013; Bell et al., 2010; Pedaste et al., 2015), seems to offer a good frame for gifted students to maintain their self-concept. Therefore, enrichment programs for gifted students in biology can offer a protected environment where students can work with equally competent peers. These experiences might counteract a BFLPE (Marsh & Parker, 1984), which can lead to negative effects on gifted students' ASC during their school and professional career, because they carefully get in touch with high-performing reference groups. There are no indications that gifted students could not benefit from social interaction in class to the same amount as grade-equivalent students, as several studies found out that interpersonal abilities, empathy, social skills, and adaptive behaviour of gifted students are comparable to same-age nongifted peers (Assouline & Colangelo, 2006; Lee et al., 2012; Shechtman & Silektor, 2012). Following that, additional lessons in enrichment programs can also lead to positive assimilation effects on gifted students ASC, because they can orientate themselves to equally performing and same-age role models. We also observed a strong impact of criteria-based ASC on the group differences regarding giftedness. Academic criteria like tests or marks help students perceive their own performance much easier. The results suggest that the high self-concept of gifted students in biology is partly based on this feedback. When we look at gifted programs, tests or other exam situations do not play a superior role. Nevertheless, we need to consider situations in which gifted students submit or present possible research projects to experts or other instances, which sometimes comes close to exam situations. Failure is a key-part of scientific work; support should be offered to enable gifted students to deal with possible failure and still profit from it. Otherwise, those failures might lead to a breakdown in self-concept and a loss of task commitment or motivation. As such situations, in which gifted students are overwhelmed by certain tasks should be avoided and possible failures should be counteracted with "reality checks" to keep their ASC in balance. The high impact of the subscale absolute ASC, which tells us how students evaluate their performances without referring to a specific reference or comparison, at first glance supports the theory that high performances in one special area influence the general understanding of one's academic capability (Plucker & Stocking, 2001). However, due to our limited selection process, we do not know if high achievements or skills in other domains contribute to the measured values. Thus, our results only provide a first indication which needs further elaboration. Nevertheless, gifted education should help gifted students benefit from their skills, creativity and task commitment within special domains and use these capabilities in other facets of life. Finally, the individual ASC had the lowest effect on the group differences. In other words, we could observe that when it comes to internal comparisons, gifted students differ less from nongifted students. Regarding how gifted students perceive their current performance compared to past performances, promotional programs should offer opportunities for objective comparisons. Possible references to past performances in biology could be previously written research documentations or diaries about their learning process.

Methods in domain specific gifted education should maintain students' high ASC. Positively perceived performances in biology might encourage gifted students to benefit from their talents and choose a professional career in this sector (Dickhäuser & Stiensmeier-Pelster, 2002; Freedman-Doan et al., 2000).

The interaction effect between giftedness and grade level led us to further analyses within the experimental group. The additional MANOVA revealed a significant effect of grade level on ASC within the experimental group. The conducted discriminant analysis showed that the significant first function discriminated gifted 4th graders strongly from 5th, 6th, and 7th graders. In this discriminant function, individual ASC had the highest impact on distinguishing between grade levels. It seems that the gifted 4th graders have a higher ASC than any other grades, maybe because they are not faced by problems in learning or difficult academic contents. We suggest that transferring to secondary school has a high impact on the gifted biology students as well as nongifted students, going along with previous findings (Marsh & Craven, 2002). Since individual ASC reflects comparisons to one's own performance in the past, the transition to the Gymnasium could negatively influence students' self-concept because of changing requirements, more difficult contents, and less learning success (Köller et al, 2006; Marsh & Hau, 2003). Furthermore, 4th graders in Germany oftentimes do not receive marks in (elementary) school, which offers the students fewer objective references for self-concept constructions (Gniewosz et al., 2012). Gifted education should pay attention to these differences and offer grade-adapted learning situations. The second discriminant function was not significant and explained a lower percentage of the observed differences between grade levels. Nevertheless, the second function discriminated 6th graders from 4th, 5th, and 7th graders. In this function, social ASC had the highest effect on group differences and 6th graders showed second highest values. We observed social ASC to decrease from 4th to 5th grade, increase from 5th to 6th grade and decrease again from 6th to 7th grade. The second function is probably due to elective options in German schools, where students can choose academic profiles with a scientific, artistic, or linguistic focus. Both, the transition to secondary school and further profile elections seem to cause ability grouping effects (Aust et al., 2010; Ireson et al., 2010) or BFLPE (Marsh & Parker, 1984), which affects gifted students' ASC as well. As there are enrichment programs in which a learning group consists of students from several grade levels, such programs need to offer differentiated tasks to address every student, avoid negative impacts on their ASC, and may mitigate the observed transition effects. Practical scientific work and self-selected topics might offer a useful method for individual learning (Bell at al., 2010, Wegner et al., 2013). Furthermore, enrichment programs should consider what compositions of age groups are most beneficial for every student.

Since ASC cannot be interpreted exclusively and must be linked to specific subjects (Marsh, 1990; Schöne et al., 2012), we additionally examined SRSCs in biology, math, and german. Moreover, because of the unique structure of gifted students' self-concepts (Chang & Lin, 2017; Skaalvik & Rankin, 1992), it is questionable if they also distinguish between different science subjects when it comes to the perception of ability. The experimental group showed significantly higher values in every measured SRSC, going along with our results about general ASC. In our conducted discriminant analysis, we examined that SRSC math had the highest impact on distinguishing between gifted and nongifted students. This outcome was rather surprising, as gifted students were chosen based on their performances in biology in the first place. Jansen et al. (2015) in their study on a general sample of students showed, that mathematical and verbal achievement equally correlated with self-concept in biology. The differences in our results raise the question, to what extent mathematical skills are crucial for the expression of giftedness in biology. Nevertheless, our results must be interpreted with care, as our additional screening aims for numeric and figurative thinking skills. This probably influenced our results and students with a high achievement in mathematics could have been in favour during the selection process. Furthermore, teachers' nominations could be influences by students' skills in math because the selecting teachers might think of it as an important part of scientific work and followed a more holistic view. Additionally, we need to review teacher nominations, and examine which focusses they set consciously or unconsciously in terms of gifted identifica-

tion. Therefore, the offered initial training on giftedness in biology must be reviewed and standardized avoiding influences of different teacher views. We have no information about SRSCs in other (scientific) subjects, so a high ASC could be due to high performance in several subjects and not only based on biology, math and german. With our study we were not able to add to previous findings on the multidimensional approach about self-concept in science subjects (Jansen et al., 2014). Nevertheless, it seems reasonable for subject-specific educational concepts to consider self-concepts in different subjects to develop a holistic and individual promotion. Since scientific work follows similar steps and requires similar skills in different fields of STEM, applying this to other subjects could be advantageous as well. This might help students maintain their ASC and develop a balanced and healthy self-reflection, which was expected to lead to well-being in later life (Robins & Beer, 2001).
There were no interaction effects found between giftedness and gender or grade level in SRSC. However, the main effects of gender and grade level on SRSCs support previous findings (Gallagher & Kaufmann, 2005; Preckel et al., 2008; Rudasill et al., 2009; Shi et al., 2008; Ziegler, 2004). Gender differences and influences of grade level on students' SRSCs should be further investigated to offer individualized promotional concepts.

5.2 Limitations

Our study has limitations that must be considered when interpreting our results. With our understanding of giftedness in biology we tried to follow Renzulli and Reis (2021) explanations and go beyond an entity-orientated approach. To the best of our knowledge there is no standardized test or screening tool to identify gifted students in biology. One may argue that our additional testing using the KFT4-12+R (Heller & Perleth, 2000) falls into this category, but we want to outline that students' scores were calculated in relation to the whole sample and no standardized cut-off scores were used to identify the experimental group. Furthermore, the KFT4-12+R measures skills important for academic performance and learning, rather than intelligence-scores (Euen, 2015; Rindermann, 2006). In the presented identification process of the experimental group the parts on quantitative numeric skills and figurative thinking of the KFT4-12+R were used, because they reflect basic skills of scientific literacy (Klieme et al., 2000), which is seen as a main indicator for giftedness in biology (Sternberg, 2018). Nevertheless, influences on our results must be assumed. Especially the results on SRSC must be interpreted with great caution, as the highest load of the subject mathematics on the discriminant function might just reflect the second step of the presented identification process, in which the quantitative numeric skills of the nominated students were tested. Additionally, we must consider that our results are highly dependent on the initial briefing for the involved teachers about giftedness in biology. If they had received different information about or views on giftedness in biology and typical indicators in class in our briefing, they would have eventually nominated different students for participation in the enrichment program. Furthermore, teacher nominations can still be subjectively influenced by aspects such as sympathy, antipathy, marks, and learning group size. Additionally, we cannot exactly know what emphasis teachers put on different factors of giftedness in biology. It is questionable how comprehensively teachers realized our instructions and could free their view from students' academic performances and predominant self-presentations (Hernández-Torrano et al., 2013; Siegle et al., 2010; but see Şahin & Çetinkaya, 2015). It should also be noted that there are different proportions of gender, grade level and school types; for example, in the Gymnasium, gifted underachievers may not be that common as they are less likely to attend this school type (Sparfeldt et al., 2006) and teachers are influenced by different reference groups (Rothenbusch et al., 2016). We also did not provide further differentiation between our experimental groups, as non-nominated students were identified as the control group without further testing. Furthermore, we did not investigate actual performance in biology, math or German, which prevents us from making judgements whether measured self-concepts are realistic or not. Even though our instruments have high internal consistencies and ASC is represented by different subscales, SRSC is still limited to biology, math and German. Finally, we need to consider that the calculated effect sizes for the initial MANOVAs on ASC and SRSC (Table 2), following discriminant analysis, and calculations within the experimental group were moderate to low (Cohen, 1988).

5.3 Conclusions

Our gifted students in biology showed an overall higher ASC and SRSCs than nongifted students, which goes along with previous findings. But the conducted DDA offered more information on what reference norms gifted students in biology set their focus when it comes to self-concept development, which allows us to draw conclusions for their education. Science enrichment programs should enable students to maintain high but realistic self-concepts to guide them to use their talents in later life. Therefore, methods must be sensitized, and teachers need to adapt their style of teaching regarding the important reference norms for gifted students. Results showed that social comparisons are important to the gifted students in this study, which harbours the risk of a BFLPE in their school and / or professional career. Enrichment programs might offer social situations with equally high-performing students and enable experiences and coping strategies, which might prevent gifted students from negative effects on their self-concepts and benefit form positive assimilation effects (Marsh & Hau, 2003). Furthermore, enrichment programs might offer teaching methods where social comparisons are less important, but teamwork and the sense of community is focussed to mitigate the relevance of the social reference norm and additionally prevent negative effects early. Scientific work, during which special attention is given to collaborative working (Wegner et al., 2013; Bell et al., 2010; Pedaste et al., 2015), provides a fruitful frame. We need further investigations on how important SRSC and actual performances in math are for the expression of giftedness in biology an if there are domain-specific differences in positive or negative effects of BFLPE. The identification process generates the problem that the results on ASC and SRSC might just reflect the outcomes of the used parts of the KFT4-12+R. As there is no standardized test or screening tool to identify domain-specific gifted students in biology, this risk is always present when certain matching tests are used. As a consequence, it is urgent, that tests or screening tools are developed aiming for concrete indicator competences of giftedness in biology (Peperkorn & Wegner, 2021; Sternberg, 2018). This might allow us to generate more elaborated findings about the self-concept development of subject-specific gifted students as we could draw connections to their achievement and proof the described multidimensional structure of the self-concept in science subjects (Jansen et al., 2014). Furthermore, differences in self-concept between different science subjects next to biology need to be investigated in gifted students as well to further substantiate the research on the approach of subject-specific giftedness. The examined differences between different grade levels within the experimental group should be assessed in more detail. Possible impacts of the transition from primary to secondary schools and changing curricula on gifted students in biology should be considered as well as possible impacts of the attendance to enrichment programs on students' ASC. Moreover, subsequent studies should aim to use matched samples and more objective diagnostical test measures, beyond self-assessments, to compare and identify gifted students in biology from different age groups. Finally, applicable instruments or educational methods for teachers, should be developed to improve and objectify nomination processes in gifted education.

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