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What Matters for Boys Does Not Necessarily Matter for Girls: Gender-Specific Relations between Perceived Self-Determination, Engagement, and Performance in School Mathematics

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Abstract: While math performance does not seem to differ systematically between males and females, it is one of the subjects that is consistently perceived as "male" with girls regularly reporting lower levels of motivation and less positive attitudes than boys. This study aimed to uncover gender-specific relations between perceived self-determination, engagement, and performance in school mathematics that might help to better understand this discrepancy. In an online study, we hence assessed perceived competence and autonomy support, social relatedness, cognitive and behavioral engagement, math performance as well as sustained attention as a basic cognitive prerequisite in a sample of $N = 221$ Seventh-Grade students from southern Germany ($M_{age} = 12.84$ years, $SD_{age} = 0.55$, $N_{females} = 115$). As expected, we found no gender differences in math performance. In multiple group path analyses, perceived autonomy support was the most consistent predictor of cognitive and behavioral engagement for both girls and boys. While it did not affect math performance directly, we found significant indirect effects via cognitive engagement for girls, and via behavioral engagement for boys, whereas competence support in the math classroom, which female students perceived as significantly lower than male students, negatively predicted only girls' performance, sustained attention explained a considerable part of boys' math performance. Girls seem to experience competence support less often than boys, and if they do, we assume it to be in response to low performance rather than to encourage high competence and nurture talent. Our results suggest promising avenues for future research and implications for math classrooms.

Keywords: math performance; gender differences; engagement; self-determination; teacher support

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1. Introduction

Understanding and explaining gender differences in preferences and performance in STEM fields are complex [1–4]. While researchers still argue about the relative importance of biological and socio-cultural factors, most agree that the STEM gender gap is a product of both nature and nurture [1,3,5–7]. In this study, we focus on the core subject of math, due to its role as a gatekeeper to educational success in many other subjects at school and beyond [8,9]. Although gender disparities in math appear to have decreased in more recent times and can be considered less pronounced than in engineering, physics, or computer science [10,11], math is still perceived as a male subject [12,13] requiring innate talent or brilliance that is stereotypically more strongly attributed to men than to women [14]. Gender-specific nature x nurture-influences in the domain of math seem to be particularly evident in motivational-affective variables such as attitudes, choices, self-concept, or interest that consistently show significant gender differences to the detriment of females [12,15–17]. The results on performance, however, are less consistent. While many studies do not find any gender differences [11,17–19], the direction of effects, if any, also varies across countries (for a cross-national meta-analysis, see [16]; for recent results from China rather indicating a small female advantage, see [20]; for an international perspective based on PISA data, see [21]), and the frequently reported advantage of girls in terms of school grades seems to be smallest or not existing in math [22,23]. Although motivational theories usually posit generally valid causal relations between different motivational-affective constructs and academic performance, research on the existence and extent of gender differences in math motivation, where differences seem to exist, and performance, where girls and boys appear to be more alike than different (or, at least, results show a large variance across studies and nations), indicates that these relations might differ systematically between girls and boys.

Motivation is considered to affect performance via increased engagement [24–26]. In this study, we hence not only analyze whether girls indeed show lower levels of motivation in math classrooms and similar levels of math performance compared to boys, but also investigate whether boys and girls differ in how motivation translates into engagement and math performance. Gender differences in these paths could be part of an explanation for the above-mentioned discrepancy between math motivation and performance among female students. The underlying cognitive capacity to engage, i.e., sustained attention, might also play an important role in predicting girls' and boys' engagement and math performance and is therefore controlled for as well [27,28].

Different from other motivational variables, such as interest or self-concept, that may emerge from diverse internal and external factors [29–31], perceived self-determination during math instruction directly reflects a student's perception of a very specific situation. Perceived self-determination (i.e., perceived competence support, autonomy support, and social relatedness) during math instruction can be expected to immediately affect the energy level in students' behavior and the intensity of their engagement in the math classroom. In the remainder of the introduction, we hence introduce self-determination theory and briefly describe cognitive and behavioral engagement as well as the concept of sustained attention (as control variable), whenever possible focusing on their role in the context of math performance and summarizing the current state of research on gender differences on these variables. Before we present our study, we synthesize research investigating relations between these variables.

1.1. Perceived Support for Self-Determination in the Classroom

Self-determination theory considers the satisfaction of three basic psychological needs—the needs of competence, autonomy, and social relatedness—as an important motive for behavior [32]. In school contexts, perceived self-determination is higher, if a situation is experienced as conducive to need satisfaction [33,34]. One common way to investigate needs satisfaction in the math classroom is by assessing (i) how students perceive the level of information provided about their own competence or progress during their math lessons (competence support), (ii) how autonomous they feel during math lessons in school (autonomy support), and (iii) how they perceive the connectedness to other students in the math classroom (social relatedness); [32,35].

Self-determination theory is considered important for understanding the underlying processes of (math-related) motivation and achievement, as students' perceived support for self-determination influences the way students learn [36,37]. In addition to evidence that autonomy support can positively affect later motivation and achievement in math [38–40], a review article more generally underpins the positive relation between classroom instruction that supports the satisfaction of those basic needs, and students' motivation, engagement, and achievement [33]. In a recent study by Szulawski et al. [41] who analyzed the influence of basic psychological needs on performance when external incentives are present, perceived competence support appeared to be the strongest positive predictor of task performance. In their literature review, Guay et al. [42] found evidence for the positive effects of perceived self-determination on performance and learning—again, in particular, for autonomous motivation that is fostered by autonomy support in the classroom. Focusing on gender disparities in science classes, Patall et al. [43] reported lower perceived autonomy support and need satisfaction for female compared to male high school students. Although not addressing perceived competence support, there is broad evidence for a male advantage in terms of the related constructs of math self-efficacy, self-esteem, and self-concept [19,44,45]. Finally, corresponding to widespread math-gender stereotypes [46–48], teachers might be biased in their attribution and evaluation of female vs. male students' performance and behavior—and accordingly, act differently towards girls and boys in the class [20,49]. Gender-related differences in teacher-created learning environments should be reflected in, on average, lower levels of female students' perceived support for self-determination during math instruction.

1.2. Cognitive and Behavioral Engagement

Students' classroom engagement is an empirically validated predictor of academic achievement in math [50–53] that is usually understood as a multifaceted construct, consisting of behavioral, cognitive, and, sometimes, emotional aspects [54]. In the present study, we focus on the most prominent and stable facets of cognitive and behavioral engagement.

Cognitive engagement can be understood as students' "desire to go beyond the requirements and [their] preference for challenge [including] flexibility in problem solving, [and] preference for hard work" [54] (pp. 63–64). Following this conceptualization, cognitive engagement describes the extent of cognitive effort invested by the student—i.e., whether deep learning strategies and adequate cognitive strategies for comprehension are used when learning math [55]. Behavioral engagement, by contrast, represents students' observable behavior during math lessons rather than psychological and cognitive processes—i.e., positive conduct, effort, attention, involvement, persistence, and active participation in classroom and learning activities [54,56].

Regarding gender-specific differences, there is broad evidence that girls seem to be more engaged than boys during classroom learning [57–62]. Looking specifically at math and science and the individual facets of engagement, Fredricks and colleagues [24] likewise reported a female advantage in cognitive and behavioral engagement in middle and high school students—although other studies have suggested an advantage for boys [51,63] or no significant gender differences [64].

1.3. Sustained Attention

We are also interested in students' sustained attention due to its important role in ultimately enabling and constraining engagement and performance [28,65,66]. Sustained attention enables learners to maintain focus on a task for a longer time [27]. High levels of sustained attention require vigilance as well as executive functions such as response inhibition and distractor suppression [67]. Sustained attention is hence important to stay on-task, show on-task behavior, and resist distractions [68,69]—especially during learning that involves complex processing of information [28,65]. Accordingly, sustained attention has been shown to moderate the relationship between intellectual potential and performance (including math grades) at school [66]. Although the basic cognitive function of sustained attention is heritable [70], it can also be affected by nurture during an individual's development [71]. Existing results on gender effects on sustained attention are mixed. While some studies do not find any differences [72], there is evidence for male or female advantages on subcomponents, including vigilance and inhibitory control [73,74]. Riley and colleagues [75], using a gradual-onset continuous performance task, found less variance and faster performance together with more commission errors for males and more omission errors among females. Currently, however, there is no indication to expect gender differences on an overall measure of sustained attention.

1.4. Interrelations between these Bariables and the Role of Gender

While a few studies have looked at interrelations between those constructs of interest to our study, researchers have just started to analyze potential differential effects of students' gender. Simpkins and colleagues [76], for instance, investigated how children's motivational beliefs predict changes in their behavioral engagement in sports, instrumental music, and math. Despite domain-specific mean differences between boys and girls, no significant gender differences were found for the relations between the constructs over time, suggesting similar socialization processes [76]. Fredricks et al. [24] likewise analyzed associations between middle and high school students' motivational beliefs (including utility and attainment values as well as expectancy beliefs), social relatedness support from peers and teachers, and characteristics of instruction with engagement in math and science classrooms. While their quantitative analyses indicated significant relations between the motivational and contextual variables and engagement that were similar for boys and girls, there was some evidence for gender differences derived from student interviews. A personal relationship with their teacher (cf., perceived social relatedness) seemed to be more important to be engaged during instruction for girls than for boys. While teacher support was significantly related to engagement for boys and girls in the quantitative analyses as well, there was a moderating effect of gender with respect to teacher social support, which was associated with higher behavioral engagement in math for girls substantiating the conclusions from the interview. Although many students (irrespective of gender) reported that their participation and engagement in science and math classes also depended on their perceived competence as demonstrated in front of their teachers and peers, female students were more likely to also talk about disengagement and frustration in the face of content perceived as too challenging—particularly in math classes; and they more often mentioned that they preferred to keep silent rather than participate for fear of looking stupid. To sum up, social teacher support (cf. perceived social relatedness) hence seems to be particularly important for girls in math and more so for behavioral engagement. Perceived competence (support) appears to be critical for both girls' and boys' engagement, although girls might have less confidence in their abilities and be more susceptible to external evaluation. Moreover, there is evidence that perceived social relatedness (or classroom emotional climate) is directly and indirectly—via engagement—related to academic achievement [77,78]. In Reyes et al.'s [78] study, the effects were robust across gender. In line with the findings on perceived competence in Fredericks et al.'s [24] study but without focusing on gender effects, individuals, in general, seem to be more likely to engage cognitively, which is associated with higher performance, when they feel competent in a specific content area [26]. Similarly, Shernoff et al. [79] expect autonomy support and appropriate challenge (i.e., competence support) to lead to more engagement. Patall et al. [43] also did not investigate gender effects on relations between variables but analyzed whether male and female high school students differ in perceived autonomy support in the classroom, in need satisfaction (a joint measure of all three sources of need satisfaction), and in engagement (a joint measure of different types of engagement) in science classes and whether gender differences in engagement can be explained by gender differences in perceived autonomy support and need satisfaction. In line with their hypotheses, compared to boys, girls indicated lower autonomy support and need satisfaction and these gender differences accounted for female students' lower engagement in science courses.

To conclude, most studies that examine relations between variables we are interested in do not focus on the differential effects of gender on these relations; and those that do indicate more similarities in the patterns of relations than differences. In order to better understand what matters for girls and boys to explain math performance, we model and compare the paths between perceived self-determination support, engagement, and performance for male and female students. Unlike other studies, we differentiate between perceived competence support, autonomy support, and social relatedness, as well as between behavioral and cognitive engagement—and we additionally consider sustained attention as a basic cognitive prerequisite.

2. The Present Study

Students' engagement in the classroom can be expected to strongly depend on their perception of the learning environment: Do they feel encouraged and supported to develop competence and learn autonomously? Do they feel like they belong? Perceived autonomy support, competence support, and social relatedness may motivate students to both cognitively and behaviorally engage with the content to be learned [80–82]. Higher engagement, in turn, has been shown to be associated with learning and higher performance [78,83,84]. As motivational indicators of the perceived quality of instruction and provided learning opportunities, perceived autonomy support, competence support, and social relatedness can also be expected to directly affect performance and school success [41,78,85]. Finally, students' sustained attention may play an important role in ultimately enabling and constraining engagement and performance, as well as performance via engagement [66]. While male and female students either do not differ in terms of math performance [17] or boys rather outperform girls on standardized tests [86,87]), girls have been repeatedly reported to show, on average, lower levels of motivation [17,45,88] and higher engagement in the classroom than boys [58,62]. These findings suggest gender differences in the prediction of math performance. To conclude, based on potential differences in gender-specific external (teachers) and internal attributions, relations between perceived autonomy support, competence support, and social relatedness, engagement and performance in school mathematics can be expected to differ between girls and boys. In this study, we hence test the following hypotheses derived from existing research stating (1) a male advantage in terms of perceived self-determination in the math classroom, a female advantage in terms of engagement in the math classroom, and no gender differences in terms of math performance and sustained attention, and (2) predict math performance by modeling the direct paths from the three self-determination variables and the indirect path via cognitive and behavioral engagement comparing the resulting models for girls and boys. In an additional analysis, we further include the direct and indirect (via engagement) paths from students' sustained attention to math performance. The second part of this study is explorative in nature because existing research has not accumulated enough evidence yet to derive specific hypotheses regarding gender differences in the relations between the study variables. Based on online survey data from German Seventh-Grade secondary school students, *t*-tests are used to test the hypotheses of the first part of this study. For the second part, multiple group path analyses with gender as a group variable allow us to test for gender differences in the relations between the study variables and, hence, in the prediction of math performance.

3. Methods

3.1. Sample and Procedure

The sample investigated in this study has also been analyzed in another study, however, focusing on a different set of variables and addressing research questions related to remote schooling during the COVID-19 pandemic [89]. We hence examine a convenience sample of $N = 221$ Seventh-Grade students from Germany ($M_{age} = 12.84$ years, $SD_{age} = 0.55$), consisting of $n = 106$ male and $n = 115$ female students ($n = 2$ students who did not indicate male or female gender had to be excluded for the purpose of this study). Students and their parents from 18 schools in Bavaria, Germany, were informed about the study by their math teachers who belonged to a pool of teachers we had already cooperated with in the context of other projects. All students whose parents provided written consent received a link to our online survey in July 2020 to be completed in the next weeks until the end of the school year as voluntary homework assignment. The survey was run via a secure and established tool (Unipark; https://www.unipark.com/en/, accessed on 1 October 2022), conforming with the General Data Protection Regulation. The survey could be accessed from both desktop or laptop computers as well as touchscreen devices such as tablets or smartphones. The students could click through the survey at their own pace. The last page of the survey was linked to the web-based version of the sustained attention test, which is described below in more detail. The whole assessment was intended to be completed in approximately 30 min. After the end of the school year, in August 2020, we closed the survey and obtained the data. Altogether, $N = 421$ people accessed the survey, however, only $N = 223$ students produced valid data sets. The remaining $N = 198$ participants did not finish the survey. The majority stopped in the first third of the survey. Because participation in the survey was not obligatory, the number of students from one class varied considerably—from one student to 23 students at the maximum. Due to the large variation and mostly small number of students per class, it was not possible to consider the classroom structure in our analyses.

Although all $N = 221$ students completed the full set of survey items, several students did not finish the sustained attention test attached at the end of the survey, resulting in invalid measures. While the main analysis is based on the whole sample and the full set of survey items, we also report additional analyses based on the reduced sample of $N = 149$ ($M_{\text{age}} = 12.78$ years, $SD_{\text{age}} = 0.46$; $n = 72$ male and $n = 77$ female students) who also completed the sustained attention test. Since students not finishing the sustained attention test cannot be considered missing at random but rather likely share some common characteristics, the reduced sample must be conceived of as an even more selective sample than the full sample. To take this into account, we compare the model results between the different samples.

Online data collection took place at home on a voluntary basis and only for those students whose parents provided written consent after both parents and students had been informed about the study. In line with the ethics committee of the concerned institution, there was no compelling need for an ethics approval for this project.

3.2. Instruments and Scales

The instruments and scales, which have already been described in [89], are summarized in the following sections. Basic demographic information including age, gender, or school type, was assessed via self-report in the online survey.

Math performance. With Seventh-Graders in focus of the present study, we assessed math performance with 12 items representing basic knowledge of fractions. This content represents the core content of Grade Six in the present curriculum for all participants—i.e., content that should already have been taught to all the students at the time of the study. Basic fraction knowledge is operationalized with both conceptual knowledge items (e.g., students needed to name the fraction depicted in a pie chart with non-equal parts) as well as procedural knowledge items (e.g., students needed to divide 8/35 by 4/15). The instrument's reliability in the sample was estimated as Cronbach's $\alpha = 0.89$ and McDonald's $\omega = 0.91$.

Engagement. The two scales (cognitive and behavioral engagement) originate from a questionnaire by Wang and colleagues [90]. Students were prompted to think about "normal math classes" when answering the following items. Nine items on *cognitive engagement* ($\alpha = 0.78$ and $\omega = 0.83$) assess whether deep learning strategies and adequate cognitive strategies for comprehension are used (sample item: When I do not understand something in math, I try to clarify it). Eight items focusing on *behavioral engagement* ($\alpha = 0.77$ and $\omega = 0.85$) address involvement and active participation in classroom and learning activities related to math (sample item: I stay focused in math). Both scales are based on a 4-point Likert scale from 1 = "*almost never*" to 4 = "*almost always*".

Competence, autonomy, and social relatedness support. The following scales were adopted from Prenzel and Drechsel [91] and adapted to school students and math instruction. Just as with the engagement scales, students were prompted to think about "normal math classes" when answering the items. We used 4-point Likert plural from 1 = "*do not agree at all*" to 4 = "*totally agree*". The scale *perceived competence support* ($\alpha = 0.73$ and $\omega = 0.77$) assesses the students' perception of the awareness, communication, and appreciation of competence in their math lessons (five items; sample item: In math, I am informed about my individual progress). The scale *perceived autonomy support* ($\alpha = 0.64$ and $\omega = 0.75$) focuses on students' perception of the degree of autonomy they have in their math lessons (six items; sample item: In math, I have the opportunity to try out new things myself), and finally, the scale *perceived social relatedness* (α = 0.80 and ω = 0.84) addresses students' perception of the social climate and, in particular, the level of their own integration in the math classroom context (five items; sample item: In math, I feel like I belong).

Sustained attention. The attention swiping task (AST; [92]) was developed as a test of sustained visual attention that can be administered on any mobile device. Throughout the test, participants are presented with rows of nine stimuli (pictorial flowers) which are constructed based on two dichotomous dimensions, resulting in four different stimulus categories (see Figure 1A). The instructions are presented self-paced and the participants are required to remember two stimulus categories (the targets) which they will need to push toward the upper third of the screen. All stimuli which do not meet these criteria (the distractors) must be pushed toward the lower third. To further increase the requirements for participants' sustained attention, the original test was modified in a way that the background color would switch randomly indicating a rule change (i.e., the direction into which stimuli were to be pushed was inverted). After reading the instructions, participants first received a practice row of nine stimuli without any rule changes. After completing this row, they received a practice row with the rules being switched for all nine stimuli. Finally, participants received a row where the rule switched. During the practice rows, participants received visual feedback on their performance (see Figure 1B). To provide all participants with comparable prerequisites before starting the real test, each time they committed more than three mistakes per practice row, they would be presented with another practice row. This process was repeated up to three times. Once the real test started, no more feedback was provided, and participants were required to work on the task for three minutes as fast and conscientiously as possible. In order to constantly remind participants of the time limit, a progress bar was presented at the upper border of the screen, indicating how much time had passed already. Reactions to each item were collected as one of four categories (i.e., hits, omissions, mistakes, and dismissals). For further analyses, a measure of sustained attention was computed by subtracting the number of mistakes and omissions from the hits. This score was used to correct for correct responses that resulted from inattentive guessing. Due to the novelty of this test instrument, there are no norming samples yet, and the resulting score has to be interpreted relative to the study sample. In order to estimate the reliability of sustained attention, the split-half reliability has been used. To avoid overestimation, this split was carried out by separating the items at the 90 s mark (i.e., after half of the test time has passed), resulting in a reliability of r_{tt} = 0.86.

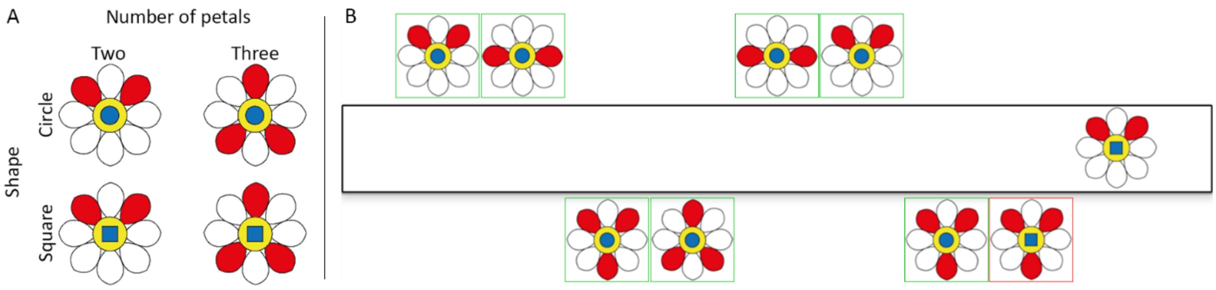

Figure 1. Stimuli and Practice Row of the AST. Note. In (**A**), all possible combinations of stimuli can be seen. The stimuli vary by the shape in the center and the number of colored petals. For each stimulus, four variants exist to prevent participants from memorizing and thus relying too much on visual comparison. In (**B**), an example from a practice trial is presented. The rule was to move stimuli with a circle and two-colored petals as well as stimuli with a square and three colored petals to the upper part of the screen. The first seven stimuli were categorized correctly and have thus been highlighted with a green box. The eighth stimulus should have also been moved to the upper part; thus, it has been marked red and the participant is required to correct their response before continuing with the last stimulus.

3.3. Statistical Analysis

While gender-specific basic correlational analyses on the study variables, descriptive statistics, and *t*-tests between female and male students were run on IBM© SPSS© Statistics Version 27, we used R-4.0.2 for data compilation and all other analyses. The multiple group path analyses and regressions were conducted with the package 'lavaan' version 0.6-7 [93]. In order to protect against potential errors due to not normally distributed variables, maximum likelihood estimation with robust standard errors and a Satorra-Bentler scaled test statistic were used. In the main analysis, both cognitive and behavioral engagement were regressed on perceived autonomy support, perceived competence support, and perceived social relatedness. Math performance was regressed on cognitive and behavioral engagement as well as on perceived autonomy support, perceived competence support, and perceived social relatedness. We also calculated the indirect paths from perceived autonomy support, perceived competence support, and perceived social relatedness via cognitive or behavioral engagement on math performance. The model was estimated separately for female and male students. The model with gender-specific estimates was compared to a joint model that did not distinguish between male and female students to test for an overall effect of gender. Differences in terms of coefficients between females and males were tested by comparing the model with all parameters estimated freely for each gender to nested models with single coefficients being constrained to be equal between female and male students. The nested models' fit to the data was contrasted using the scaled chi-squared difference test [94]. A significant chi-square indicates a significant gender difference on the coefficient set to be equal between female and male students.

3.4. Transparency and Openness

We report how we collected our sample, all data exclusions, and all measures in the study. All data and analysis code are available by emailing the corresponding author. Research materials are available at https://doi.org/10.1007/s10212-021-00590-w (accessed on 1 October 2022). This study's design and its analysis were not pre-registered.

4. Results

In the following section, we first present the results of gender-specific basic correlational analyses on the study variables, descriptive statistics, and *t*-tests between female and male students. The results of the main multiple group path analysis based on the full sample are summarized next, before we focus on the extended analysis including sustained attention based on the reduced sample of $N = 149$ students.

4.1. Basic Gender Differences

Table 1 contains the correlations between all study variables separately for girls and boys. Gender-specific descriptive statistics are presented in Table 2, together with the results of the *t*-tests.

When looking at the correlations in Table 1, we recognize gender differences in the correlations of the different study variables with math performance and, albeit to a smaller extent, with sustained attention—with less significant bivariate correlations on the part of the girls. Significant gender mean-differences exist only in terms of competence support with higher perceived support on the part of male students and in terms of behavioral engagement with girls indicating higher manifestations (Table 2). For cognitive engagement, the same tendency was evident but not significant. The girls' sustained attention also appeared to be slightly higher, however, again not reaching significance based on an α-level of 0.05.

Table 1. Correlations between all Study Variables for Girls and Boys.

	1	2	3	4	5	6	7
Girls (n = 115)							
1. Autonomy support	-						
2. Competence support	0.45 ***	-					
3. Social relatedness	0.54 ***	0.46 ***	-				
4. Cognitive engagement	0.45 ***	0.31 **	0.34 ***	-			
5. Behavioral engagement	0.38 ***	0.25 **	0.32 ***	0.75 ***	-		
6. Math performance	0.18	−0.03	0.15	0.51 ***	0.33 ***	-	
7. Sustained attention [a]	0.06	0.02	0.09	0.19	0.18	0.28 *	-
Boys (n = 106)							
1. Autonomy support	-						
2. Competence support	0.53 **	-					
3. Social relatedness	0.65 **	0.58 **	-				
4. Cognitive engagement	0.47 **	0.34 **	0.43 **	-			
5. Behavioral engagement	0.48 **	0.34 **	0.50 **	0.76 **	-		
6. Math performance	0.39 **	0.38 **	0.53 **	0.54 **	0.56 **	-	
7. Sustained attention [a]	0.30 *	0.20	0.48 **	0.50 **	0.48 **	0.70 **	-

[a] Sample size for sustained attention is n = 77 for girls and n = 72 for boys. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

Table 2. Gender-specific Descriptive Statistics and *t*-Test Results.

Variables		Girls (n = 115)		Boys (n = 106)		t	95% CI [*LL*; *UL*]
	Range	*M*	*SD*	*M*	*SD*		
Autonomy support	1–4	2.80	0.46	2.83	0.53	−0.47	[−0.16; 0.10]
Competence support	1–4	2.97	0.50	3.14	0.60	−2.25 *	[−0.31; −0.02]
Social relatedness	1–4	3.04	0.55	3.03	0.66	0.10	[−0.15; 0.17]
Cognitive engagement	1–4	3.15	0.49	3.02	0.53	1.90	[−0.01; 0.27]
Behavioral engagement	1–4	3.08	0.50	2.94	0.53	2.09 *	[0.01; 0.28]
Math performance	0–12	8.75	3.34	8.53	3.80	0.46	[−0.73; 1.17]
Sustained attention [a]	-	12.45	23.89	4.07	28.53	1.94	[−0.17; 16.94]

Note. *LL* = lower limit; *UL* = upper limit. [a] Sample size for sustained attention is n = 77 for girls and n = 72 for boys. * $p < 0.05$.

4.2. Main Multiple Group Path Analysis

In order to test for an overall effect of gender, the model with gender-specific estimates was compared to a joint model that did not distinguish between male and female students. The latter fitted the data significantly worse (chi-squared difference = 36.27, $p < 0.001$), indicating overall gender differences. The results of the main multiple group path analysis are summarized in Table 3. Perceived autonomy support was a significant predictor for both cognitive and behavioral engagement for female and male students. Perceived social relatedness was the only other significant predictor and only for behavioral engagement for male students—although this coefficient did not differ significantly between male and female students (see Table 3). To conclude, there were no considerable gender differences in the prediction of cognitive and behavioral engagement based on the three self-determination variables.

Cognitive engagement, in turn, predicted math performance for both girls and boys. The predictor, however, was significantly stronger for female students. Behavioral engagement, by contrast, was no significant predictor for girls' math performance at all, whereas boys' math performance could be regressed on behavioral engagement, indicating a significant difference between female and male students. Social relatedness again appeared to be slightly more important for boys than for girls, being a significant predictor of only boys' math performance (but no significant gender differences). Importantly, perceived competence support turned out to be a significant negative predictor of female students' math performance, while showing no significant association with male students' performance, reflecting a significant effect of gender. Among the indirect paths to math performance, the path from autonomy support via cognitive engagement to math performance was the only one reaching significance—and only for female students (male students: $p = 0.055$). The path coefficient, however, did not significantly differ between gender. For female students, the model explained 36.77%, and for male students, 39.51% of the variance in math performance. To sum up, despite a similar proportion of variance in math performance explained, the paths to math performance showed considerable differences between female and male students. Figure 2 depicts all significant paths for female (left panel) and male (right panel) students.

Table 3. Results of the Main Multiple Group Path Analysis.

	Main Model									
	Girls (n = 115)				**Boys (n = 106)**				**Gender Differences**	
Model Path	**β**	***SE***	***z***	***p***	**β**	***SE***	***z***	***p***	**Δchi²**	***p***
Aut. sup. → Cog. eng.	0.37	0.11	3.34	<0.001	0.31	0.11	2.77	0.006	0.14	0.713
Comp. sup. → Cog. eng.	0.1	0.09	1.13	0.26	0.06	0.1	0.63	0.53	-	-
Soc. relat. → Cog. eng.	0.09	0.09	1.02	0.31	0.15	0.11	1.46	0.143	-	-
Aut. sup. → Beh. eng.	0.29	0.12	2.34	0.019	0.26	0.1	2.5	0.013	0.03	0.866
Comp. sup. → Beh. eng.	0.07	0.09	0.74	0.461	0.02	0.09	0.16	0.872	-	-
Soc. relat. → Beh. eng.	0.13	0.12	1.12	0.262	0.26	0.08	3.07	0.002	0.72	0.395
Cog. eng. → Math	4.52	0.63	7.22	<0.001	1.77	0.65	2.74	0.006	4.49	0.034
Beh. eng. → Math	−0.85	0.57	−1.49	0.135	1.62	0.64	2.53	0.011	4.23	0.04
Aut. sup. → Math	−0.11	0.79	−0.13	0.893	−0.64	0.73	−0.88	0.38	-	-
Comp. sup. → Math	−1.50	0.6	−2.49	0.013	0.49	0.59	0.83	0.405	5.65	0.017
Soc. relat. → Math	0.43	0.71	0.61	0.539	1.85	0.68	2.71	0.007	2.11	0.146
Aut. sup. → Cog. eng. → Math	1.67	0.57	2.94	0.003	0.55	0.29	1.92	0.055	4.99	0.083
Comp. sup. → Cog. eng. → Math	0.44	0.41	1.09	0.277	0.11	0.17	0.63	0.527	-	-
Soc. relat. → Cog. eng. → Math	0.42	0.41	1.02	0.305	0.27	0.23	1.2	0.232	-	-
Aut. sup. → Beh. eng. → Math	−0.24	0.17	−1.43	0.154	0.42	0.24	1.73	0.084	-	-
Comp. sup. → Beh. eng. → Math	−0.06	0.08	−0.69	0.49	0.02	0.15	0.16	0.872	-	-
Soc. relat. → Beh. eng. → Math	−0.11	0.14	−0.79	0.429	0.42	0.22	1.88	0.059	-	-
R^2										
Cognitive engagement	0.23				0.25					
Behavioral engagement	0.16				0.29					
Math performance	0.37				0.4					

Note. Δchi^2 is based on scaled chi-squared difference tests; the test was performed only for significant predictors.

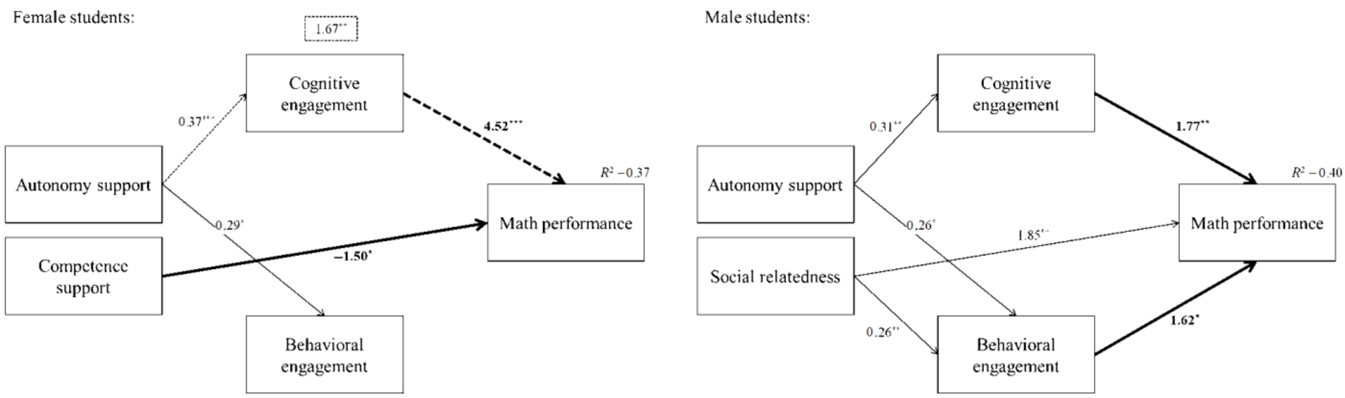

Figure 2. Significant Paths for Female (**Left** Panel) and Male (**Right** Panel) Students Based on the Main Model in the Full Sample. Note. Bold values and paths indicate significant gender differences. Dashed lines represent indirect paths and indirect path coefficients are shown in dashed boxes. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

4.3. Extended Multiple Group Path Analysis including Sustained Attention Based on Reduced Sample

In the following section, we refer to the reduced sample of only those students who also completed the sustained attention test that can be considered as an objective, behavioral measure of students' cognitive potential to engage in the math classroom. We added this predictor to the multiple group path analysis described in the previous part. To be able to estimate the effect of the reduced sample and disentangle it from the effect of including sustained attention as a predictor, we ran the main multiple group path analysis without sustained attention (described in the previous section) on the reduced sample. These results are listed in Table 4, together with the results of the extended multiple group path analysis described in the next paragraph. Importantly, the coefficients resulting from the main multiple group path analysis on the reduced sample did not differ significantly from those reported in Table 3 (i.e., we set each coefficient in the reduced sample-model to the corresponding value obtained with the full sample and compared the restricted and unrestricted reduced sample-models using scaled chi-squared difference tests; all $p > 0.126$). Although these findings suggest rather negligible distorting effects of the reduced sample, they still must be considered when interpreting the results reported in the following paragraph.

Table 4. Results of the Extended Multiple Group Path Analysis and the Main Multiple Group Path Analysis on the Reduced Sample.

	Extended Model (Reduced Sample)										**Main Model (Reduced Sample)**							
	Girls (*n* = 77)				**Boys (*n* = 72)**				**Gender Diff.**		**Girls (*n* = 77)**				**Boys (*n* = 72)**			
Model Path	**β**	***SE***	***z***	***p***	**β**	***SE***	***z***	***p***	**Δchi²**	***p***	**β**	***SE***	***z***	***p***	**β**	***SE***	***z***	***p***
Aut. sup. → Cog. eng.	0.32	0.12	2.61	0.009	0.36	0.11	3.32	<0.001	0.08	0.774	0.32	0.12	2.56	0.010	0.37	0.12	3.25	0.001
Comp. sup. → Cog. eng.	0.13	0.09	1.45	0.146	0.14	0.11	1.22	0.223	-	-	0.13	0.09	1.37	0.169	0.07	0.11	0.67	0.500
Soc. relat. → Cog. eng.	0.14	0.09	1.59	0.112	−0.07	0.14	−0.49	0.623	-	-	0.16	0.09	1.73	0.083	0.12	0.13	0.89	0.376
Sust. attent. → Cog. eng.	0.003	0.002	1.60	0.109	0.01	0.002	3.95	<0.001	2.84	0.092	-	-	-	-	-	-	-	-
Aut. sup. → Beh. eng.	0.18	0.12	1.49	0.136	0.36	0.10	3.52	<0.001	1.27	0.260	0.18	0.12	1.48	0.140	0.37	0.11	3.39	0.001
Comp. sup. → Beh. eng.	0.11	0.09	1.13	0.258	−0.002	0.13	−0.02	0.986	-	-	0.10	0.09	1.05	0.294	−0.06	0.13	−0.46	0.645
Soc. relat. → Beh. eng.	0.23	0.10	2.24	0.025	0.06	0.11	.54	0.591	1.05	0.306	0.24	0.11	2.24	0.025	0.22	0.11	1.92	0.055
Sust. attent. → Beh. eng.	0.003	0.002	1.50	0.134	0.01	0.002	2.81	0.005	1.64	0.200	-	-	-	-	-	-	-	-
Cog. eng. → Math	2.96	0.76	3.92	<0.001	−0.71	0.57	−1.26	0.206	9.37	0.002	3.18	0.81	3.94	<0.001	0.47	0.73	0.65	0.518
Beh. eng. → Math	−1.20	0.83	−1.44	0.149	1.81	0.65	2.80	0.005	5.25	0.022	−1.08	0.87	−1.24	0.214	2.28	0.76	3.00	0.003
Aut. sup. → Math	0.09	0.74	0.12	0.904	−0.33	0.74	−0.45	0.655	-	-	0.03	0.77	0.04	0.972	−0.86	0.92	−0.93	0.351
Comp. sup. → Math	−1.58	0.71	−2.23	0.026	0.99	0.60	1.67	0.096	7.89	0.005	−1.69	0.72	−2.34	0.019	0.35	0.73	0.48	0.630
Soc. relat. → Math	1.22	0.56	2.18	0.029	1.00	0.67	1.49	0.136	0.06	0.801	1.28	0.56	2.30	0.022	2.41	0.72	3.36	0.001
Sust. attent. → Math	0.03	0.01	1.95	0.051	0.07	0.02	4.19	<0.001	4.35	0.037	-	-	-	-	-	-	-	-
Aut. sup. → Cog. eng. → Math	0.94	0.44	2.12	0.034	−0.26	0.21	−1.23	0.220	9.38	0.009	1.01	0.47	2.14	0.032	0.18	0.28	0.63	0.530
Comp. sup. → Cog. eng. → Math	0.39	0.28	1.40	0.162	−0.10	0.11	−0.87	0.386	-	-	0.40	0.31	1.29	0.197	0.03	0.06	0.53	0.598
Soc. relat. → Cog. eng. → Math	0.42	0.30	1.43	0.154	0.05	0.11	0.46	0.642	-	-	0.50	0.33	1.52	0.129	0.06	0.12	0.48	0.633
Sust. attent. → Cog. eng. → Math	0.01	0.01	1.45	0.148	−0.01	0.005	−1.18	0.237	-	-	-	-	-	-	-	-	-	-
Aut. sup. → Beh. eng. → Math	−0.21	0.21	−1.00	0.317	.66	0.32	2.06	0.040	6.91	0.032	−0.19	0.21	−0.92	0.359	0.85	0.43	1.98	0.048
Comp. sup. → Beh. eng. → Math	−0.13	0.15	−0.83	0.408	−0.004	0.24	−0.02	0.986	-	-	−0.11	0.14	−0.76	0.446	−0.13	0.30	−0.44	0.663
Soc. relat. → Beh. eng. → Math	−0.27	0.22	−1.24	0.214	0.11	0.20	0.54	0.591	-	-	−0.26	0.23	−1.11	0.267	0.50	0.32	1.57	0.117
Sust. attent. → Beh. eng. → Math	−0.003	0.003	−1.14	0.254	0.01	0.01	1.79	0.073	-	-	-	-	-	-	-	-	-	-
R^2																		
Cognitive engagement	0.33				0.42						0.30				0.30			
Behavioral engagement	0.28				0.38						0.26				0.30			
Math performance	0.33				0.62						0.29				0.43			

Note. Δchi^2 is based on scaled chi-squared difference tests; the test was performed only for significant predictors.

For the extended model in the reduced sample, we again found a significant overall effect of gender (chi-squared difference = 38.86, $p = 0.002$). The new variable sustained attention was a significant predictor for cognitive and behavioral engagement as well as for math performance—but only for male students (with $p = 0.051$ for the prediction of girls' math performance). While the coefficients did not significantly differ between boys and girls when predicting both engagement variables, the path from sustained attention to math performance differed significantly between genders.

Similar to the main analysis, perceived autonomy support significantly predicted cognitive engagement for both boys and girls. Within the group of the girls, however, autonomy support did no longer predict behavioral engagement, but social relatedness did, while in the group of the boys, social relatedness was no longer a significant predictor of behavioral engagement. These slight differences to the results of the main multiple group path analysis based on the full sample might at least partly reflect the effects of the more selective sample, since they are also recognizable when looking at the results of the reduced sample-model without sustained attention (right part of Table 4). In line with the results of the main multiple group path analysis based on the full sample, there were no considerable gender differences in the prediction of cognitive and behavioral engagement.

The results on the prediction of math performance also strongly resembled the results of the main analysis. Cognitive engagement predicted math performance only for girls, representing a significant gender difference. Behavioral engagement, by contrast, was no significant predictor for girls' math performance, whereas boys' math performance could be regressed on behavioral engagement, indicating a significant difference between female and male students. Perceived social relatedness was a significant predictor of only female students' math performance, but we found no significant gender differences on this coefficient. Again, perceived competence support turned out to be a significant negative predictor of female students' math performance, while showing no significant association with male students' performance, reflecting a significant effect of gender.

Among the indirect paths to math performance, the path from perceived autonomy support via cognitive engagement to math performance was the only one reaching significance for female students and significantly differed between boys and girls. In the group of male students, the indirect path from autonomy support via behavioral engagement to math performance was significant and significantly differed between boys and girls. For female students, the extended model explained 32.50%, and for male students, 61.89% of the variance in math performance. To sum up, with sustained attention included, the prediction of male students' math performance improved considerably, while this behavioral measure of students' basic cognitive potential seemed to be less relevant for girls' performance. Figure 3 depicts all significant paths for female (left panel) and male (right panel) students.

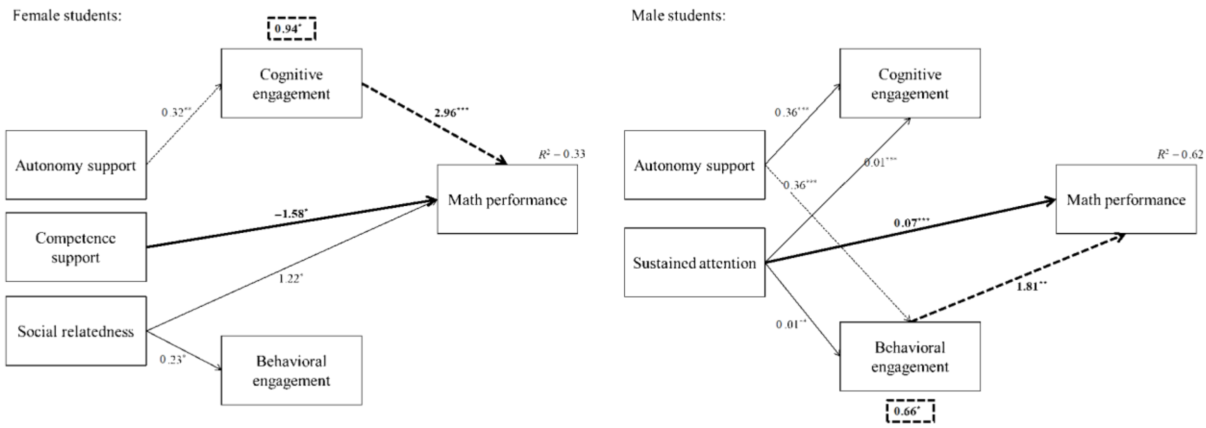

Figure 3. Significant Paths for Female (**Left** Panel) and Male (**Right** Panel) Students Based on the Extended Model in the Reduced Sample. Note. Bold values and paths indicate significant gender differences. Dashed lines represent indirect paths and indirect path coefficients are shown in dashed boxes. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

5. Discussion

While there is now widespread agreement that boys and girls do not consistently differ in their math proficiency, several studies document gender differences in math motivation as well as persistent gender-STEM stereotypes at the societal level. Thus, the question arises if different mechanisms contribute to girls' and boys' knowledge development in math. How do female and male students' (potentially different) perceptions of support in the math classroom influence their engagement and math performance and how does engagement itself affect math performance when controlling for sustained attention as a basic cognitive prerequisite? As expected, we did not find a gender difference in math performance. Regarding the motivational variables, the only significant gender difference consists of a male advantage in perceived competence support. Moreover, in line with the literature, female students reported significantly higher behavioral engagement than male students. Aside from these mean-level differences, however, what matters for math performance indeed seems to differ markedly between female and male students. Whereas perceived competence support in the math classroom and cognitive engagement seem to play a more important role for girls, behavioral engagement and, in particular, sustained attention explain a considerable part of boys' math performance. We propose that these disparate prediction paths epitomize the core of the pertaining mismatch between girls and math. In the following sections, we mainly focus on those paths that turned out to be consistent predictors in the models in both the full and the reduced sample and introduce our idea of underlying mechanisms.

5.1. The Paths Predicting Math Performance

In this study, we only look at influences on math performance that directly refer to what happens during math instruction in the classroom, thereby excluding all variables with diffuse reference and origin (e.g., self-concept, interest, anxiety). This narrow focus allows us to derive assumptions that can be tested on the classroom level (as further illustrated in the next section). We accordingly expected autonomy support, competence support and social relatedness as experienced in the math classroom to influence students' cognitive and behavioral engagement in the math classroom as well as math performance directly. Both types of engagement, in turn, were assumed to affect math performance. Sustained attention, as an objective behavioral measure of students' capacity to engage in learning during math instruction was hence hypothesized to predict both cognitive and behavioral engagement and math performance directly.

In line with existing research emphasizing the role of autonomy for learning [33,38,39,42,95], perceived autonomy support was the most consistent predictor of cognitive and behavioral engagement. There were no significant gender differences in their prediction. The extent to which male and female students are given the freedom to explore content and to work according to their own needs (autonomy support) seems to stimulate them to deeply engage with, elaborate and reflect on the content (cognitive engagement) and perseveringly and diligently participate in learning activities (behavioral engagement). Because we analyzed cross-sectional data, we cannot preclude inverse influences: The higher the students' engagement during class, the more autonomy a teacher may be able and willing to grant. However, there is existing research supporting our interpretation [42,79]. Interestingly, autonomy support indeed seems to take effect on performance via engagement. While it did not affect math performance directly, we found significant indirect effects via cognitive engagement for girls (in both the main and the extended model) and via behavioral engagement for boys (in the extended model only)—with significant gender differences.

These two divergent indirect paths reflect pronounced gender differences in the direct paths from engagement to performance, with much stronger effects of cognitive engagement on performance for girls and of behavioral engagement on performance for boys. Female students, on the mean-level, indicated higher behavioral engagement than male students, suggesting that, for girls, behavioral engagement is more the rule rather than game-changing [24,58,62]. However, the more female students reported to deeply engage with, elaborate on, and reflect on the content addressed in math classes (cognitive engagement), the higher their performance. This relation holds for boys in the main model as well, but cognitive engagement ceases to predict performance in the extended model with sustained attention included. This might suggest that the part of cognitive engagement that predicted the boys' performance in the main model largely reflected their level of sustained attention during math classes. The part of cognitive engagement that predicted the girls' performance, by contrast, showed less overlap with the basic cognitive prerequisite of sustained attention that was no significant predictor for female students at all. For them, strategic knowledge about cognitive elaboration, as well as control and reflection strategies, which can be considered to be less strongly dependent on sustained attention, seems to be of central importance. While some studies, focusing on learning strategy use do not find differences between girls and boys in science classes, language, or math [96,97], Ruffing et al. [98], investigating college students, found females to apply most learning strategies more frequently than males. These strategies could be related to learning discipline and conscientiousness. However, they incrementally predicted academic performance beyond general cognitive ability independent of students' gender. Our results might have resembled Ruffing et al.'s [98] findings if we had not distinguished between cognitive and behavioral engagement.

Sustained attention turned out to be a strong predictor of cognitive engagement, behavioral engagement, and math performance, but only for male students ($\Delta R^2 = 0.19$ for the comparison between the main and the extended model with sustained attention for boys in the reduced sample). The path from sustained attention to math performance showed a significant gender effect (stronger effect for male students). While it is perfectly in line with our expectations that students' ability to concentrate on a task and stay focused for a longer period of time predicts both engagement in a learning situation and its outcome (i.e., performance; [28,65]), the relative irrelevance of sustained attention in the female sample (which is presumably also reflected in the considerably lower proportion of variance explained, $R^2 = 0.33$, as compared to $R^2 = 0.62$ for male students) is surprising. In line with the female advantage in terms of behavioral engagement and the more important role of cognitive engagement for girls' math performance, boys', on the average, less conscientious and disciplined behavior and strategy use might increase the importance of sustained attention for learning. At the same time, it seems that something in the math classroom keeps female students from relying on their cognitive potential and investing it in learning (for similar results in physics, see [99])—as explicated in the next section.

This is the right moment to turn to another unexpected finding: the negative path from perceived competence support to math performance for girls (representing a significant gender difference). Since it is highly unlikely that higher competence support leads to lower math performance, we assume a bidirectional or even inverse relationship in this case: Female students with lower performance might receive more competence support from their math teachers—they get more time to practice, are praised more often, are more often informed about their progress and what they still can improve and are more often given credit for difficult tasks. Overall, female students seem to receive less competence support than male students, as indicated by the significant mean-level difference, and while the bivariate correlation between competence support and performance is significant and positive for male students, it is negative, albeit not significant, for female students. Girls hence seem to experience this kind of care in the math classroom less often than boys and if they do, it tends to be in response to low performance—rather than to encourage high competence and nurture talent. Such experiences in the math classroom might be the product of gender-STEM stereotypes that associate math proficiency with innate ability or brilliance that you either have or do not have and that, in turn, is more strongly associated with male than female students [12–14] and teachers, probably unintentionally, acting accordingly [100–103]. Relatively independent of female students' level of sustained attention, they might consequently not feel encouraged to invest their cognitive potential in math [19,44,45] and highly capable girls might lack chances to exploit their potential. This mechanism might partly explain the weak connection between sustained attention and math performance for girls. To build math knowledge, female students acquire and apply helpful cognitive learning strategies, while naturally behaving conscientiously and putting in the work, which seem both to be easier in autonomy-supportive classrooms [79]. Figure 4 summarizes our findings including underlying assumptions that have to be examined in future studies.

Although perceived social relatedness appeared to be positively associated with both girls' and boys' math performance and behavioral engagement, the significance of these relations varied across the different samples and models analyzed. We found no evidence of significant gender differences regarding this variable. Nevertheless, our findings are compatible with existing research that has demonstrated the importance of social relatedness in the math classroom, especially for behavioral engagement and female students [24], as well as its direct and indirect—via engagement—association with academic achievement [77,78].

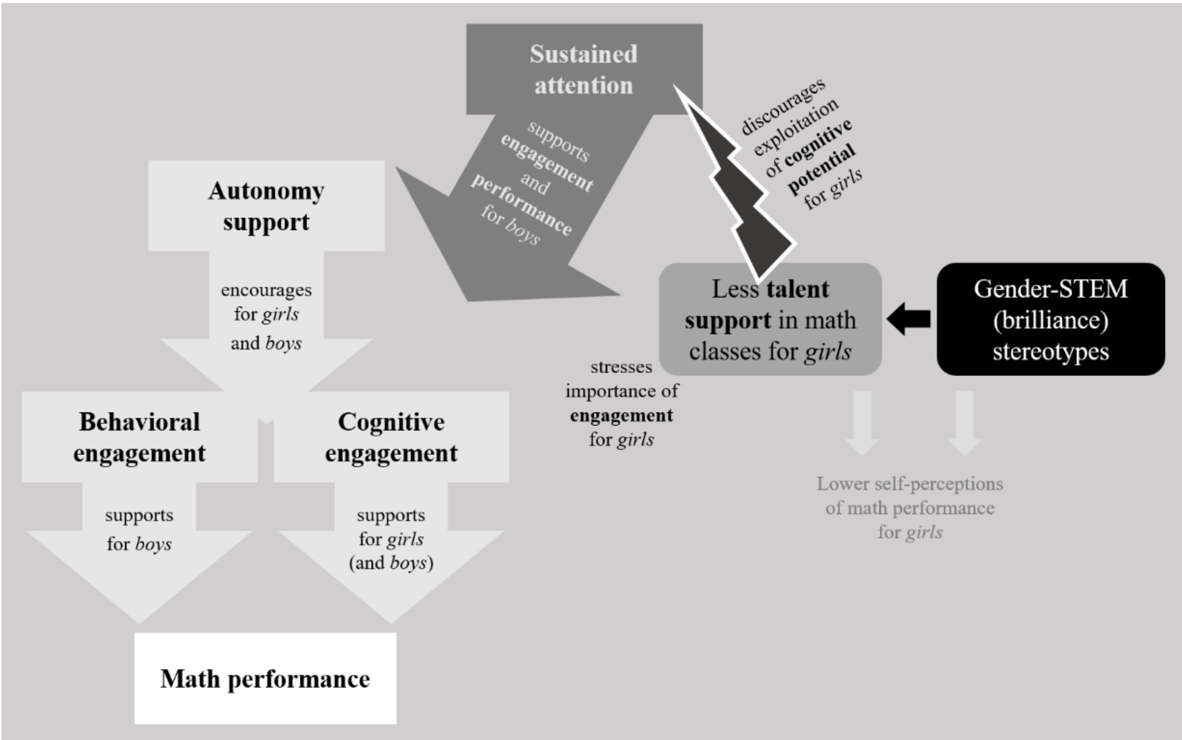

Figure 4. Gendered Pathways to Math Performance.

5.2. Limitations and Implications for Research

In particular, the hypothesized relations on the right half of Figure 4 are not derived from the present data and have to be evaluated in future studies. The idea that female students do not exploit their cognitive potential in math classrooms, which is empirically mainly based on the weaker direct and indirect influence of sustained attention on math performance among girls compared to boys, should be substantiated using other measures of cognitive potential, including intelligence measures. In addition, given the cross-sectional design of this study and the exploratory nature of our research questions on gender-specific relations, we are aware that all interpretations in terms of causality and directed effects must be considered with caution. Longitudinal studies with several measurement points of the same variables would be suited to substantiate the present findings based on the path analyses. Although we deliberately focus on students' perceptions of support in math classrooms, instead of assessing more objective instructional indicators, it would be worthwhile to contrast girls' and boys' subjective evaluations of teacher support with an objective assessment. Based on the present study, we do not know whether girls and boys are treated differently by their math teachers or whether they might interpret similar teacher behavior in different ways, maybe based on their expectations [104,105] and attributional tendencies [106,107]. In addition, experimental designs that vary the level of teacher support over a specific period of time or that implement motivational-affective interventions such as attributional retraining (for a meta-analysis on this topic, see [108,109]) could help to better understand underlying mechanisms. In the present study, we used a math performance test that is closely tied to the topics covered in the German secondary school curriculum and based on problem types typically encountered during math instruction and exams. Despite this test's high ecological validity, the present findings should be confirmed in more controlled pre-posttest design learning settings that allow direct relationships to be established between perceived support for self-determination, engagement, and performance (i.e., learning).

Finally, participants in our study could opt in or out on a voluntary basis. Accordingly, we must assume selection bias in our sample: Students completing the survey might differ systematically from other students, presumably, especially in terms of higher manifestations on variables positively associated with perseverance and compliance [110,111]. Our mean-level findings and gender-specific relations between variables may hence only apply to this specific sample and look different in a less committed group of students. However, a comparison between the overall sample and the even more selective sample of students who completed the sustained attention test revealed no substantial differences in model results—which could be interpreted as the first indication of robust effects that still need to be verified in further samples.

6. Conclusions

For researchers and practitioners alike, knowing more about the correlates of engagement and performance in the math classroom and the extent of gender differences in that regard is instrumental [76]. One central finding of this study that applies to both female and male students, is the importance of autonomy supportive instruction for student engagement. Although perceived autonomy support does not seem to affect math performance directly, we provide evidence for its indirect influence via engagement. If students are allowed to make autonomous decisions (at least to some degree) and are supported to explore content and to work according to their own needs, they seem to be more likely to deeply engage with, elaborate and reflect on the content (cognitive engagement) and perseveringly and diligently participate in learning activities (behavioral engagement).

Because behavioral engagement seems to be particularly important for boys' math performance and boys tend to show lower behavioral engagement than girls, math teachers might especially focus on creating calm and distraction-free learning environments to help increase their male students' perseverance and diligence.

The finding that girls perceive less competence support than boys together with its negative relation with math performance only in the group of female students, suggests either considerable gender differences in the perception of teacher behavior or considerable differences in teacher behavior dependent on student gender (or a mixture of both). Although we cannot disentangle the underlying mechanisms based on the existing data, we assume that lower-performing girls receive more time to practice, are praised more often, are more often informed about their progress and what they can still improve and are more often given credit for difficult tasks, while this kind of competence support might often be withheld from higher-performing female students. This does not seem to be the case in the group of the male students. Making math teachers aware of the risk of discriminative behavior involving missing out on nurturing female students with high cognitive potential (i.e., sustained attention as a proxy) and the implicit confirmation of math-gender stereotypes, could be one possible way to intervene. In addition to helping more female students to perform at a high level in math, such interventions could also be key to changing girls' self-perceptions, motivation, and attitudes toward this fundamental subject.

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Institutional Review Board Statement: In line with the ethics committee of the concerned institution, there was no compelling need for an ethics approval for this project.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: We report how we collected our sample, all data exclusions, and all measures in this study. All data and analysis code are available by emailing the corresponding author. Research materials are available at https://doi.org/10.1007/s10212-021-00590-w (accessed on 1 October 2022). This study's design and its analysis were not pre-registered.

Conflicts of Interest: The authors declare no conflict of interest.

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