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Views on Gender Differences in the Physics Classroom

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Abstract: Concerns about the differences between boys and girls in educational achievement, school careers and educational choices have existed since the last century. Despite ongoing research, we still do not have a complete picture of gender-based differences in education. In particular, there is little comparative research on how teachers and students experience and deal with gender differences in their classrooms. Therefore, this study focuses on teacher and student perspectives on gender differences in the physics classroom of Dutch upper secondary education. The data were collected through questionnaires distributed among physics teachers (N = 72) and students (N = 212). The questionnaires for students and teachers were designed to reveal their perceptions of gender differences in the classroom, focusing on student learning characteristics and teacher–student interactions. Gender differences are reported to a larger extent by teachers than by students, especially in the area of students' learning characteristics (e.g., boys showing more talent and interest in physics, girls showing more effort and self-regulation) and some in teacher–student interactions (e.g., girls asking teachers more questions). We conclude that concerns about differences between boys and girls are still present and need further research. More work is needed to fully understand the implications of these differences, which are expected to have an important impact on classroom interventions and guidelines for teachers to use in their classrooms.

Keywords: gender differences; physics; teachers; students; secondary education

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1. Introduction

"Gender disparities in achievement are a matter of considerable concern, as they may have long-term consequences for girls' and boys' personal and professional future" [1], p. 142. Concerns about the differences between boys and girls in educational achievement, school careers and educational choices have existed since the last century [2–7]. In the Netherlands, gender differences are also a longstanding and still current field of interest. A study conducted by the Dutch education council [8] concluded that in secondary education, girls have more favorable school careers than boys, while boys drop out, repeat a schoolyear or continue at a lower level more often. Although boys may struggle more with motivation and attitude toward learning and homework [9], they outperform girls on the Dutch physics final exams. In a prior project, physics exam results from 2013–2014 to 2018–2019 (N = 15,660) from a school consortium of 68 schools in the south of the Netherlands (called OMO) were analyzed in relation to gender differences. We found a significant difference in grades, with boys performing better (M = 6.68759, SD = 0.17364) than girls (M = 6.3037, SD = 0.165981), t (15,197.979) = −139.184, p < 0.001. These results suggest that gender indeed correlates with the final physics exam score. Physics is a compulsory subject for the lower grades of the two highest levels of secondary education in the Netherlands (senior general secondary education—HAVO—and pre-university education—VWO). In their fourth year, students can choose to (dis)continue physics. Within OMO schools (data from 2021), more boys choose physics at this later stage than girls (55%). In this study, we focus on this stage, when students have voluntarily chosen to continue with physics in upper secondary education.

One plausible reason why girls perform worse in physics than boys is that there is an improper or even a lack of gender-equitable physics education [10,11]. Equity means that whatever variations there may be in educational outcomes, they are not related to students' backgrounds, including gender [1]. Gender is not a definite binary description of just boy or girl [12]. For this study, we follow the description of the World Health Organization [13]: "Gender refers to the characteristics of women, men, girls and boys that are socially constructed". Gender-equitable education is what we describe as a learning climate in which all students, boys, girls and others are given the best opportunities.

The debate regarding gender-based differences started with the perceptions of people regarding these differences [14–16]. Earlier research has not yet led to conclusive results or a complete picture. While numerous studies focused on career paths and achievements, little is known about the views of physics teachers and students on gender differences in their physics classrooms. In the remainder, we will focus on two factors that have often been mentioned as being potentially important to explain gender differences: students' learning characteristics [17–19] and teacher–student interactions [9,20,21].

1.1. Students' Learning Characteristics

Gender differences in the physics classroom may have origins in student learning characteristics. Several studies have shown that girls differ from boys in learning characteristics, such as self-efficacy, self-discipline, learning strategies, motivation, deep understanding and competition.

Concentration and motivation can result in more self-discipline, or vice versa. Duckworth and Seligman [17] report girls having more self-discipline and scoring higher on regular tests. Although their research was conducted for algebra, English and social studies, it shows a more general trend of girls having more self-discipline and scoring higher on their achievement tests but achieving lower than boys on intellectual ability tests. Wetering and Groenendijk [22,23] state, based on their own teaching experiences, that boys are motivated less easily than girls, although boys can be motivated by a positive approach through a compliment and the feeling of being taken seriously as a person more. When a teacher gives a high grade, boys still want confirmation from the teacher that they performed well [22]. Girls having more self-discipline may originate from having to compensate for less self-efficacy or feeling more anxiety [19]. Studies by Kalender et al. [18] and Udo et al. [24] found that female (university) students experience significantly lower self-efficacy in physics than boys, even when they perform equally well. Hänze and Berger [19] report on gender differences in teaching settings, where girls feel more competent when engaging in cooperative learning than in a traditional setting. Day et al. [25] and Labudde et al. [26] concluded that for learning physics, girls report lower self-confidence than boys. Stadler et al. [21] state that teacher–student interaction, where boys tend to lead, may confirm girls in their limited self-confidence.

In addition to having more self-confidence, boys in Dutch secondary education reportedly feel more solid in their emotions than girls. Havik and Westergård [27] report girls having significantly more behavioral engagement than boys. Boys feel motivated by competition [28,29]. With this competitive spirit, boys also bring more energy into the classroom [30]. Competing, for example in teams, can have a positive effect on boys' performance, while girls profit more from other activities [31].

1.2. Teacher–Student Interaction

Gender differences in the physics classroom can be a result of how teachers deal with boys and girls but can also have an impact on the teachers themselves. We discuss two sections to address these interactions: characteristics of the teacher influencing students (gender, expectations) and gender of the students influencing teachers (behavior).

Characteristics of the teacher influencing students: Teachers' gender. The gender of the teacher has an impact on students, both by acting as a role model and by encouraging stereotypes among students on gender. According to Bottia et al. [32], when students have a female physics teacher, boys are not (negatively) affected, but girls are more likely to graduate with a science degree. Udo et al. [33] also found that girls benefit from a female teacher in an interactive course, but they state that, conversely, boys benefit from male teachers. In their study, they concluded that girls have more anxiety for physics courses, and gender is a major predictor of science anxiety. Carrell et al. [34] state that girls who are good at mathematics perform better in mathematics and science classes when they have a female teacher, while for boys, the teacher's gender has little impact. However, Potvin and Hazari [35] state that, in general, female physics teachers receive lower scores on student evaluations from both boys and girls. This effect is stronger for students with a strong affinity for physics. Van Maele et al. [9] found that female teachers (not necessarily physics teachers) score higher than their male colleagues in providing structure and a learner-centered teaching style. Male teachers score higher than female teachers on autonomy support, task orientation, achievement orientation and learner-centered teaching style.

Characteristics of the teacher influencing students: Teachers' expectations. Teachers relate students' competencies to students' gender, as concluded by Newall et al. [20]. This can affect educational opportunities because of receiving unequal treatment from the teachers. In their study, they observed that (aspiring) teachers perceived girls as less capable in physics compared to boys, leading to these teachers offering less scientific information to female students. Girls who perform lower than boys receive more simplified feedback, like less scaffolding, but no emotional support from their teachers. Klapp and Jönnson [36] say that the lack of emotional support and simplified feedback can have unfavorable outcomes for students' learning and motivation. Teachers may also have (unconscious) prejudices, believing that boys are better in physics than girls, as stated by Van Maele et al. [9]. These prejudices can be strengthened by what students say, according to Stadler et al. [21]. On the contrary, predisposed teachers could also expect that boys are more likely to underachieve than girls based on their behavior [37]. Teachers' implicit gendered beliefs can influence their views and evaluations of male and female students [38]. Although their research was carried out on mathematics and Dutch teachers, we can apply the conclusions to other STEM subjects. This implies that teachers' expectations of students can affect students in their learning opportunities.

Gender of the students influencing teachers: Behavior. Both the teacher's teaching and interaction style, which have an impact on student learning, may be influenced by student gender. This concerns the teaching skills of the teacher, the flexibility of the teacher and the way the teacher asks questions to students and supports them. Labudde et al. [26] concluded that the skills of the teacher in explaining physics and working with the students improve students' attitudes and achievements in physics. Girls prefer teaching methods with more interaction, like discussions and group projects [19], while boys have no preference [19] or prefer traditional teaching methods [39]. Boys favor lectures by the teacher that are passive, such as the use of handwritten notes, while girls prefer more active lectures with more student interactions. Boys also favor student presentations and hands-on experiential activities with three or more students over girls, which calls on the ability of teachers to offer these different varieties [40]. Belfi [41] claims that teachers who use diverse teaching methods meet the needs of students, which supports equal opportunities for all students. We are aware that while students may have preferences, matching preferences does not ensure better learning [42].

Physics teachers tend to let boys overpower the conversations between teachers and students. Consequently, in these conversations, boys answer more questions. Stadler et al. [21] found that closed questions are answered more by boys (in technical terms), while girls participate more in open questions (phrasing). For the teacher, a longer answer is more difficult to process and apply in class than a short answer. This can create an imbalance between boys and girls [43]. Teachers (not restricted to physics) can help in their interactions with students to give them a more positive feeling about school.

1.3. Scope of the Present Work

In sum, influencing factors on gender differences in the physics classroom are students' learning characteristics and teacher–student interaction. Boys and girls differ in their learning characteristics mainly in the areas of self-discipline and self-efficacy. The teachers are the persons who are the facilitators of science learning in the classroom, setting in place contextual factors that can promote science culture in the classroom, which can increase student interest [39]. However, the teacher's role is not always used to its full potential and can cause gender differences in the physics classroom. We described two sections of differences in teacher–student interaction: characteristics of the teacher influencing students, addressed as the gender of the teacher and expectations of the students by the teacher, and characteristics of the students influencing teachers through their behavior, addressed as teaching and interacting by the physics teacher.

The differences in physics classrooms between boys and girls highlight the need to create gender-equitable physics education. This study aims to add to this body of literature by exploring physics teachers' and students' perspectives on gender differences in Dutch upper secondary physics classrooms, with a focus on students' learning characteristics and teacher–student interaction. Therefore, we seek to answer the following research question: What are students' and teachers' views on gender differences in upper secondary physics education?

2. Materials and Methods

This section consists of two parts. Respondents and procedures are introduced from the perspective of students (Section 2.1) and physics teachers (Section 2.2). Participation was voluntary, and informed consent was obtained from all participants in this study (teachers, students or parents of students below the age of 16) in accordance with the ethical guidelines from the Tilburg School of Humanities and Digital sciences from Tilburg University.

2.1. Students

2.1.1. Respondents

Students (N = 212) were invited to complete an online questionnaire via their teacher. All physics teachers who had been invited to participate (as described in the next section) were asked to invite their students to complete the questionnaire. In addition to these physics teachers, teachers of other subjects who were willing to have physics students from their class complete the questionnaire were included. Teachers either asked students to fill out the questionnaires in their classroom or asked them to complete them at home.

A total of 225 students started the questionnaire, seven of whom did not have physics in his/her curriculum or did not have permission from their parents. Another nine students were excluded from the dataset because they did not give consent to share their answers with the researchers. Lastly, we checked whether participants had answered the main question on gender, and this resulted in 212 eligible participants.

The participating 212 students consisted of 128 boys and 84 girls, which is representative of upper secondary physics students, as this matches the relative distribution in the OMO dataset (N = 15,660, boys 56% and girls 44%). The ages of students ranged from 13 to 20, with an average of 16.6 years. Students were all in the two highest levels of Dutch secondary education (i.e., HAVO or VWO). Almost all students were in a curriculum in the field of science, namely science and health (NG) or science and technology (NT, in which physics is an obligatory subject). Only five students were in the curriculum of economics and society (EM). Details can be seen in Table 1.

Table 1. Descriptions of students.

		Boys		Girls		All Students	
		N = 128		N = 84		N = 212	
			(60%)		(40%)		
Age (year)		16.6		16.5		16.6	
Grade	4	31	(15%)	26	(12%)	57	(27%)
	5	67	(32%)	37	(18%)	104	(49%)
	6	30	(14%)	21	(10%)	51	(24%)
Educational level	HAVO	52	(25%)	30	(14%)	82	(39%)
	VWO	76	(36%)	54	(26%)	130	(61%)
Subject combination	NTNG	48	(23%)	42	(20%)	90	(42%)
	NT	61	(29%)	10	(5%)	71	(33%)
	NG	15	(7%)	31	(15%)	46	(22%)
	EM	4	(2%)	1	(.5%)	5	(2%)

2.1.2. Procedure: Students' Questionnaire

Students first had to respond to background questions regarding gender, age, grade, educational level and chosen subject combination. To obtain insight into students' experience, the questionnaire continued with an open-ended question: "Do you experience differences between boys and girls when it comes to physics? Write down your own experience below:" This question had the purpose of obtaining a prompt response from the students on gender differences in their classroom.

The questionnaire continued with closed questions on student learning characteristics (e.g., physics topic preferences, self-efficacy and learning strategies), teachers and learning materials, with a total of 64 items. These closed questions were based on the previously validated questionnaire of Tuan et al. [44], which was translated into Dutch [45]. In the current study, however, we use only the question of whether and how the respondents experience gender differences in the physics classroom.

Before distribution, the questionnaire was pretested with five secondary school students who provided us with useful feedback. These students appreciated the short sentences and the layout that was easily used on their smartphones. It was observed that the questionnaire was not too long, and everyone could complete it within 10 min. This pilot provided confirmation of the estimated time frame and led to improvements in the wording of some items. In addition, we informed the teachers about the time frame, so they could (and mostly did) spend 10 min of the lesson time to facilitate students to complete the questionnaire.

2.1.3. Students' Questionnaire Analysis

The student questionnaires were created and run using the Qualtrics [46] software tool and distributed by the teacher to the students (text message, mail or QR-code). Students' answers to the open question were translated from Dutch to English with support from DeepL [47] software and were checked by an English teacher with a master's degree in Teaching English as a Foreign Language. For further qualitative analyses, we used ATLAS.ti [48] (version 23.3.4), a qualitative data analysis software.

Responses to the question regarding the views of students on differences between boys and girls in their classroom were categorized as "yes difference" or "no difference". The yes or no question was analyzed using a one-sample proportion test. The open-ended answers were coded by using a fusion approach of deductive and inductive coding. We used a grounded approach in which codes were derived from the data. In the next step, these detailed codes were categorized into broader categories. Finally, these categories were assigned to one of the two factors which were derived from the literature: student learning characteristics and teacher–student interactions. The final codes that resulted from coding both the students' and the teachers' questionnaires can be seen in Table 2.

Table 2. Final codes of the open-ended answers of students and teachers.

Factors	Categories		Codes *
Student learning characteristics			
	Talent for and interest in physics		
			Boys/girls are better
			Curiosity and interest in physics
			Deep understanding
			Performance
	Way of learning		
		Effort	
		Self-regulation	
			Attention
			Concentration
			Motivation
			Planning
			Serious
			Structure
			Self-efficacy
		Learning attitude	
			Diligent
			Neat
			Precise
		Learning strategies	
			Memorizing
			Summarizing
		Start by acting	
			Fast
			Practical
			Trying
			Non-overcomplicate
	Behavior in class		
			Active in class
			Bored
			Chatting/giggling/making noise
			Competition
Teacher–student interactions			
	Asking questions by the student		
	Answering questions by the student		
	Teacher treats equally		
Other	Classroom composition		

* Open-ended answers are coded according to these codes. Each code subsequently specified whether this is 'boys more', 'girls more' or 'equal'.

Interrater reliability was calculated by comparing the coding performed by the first and second authors, as described by Friese [49]. The first author coded and created a codebook in ATLAS.ti. Before sending the project to the second author, the codes were removed, but the codebook and quotations were kept. Then, the second author coded a randomly assigned part (17%) of the project, and the initial inter-coder reliability was 73%. Then, the results were compared, discussed and revised so that inter-coder agreement was reached.

2.2. Physics Teachers

2.2.1. Respondents

Physics teachers (N = 72) were also invited to complete an online questionnaire. The questionnaire was shared in a private Facebook group for Dutch physics teachers ("Vaksteunpunt Natuurkunde"), published on the personal LinkedIn of the first author and distributed by email. All (HAVO/VWO) schools (N = 27) of conglomerate OMO received an email, as well as teachers from the personal network of the first author. This led to a respondent group of 72 physics teachers, consisting of 48 males and 24 females. One respondent could not be included as gender was not specified. The sample consisted of 56 teachers (17 female, 39 male) with a first degree teaching qualification (qualification needed for teaching in upper secondary education, which can be obtained through a professional or university master's program [50]). A total of 15 teachers (7 female, 8 male) had a second degree teaching qualification (qualification needed for teaching lower secondary education, which can be obtained through a professional bachelor's program [50]). One teacher did not have a teaching qualification. The participants had an average of 15.8 years of teaching experience, of which men had 16.1 years and women 15.3 years. Teachers with a first degree teaching qualification had an average of 17.3 years of teaching experience, teachers with a second degree had an average of 11.4 years and the unqualified teacher had eight years of teaching experience.

2.2.2. Procedure: Teachers' Questionnaire

The questionnaire for the teachers started with three background items: (1) gender, (2) teaching qualification and (3) teaching experience. The main question was designed to obtain a spontaneous answer to the question of whether or not teachers experience differences between boys and girls in their classrooms. After their answer to this yes or no question, teachers were asked to comment on their answer.

The questionnaire continued with closed and open questions on student learning characteristics (e.g., physics topic preferences and teaching method preferences), teachers (e.g., being a role model and asking questions) and learning materials, with a total of 49 items. These additional questions were not included in this study because we intended to focus on teachers' spontaneous responses to possible differences between boys and girls in the physics classroom.

2.2.3. Teachers' Questionnaire Analysis

The teacher questionnaires were again made in Qualtrics and distributed through mail. Further, the same procedure was used as in the students' questionnaire, using Jamovi and ATLAS.ti. Responses to the questions were analyzed in the same way as the students' answers. To this end, a randomly assigned part (19%) of the project was sent to the second author. In coding the open-ended answers, the codebook of the students' questionnaire was used as a starting point, but when 'new' answers arose, additional codes were made. The final codes that resulted from the different cycles of coding of the students' and the teachers' questionnaires are shown in Table 2.

Interrater reliability was calculated by comparing the coding made by the first and second authors, using the same procedure as described earlier in the student section. The initial inter-coder reliability was 69%, after which the codings were discussed and revised in order to reach an inter-coder agreement.

3. Results

Table 3 shows how gender differences in physics classes are experienced by teachers and students. A large majority of 85 percent of physics teachers experience differences in their classrooms, while 15 percent of the teachers do not. Students' answers to the question "Do you experience differences between boys and girls when it comes to physics?" showed that a small majority experience no differences between boys and girls, but about 43 percent of the students experience a difference.

Table 3. Experience of gender difference in physics classes by physics teachers and students.

Participants	Difference	No Difference	Neutral
Teachers	61 (85%)	11 (15%)	
Teachers: male	41 (85%)	7 (15%)	
Teachers: female	20 (83%)	4 (17%)	
Students	91 (43%)	119 (56%)	2 (2%)
Students: boys	53 (41%)	73 (57%)	2 (2%)
Students: girls	38 (45%)	46 (55%)	

The answers of the teachers and students to the open-ended questions on gender differences provide us with a more detailed insight into their experiences. Their responses were coded and grouped into factors and categories.

Comparing the open answers of students and teachers, we noticed that students gave direct and straightforward answers, while teachers described their answers more extensively. Teachers' and students' views on gender differences in their physics classes point to a number of themes, which are previewed below in two quotes. Characteristics of the students (gender, age, grade and educational level) and teachers (gender, teaching qualification and years of teaching experience) are shown below the quotes.

> "*Boys are better, girls study harder*."
>
> Student (boy; age 17; grade 5; VWO)

> "*Boys are more likely to feel confident in the subject. Girls more often assume they can't do it. Girls often choose it because they need it for further education, boys because they like it*."
>
> Teacher (male; 1st degree; experience unknown)

In the open-ended questions, both students and teachers made comments about student learning characteristics and teacher–student interactions, the factors we previously identified in the literature [9,17–21]. We also found comments that could not be categorized. We discuss the open answers below.

Within the factor student learning characteristics, three broad categories emerged from the analysis: talent for and interest in physics, way of learning and behavior in class. Table 4 shows the first category: talent for and interest in physics. This table (and the next ones) is organized into factors, then categories with possible subcategories and, finally, the codes. The number indicates how often an answer was given; the percentage indicates the frequency relative to the total (sub-)group.

Table 4. Teachers' and students' coded answers on the experience of gender differences in the physics classroom in the category: talent for and interest in physics.

			Students						Teachers		
			Girls			Boys					
Factors	Categories	Codes	*N* = 84			*N* = 128			*N* = 72		
			Boys more	Girls more	Equal	Boys more	Girls more	Equal	Boys more	Girls more	Equal
Student learning characteristics											
	Talent for and interest in physics										
		Boys/girls are better	8 (10%)	1 (1%)		10 (8%)	1 (<1%)				
		Curiosity and interest in physics	7 (8%)			4 (3%)		2 (2%)	5 (7%)		
		Deep understanding	5 (6%)			6 (5%)		1 (<1%)	9 (13%)		1 (1%)
		Performance	2 (2%)	1 (1%)	2 (2%)	6 (5%)	2 (2%)	4 (3%)	2 (3%)	2 (3%)	

This first category, talent for and interest in physics, was indicated in the answers by students and teachers in wordings such as "instinct", "talent", "more interested" and "being better". Nine percent of the students commented that "boys are better in physics", and less than one percent said that girls are better. A total of 11 students (5%) and 5 teachers (7%) responded that boys have more curiosity and interest in physics than girls. Boys are also viewed as having more "deep understanding": 11 students (5%) and 9 teachers (13%) indicated this as a difference between boys and girls in the physics classroom. Performance in physics was mentioned 15 times to be different, but six participants indicated performance as equal.

> "*Girls are slower to understand and need much more explanation*."
>
> Student (boy; age 18; grade 5; HAVO)

> "*Yes, boys are usually more likely to understand because they have a talent for it*."
>
> Student (girl; age 16; grade 5; VWO)

> "*Not really because I work with girls a lot. In my opinion, boys are more likely to think they understand the material when they don't*."
>
> Student (girl; age 17; grade 6; VWO)

> "*Girls are more serious, but also ask questions about details. Boys more deep understanding*."
>
> Teacher (male; 1st degree; experience unknown)

> "*There are more boys with high grades than girls, even in a class of equal numbers. Among weak learners, girls and boys perform equally well*."
>
> Teacher (female; 1st degree; experience 9 years)

The second category, way of learning, was indicated in very different wordings in the answers of students and teachers. Five subcategories therefore emerged under this category: effort, self-regulation, learning strategies, learning attitude and start by acting. This is shown in Table 5.

Table 5. Teachers' and students' coded answers on the experience of gender differences in the physics classroom in the category way of learning and subcategories effort, self-regulation, learning strategies, learning attitude and start by acting.

				Students						**Teachers**		
				Girls			**Boys**					
Factors	**Categories**		**Codes**	***N* = 84**			***N* = 128**			***N* = 72**		
				Boys more	Girls more	Equal	Boys more	Girls more	Equal	Boys more	Girls more	Equal
Student learning characteristics												
	Way of learning											
		Effort			2 (2%)	1 (1%)	2 (2%)	5 (4%)		3 (4%)	23 (32%)	
		Self-regulation										
			Attention		1 (1%)			1 (<1%)	1 (<1%)			
			Concentration		1 (1%)			1 (<1%)			3 (4%)	
			Motivation							1 (1%)	5 (7%)	
			Planning					1 (<1%)		1 (1%)	7 (10%)	
			Serious								5 (7%)	
			Structure								2 (3%)	
			Self-efficacy	1 (1%)			1 (<1%)			15 (21%)		
		Learning attitude										
			Diligent								1 (1%)	
			Neat		1 (1%)			1 (<1%)			7 (10%)	
			Precise					3 (2%)			5 (7%)	
		Learning strategy										
			Memorizing								1 (1%)	
			Summarizing					1 (<1%)			3 (4%)	
		Start by acting										
			Fast	3 (4%)			2 (2%)	1 (<1%)				
			Practical				1 (<1%)			6 (8%)		
			Trying							3 (4%)		
			Non-overcomplicate				2 (2%)					

Female students showing more effort was most frequently (32%) mentioned by teachers as an indicator of difference. Five boys and two girls experienced this difference too.

> "*Effort of the girls. Different expression of insecurity. Different approach to physics content*."
>
> Teacher (female; 2nd degree; experience 22 years)

"*Girls often learn very hard and are very focused on the test result, and less on understanding the material*."

Teacher (male; no degree; experience 8 years)

The second subcategory, self-regulation, is described by Zimmerman [51], p. 65, as "self-generated thoughts, feelings, and behavior that are oriented to attaining goals" and includes a wide range of features that were also named by students and teachers. Terms like "attentive", "planning", "structure" but also "self-efficacy" were mentioned. Most of these features were in favor of girls: "planning" is more for girls was said by 10 percent of the teachers, and girls have more "motivation" and are more "serious" was said by five teachers each (7%). On the contrary, self-efficacy was mostly attributed to boys by 15 teachers (21%).

"*Boys better of course, girls learn better so scores are about equal*."

Student (boy; age 16; grade 5; VWO)

"*Boys are more likely to be lazy and seem to experience little stress. They are more confident. . . .. During tests, girls are often very insecure*."

Teacher (male; no degree; experience 8 years)

"*On average, girls work much neater and more precisely than boys. They also plan better. Furthermore, they are generally slightly more insecure about their own talents than boys. They underestimate their own understanding of the subject, while boys sometimes overestimate their knowledge*."

Teacher (male; 1st degree; experience 28 years)

Learning attitude as the third subcategory of the category way of learning was described in the words "diligent", "neat" and "precise". Most mentioned by teachers were "neater" by 10 percent and "precise" by seven percent. All the descriptions were assigned to girls.

"*When I make a lab report I work with **** and she always makes the layout a lot nicer. I often fill in the content and she does the layout*."

Student (boy; age 18; grade 5; VWO)

"*Girls work more neatly but are less likely to see how to get to the answer when having to take several thinking steps*."

Teacher (male; 1st degree; experience 9 years)

Learning strategy, as the fourth subcategory of the category way of learning, contained the answers "memorizing" and "summarizing". All answers in this subtheme pointed to girls using more of these learning strategies.

"*Girls are more obedient and modest. Make more summaries, have done more homework. Boys are bolder and more playful. But perhaps, they are more attuned to what is essential*."

Teacher (female; 1st degree; experience 9 years)

"*Girls often have whole summaries and work very precise. Boys often work at physics for a very long time*."

Student (boy; age 17; grade 6; VWO)

Start by acting, as the fifth subcategory of the category way of learning, is described in answers with "faster", "practical, "trying" and "non-overcomplicate". Eight percent of teachers mentioned boys being more comfortable in practical work, such as lab experiments. Three teachers (4%) said that boys try more, while girls are more hesitant.

"*I notice that girls more often want to keep their own overview and ask too many questions, as it were, thus making it more complicated for themselves*."

Student (boy; age 16; grade 6; VWO)

"*Stereotypical: boys are restless, try without thinking, girls are more reserved, more thoughtful but show little courage in experimentation*."

Teacher (male; 1st degree; experience 12 years)

"*Girls take notes more often during instruction. Boys answer questions more easily (even if the answer is wrong). Girls more often complete the homework completely where boys more often complete only the most difficult assignments (which is an option in my classes).*"

Teacher (female; 1st degree; experience 10 years)

"*Generally speaking, boys use the experiments to figure things out while girls memorize theory. Once the students are better at physics (more analytical), there is less difference. So, the differences are more evident in the 'low performing' students.*"

Teacher (female; 1st degree; experience unknown)

Table 6 shows the category: behavior in class, which is part of the factor of student learning characteristics.

Table 6. Teachers' and students' coded answers on the experience of gender differences in the physics classroom in the category of behavior in class.

			Students						Teachers		
			Girls			Boys					
Factors	**Categories**	**Codes**	*N* = 84			*N* = 128			*N* = 72		
			Boys more	Girls more	Equal	Boys more	Girls more	Equal	Boys more	Girls more	Equal
Student learning characteristics											
	Behavior in class										
		Active in class				1 (<1%)					
		Bored	1 (1%)								
		Chatting/giggling/making noise			1 (1%)	1 (<1%)	2 (2%)			1 (1%)	
		Competition							1 (1%)		

Behavior in class, as the third category of student learning characteristics, was not mentioned very often. Descriptions used were "active in class", "bored", "chatting/giggling/making noise" and "competition".

"*Boys are more bored because they are better at understanding the material while girls pay more attention and participate in class.*"

Student (girl; age 18; grade 6; VWO)

"*Boys are bolder and more playful. But perhaps, they are more attuned to what is essential.*"

Teacher (female; 1st degree; experience 9 years)

"*Boys are more likely to be lazy.*"

Teacher (male; 1st degree; experience 8 years)

Table 7 shows the factor of teacher–student interactions.

Table 7. Teachers' and students' coded answers on the experience of gender differences in the physics classroom in the factor of teacher–student interactions.

			Students						Teachers		
			Girls			Boys					
Factors	**Categories**	**Codes**	*N = 84*			*N = 128*			*N = 72*		
			Boys more	Girls more	Equal	Boys more	Girls more	Equal	Boys more	Girls more	Equal
Teacher–student interactions											
	Asking questions by the student					1 (<1%)	1 (<1%)		1 (1%)	3 (4%)	
	Answering questions by the student								1 (1%)		
	Equal treatment by teacher				1 (1%)			1 (<1%)			

Teacher–student interactions, as the second factor, includes answers in the categories "asking questions by the student", "answering questions by the student" and "treatment by teacher".

"*Girls are quieter in class than boys, but boys dare to ask more questions than girls.*"

Student (boy; age 16; grade 4; HAVO)

"*Girls are more serious, taking notes and asking questions. Boys do this less often, they also work in a less structured way*."

Teacher (female; 2nd degree; experience 19 years)

There were 18 answers (8%) that could not be coded as belonging to one of the factors or categories. These answers were all comments on classroom composition regarding the number of girls and boys in the classroom. Students remarked 15 times that there were more boys than girls in the classroom, one said that there were more girls and two comments stated that the number was equal.

"*I do notice that there are more boys than girls*."

Student (girl; age 17; grade 5; HAVO)

"*Yes, there are no girls in my class*."

Student (boy; age 16; grade 5; HAVO)

In the answers of the participants to the open-ended question on gender differences in the classroom, we noticed a difference between the answers of teachers and students. Students answered shortly and directly, while teachers elaborated more. Their answers fitted in the factors of student learning characteristics and teacher–student interactions and were coded into relevant categories and subcategories. The perspectives of teachers and students on gender differences in their physics classroom were most pronounced with regard to student learning characteristics: boys are considered as most interested in physics, having the deepest understanding, being "better" generally and being more comfortable with practical work. Girls are described as showing more effort, more planning, having more motivation and working more neatly and precisely.

Together these results provide useful insights into teachers' and students' views on gender differences in the physics classroom. The results indicate that teachers and students experience differences between boys and girls but not necessarily in the same areas or to the same extent. Next, we move on to discuss these results in relation to the existing literature, and we will discuss their implications for improving school practices.

4. Discussion and Conclusions

Prior work has shown that gender differences are present in education [2–7]. The focus of most studies has been on differences in career paths and achievements, but less is known about the perspectives of teachers and students on gender differences. Therefore, the present study aimed to investigate students' and teachers' views on gender differences in the Dutch upper secondary physics classroom. By asking them to describe their own experiences, we received rich content and valuable insights. The first outcome was the observation that students' open-ended answers were more straightforward, whereas teachers elaborated more. Therefore, teachers' answers could be analyzed with a more varied set of codings than students' answers. The elaborated answers of physics teachers and students on an open-ended question were first categorized into two main factors: students' learning characteristics and teacher–student interactions. The largest part of the answers was concerned with students' learning characteristics, in which three categories could be distinguished: talent and interest in physics, way of learning and behavior in class. A smaller part of the answers was in the area of teacher–student interactions. In addition, a number of answers commented on classroom composition, mainly stating that there were more boys than girls in the classroom.

Though the results of our study may be specific to the educational system and gender-specific situation in the Netherlands, the results confirm that gender differences continue to exist in the upper secondary physics classroom yet tend to vary in interesting ways between teachers' and students' perspectives. A large majority of physics teachers report experiencing differences between boys and girls in the physics classroom. This contrasts with the students' reactions, as less than half of the students experience gender differences, albeit girls report slightly more differences than boys.

Concerning students' learning characteristics, gender differences are present according to both teachers and students. Teachers and students may differ in the extent of experiencing gender differences; among the students, boys and girls gave nearly identical answers. The main argument raised by students, see Figure 1, is that boys have more talent and interest in physics.

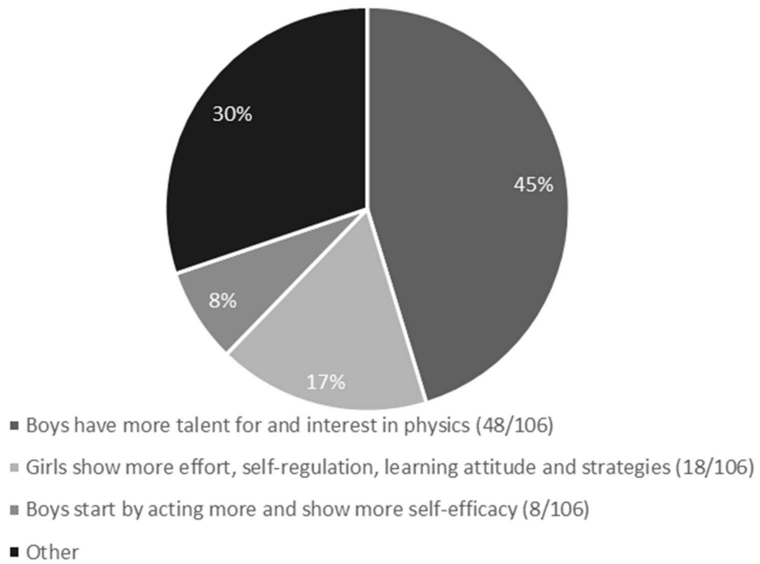

Figure 1. Students' most given responses.

More specifically, boys are perceived to be more curious and interested in physics and have a deeper understanding and higher performance than girls. Teachers turn out to seek arguments for the gender difference in other areas: effort (girls more) and self-efficacy (boys more), see Figure 2.

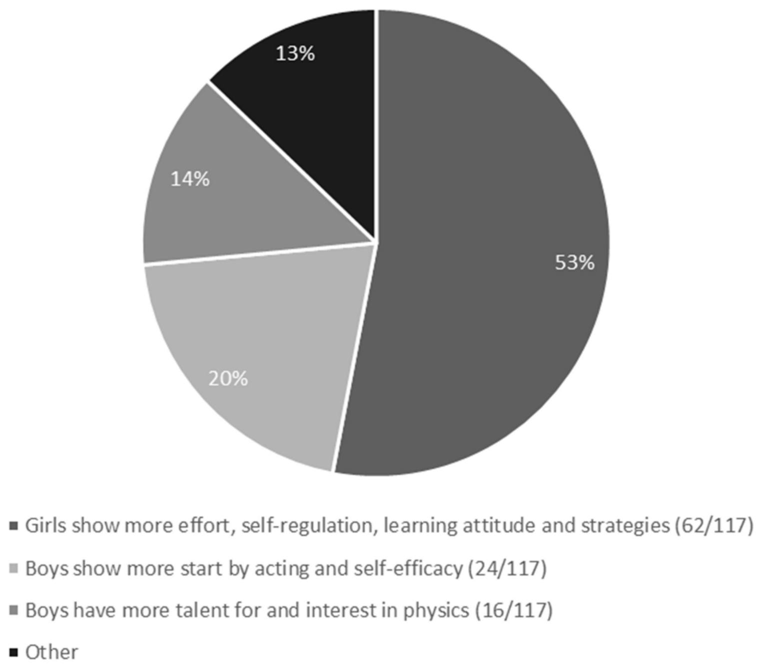

Figure 2. Teachers' most given responses.

Our results confirm the results of Jungbluth [52] and Bergh et al. [53] that girls show more effort and work more neatly, as indicated by both teachers and students. Teachers report girls having less self-efficacy in physics. This result, in addition to the statement that girls are more anxious, diligent and hard-working, meets the findings of Perander et al. [54] and Britner et al. [55].

In addition to the data collected through the questionnaire, we have produced a unique dataset based on the spontaneous and self-described responses, which gives valuable insights into the thoughts of teachers and students. There is a remarkable gap between what students and teachers experience, which obviously begs the question as to what causes these different views and how it is possible that they experience it so differently. Future studies may be focused on whether the differences are due to teachers perhaps being more conscious of gender issues or whether this is just a difference between generations being asked about gender. Possibly, teachers may also have different expectations for boys and girls, which may influence interaction and teaching (cf. the Pygmalion effect [56,57]).

The results of our research may eventually lead to gender-specific interventions that may improve teachers' classroom practices. Teachers, after all, are in a special position to influence new generations of students, as Larsson and Danielsson concluded [58].

This study focused on gender differences in the areas of student learning characteristics and teacher–student interactions. Additional research is needed to better understand the differences between boys and girls in the upper secondary physics classroom. Follow-up research within this research project aims to determine the physics classroom practices and will conduct interviews with physics teachers and students through focus groups and examine classes through classroom observations. We will also address the gender balance in learning materials. We hope to eventually be able to contribute to providing teachers with guidelines to be used in their physics classrooms.

Identifying possible gender differences can lead to more awareness among physics teachers about how to address students in their classrooms. This study is a step forward to gender-equitable physics education, in which all students are given the best opportunities.

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