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The Influence of the Teacher's Sex on High School Students' Engagement and Achievement in Science

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ABSTRACT

The purpose of this article is to explore relationships between teachers' sex and a range of variables relating to adolescent students' perceptions of their classroom engagement, quality of teaching and responses to their teacher, and their own achievements in science. A cross-sectional survey of 798 Norwegian students showed the potential influence of the sex of the teacher on engagement, motivation, volition, and learning outcomes which was estimated after they had known their teachers for six months. The conclusion is that there are interesting interactions between the sex of students and the sex of science teachers in high school along some dimensions. The statistical significant findings support the sex-stereotypic notion, while there are also tendencies supporting the sex-opposite notion. However, in most instances significant interactions between teacher sex and student sex are not established. The conclusion is more nuanced than in earlier studies. Study shortcomings and implications for the practice of future research are discussed.

KEYWORDS

Teachers' gender; teacher behaviour; student engagement; classroom interaction; student-teacher relationship; teacher influence; science.

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INTRODUCTION

Cochran-Smith and Zeichner (2005) claim that it is now widely agreed that teachers are among the most, if not *the* most, significant factors in children's learning. The question is what aspects about the teacher exactly have meaning with respect to the students' learning outcomes. The purpose of this study is to investigate what influence a science teacher's sex has on high school students' engagement and achievement in the Norwegian cultural context.

In gender theory, a distinction is made between sex and gender (Butler, 1990; Glasser and Smith, 2008). It is argued that certain traits vary significantly among persons of the same sex, and that gender is socially constructed, rather than primarily being connected to biological artifacts: '(T)he term (gender) holds promise for studies of the norms and expectations that influence people's behaviors in social contexts, including school classrooms' (Glasser and Smith, 2008, p.349). Hence, it may be more informative to focus on the notion of a social gender. However, to reduce the complexity of the research design in this study, we have chosen to focus on sex rather than gender. We would also argue that insights offered through a focus on sex are still valuable and important. When we say that we use biological categories to determine student responses, we – and other researchers - argue that male and female students also respond to teachers on their biological differences or similarities (Einarsson and Granström, 2002).

A considerable amount of literature investigates the effects of both teacher and student gender and sex on achievement. Sabbe and Aelterman (2007), for example, claim that 'so far gender difference research has not been able to uncover clear differences between male and female teachers' (p. 527). On the other hand, Li (1999) finds that teaching is imbued with gender. Other researchers found that a teacher's sex does have some influence over students' attitudes (for instance Evetts, 1993).

To what extent and how a teacher's sex can affect the students' learning process will also depend on a series of relationships, which may include a student's age, cultural characteristics and other social conditions that can vary from culture to culture. Studies have found that students' motivational orientations typically change with age (Eccles et al., 1993). In the early primary grades, teachers would likely be the targets of students' emotional projections. During adolescence, however, students are more likely to distance themselves from teachers and other adults, i.e. their own parents. The influence of a teacher's sex can therefore develop differently in high school (16-19 year olds) than it does in primary school (6-12 year olds). At

the same time, one finds studies that demonstrate a significant influence of a teacher's sex also in high school (Martin and Marsh, 2005).

One can find unique features in individual countries' schools that influence teachers' opportunities to affect students. For example, the relationship between the teacher and students is tested when faced with disorder and disruption in the classroom. International large scale studies, for example the Programme for International Student Assessment (PISA), show that students attending lower secondary schools (13-15 years olds) in Norway score high in the category of disorder and disruption (OECD, 2001).[1] Furthermore, the Trends in Mathematics and Science Study (TIMSS) shows that the Norwegian lower secondary students score relatively low in science achievement (achievement tasks). However, they score high in the areas pertaining to academic self-concept (Mullis et al., 2004). As such, the conditions for teachers' influence on students' academic work could be seen as challenging in the Norwegian school context. Classroom interactions can develop as a tug-of-war affected, in part, by conflicts of interest between high-school students and the teacher (Elstad, 2002). How a teacher manages such situations would obviously have significant effects on the students' impressions of the teacher. A number of teachers may resort to the execution of power and boundary setting, while others will attempt to build positive relationships by demonstrating empathy and providing emotional support.

This article investigates relationships between teacher's sex and high school students' perceptions of their own engagement in science, which energize their learning. Science is a compulsory subject[2] in the first year of high school in Norway, and this article is related to 16 year old students' engagement and achievement and how they perceive the teaching quality of their teachers.

THEORETICAL FRAMEWORK

High school students' engagement and achievement is influenced by how teachers and parents energize academic work. Adults do not assert their influence over children in a vacuum. Rather, attempts to execute power are based on the upbringing mandate of the school and the home. On the other hand, the relation between parents and children is interwoven by emotions. The interdependency between teachers and students are characterized by the same entanglement of both cognitions and emotions. These hidden mental processes and states are precursors to academic achievement. Students may respond to teachers according to biological differences or similarities. While students' response to teachers may initially be based on sex, gradually the students get to know their teachers, and their responses may be based more and more on how the teacher responds to them and to the pedagogical quality of the teaching. This aspect may or may not be gendered. It seems plausible that the longer the student knows the teacher, the less important becomes any influence related to sex.

To understand better the complexity of teacher influences, we must build on several strands of different theoretical frameworks. These are theories of rational choice and theories dealing with the influence of social norms and feelings on beliefs and actions (Elster, 2007). Some situations in the classroom invoke the teacher to use forceful language, which allows the teacher to handle various situations that require the execution of power. The following are categories in which a teacher executes power: (1) classroom management (Doyle, 1986) (2) exertion of teacher's pressure or introjected regulation[3] (Rigby et al., 1992). Classroom interactions will at the same time demand that the teacher (3) handles social relations so that relational trust is established (Bryk and Schneider, 2002).

The challenge is that we cannot necessarily claim that 'more is better' with respect to any one of these three categories. For example, strong academic pressure or too heavy discipline can be equally damaging (Ertesvag and Vaaland, 2007). On the other hand, when the teacher applies instruction and leadership following rules and regulations, it may positively affect students' motivation and adaptive learning (Wentzel, 2002).

A vital challenge for the teacher is to develop a *modus vivendi* with the students. Two central attributes of developing *modus vivendi* are building positive relations and building reciprocal trust. A high school student states: "We want to have teachers that are on the same wavelength as us, someone who can communicate with us and understand us. These are the teachers that capture our attention. These teachers extract the best in us and engage us" (Kathrine, 2005). To develop a *modus vivendi* it is important to bolster the student's self-efficacy in the work with the subject, so that the student's vulnerability to failure is reduced (Bandura, 1997).

Teacher professionalism in developing *modus vivendi* is presumed to influence students' mobilization of input. Students that enjoy understanding and kindness from their teacher may be more likely to energize learning in a high-achievement setting. The basis of reciprocal trust alleviates the teacher's influences. Positive relational emotions are essential for a teacher to exercise his or her talents to extract the best from the students, and is therefore of considerable importance. A tight relational bond makes it easier to communicate and articulate mutual expectations between teachers and students, including how to handle disappointments and emphasize a mastery motivational climate that is potentially effective for student learning outcomes. A mastery motivational climate (used for instance in Stornes et al., 2008) is closely related with what is described here as warm-blooded aspects of teacher-student interactions.

A fundamental question relates to the teacher's gender and sex and the significance for how a student perceives the reciprocal trust, and how sex affects the mutual relationship between teacher and student so that a student's learning can be energized. One purpose of this article is to explore the influence of the teacher's sex along several dimensions in the interactions

between a student and his or her teacher. We are particularly interested in differential effects for girls and boys. There is an insufficient knowledge base to articulate crystal clear theoretical expectations. However, in the research literature about the significance of teacher's sex (for instance Martin and Marsh, 2005) we find – among many other distinctions - three important notions: *the sex-stereotypic notion*, *the sex-opposite notion* and *the sex-invariant notion*.

The sex-stereotypic notion is that girls do better (across different school subjects) in classes taught by women, and boys fare better in classes taught by men. Noddings (1984) suggests that female teachers are more caring than male teachers. This hypothesis is often mediated as anecdotes in the media (Carrington and Skelton, 2003) and among teachers (Lahelma, 2000). The role models in socialization have their background in role theory (Merton, 1957), but the idea that teachers are seen as role models to young people, has meagre empirical support (Carrington and Skelton, 2003; Hutchings et al., 2008). However, Martin and Marsh (2005) found that girls, in fact, rate their relationships with female teachers better than they rate their relationships with male teachers.

The sex-opposite notion provided includes commonsense ideas about school girls as seducers, as well as the perception of the stereotype involving female teachers and childish boys (Francis and Skelton, 2001). At the root of these perceptions are the emotional bonds between the teacher and students of the opposite sex, yet it is difficult to find clear evidence of this. Einarsson and Granström (2002) found that male teachers increase the attention in classrooms paid to girls (compared to boys) as the girls get older, while female teachers always give more attention in classrooms to boys than to girls, irrespective of school level. Additionally, teenage boys initiate more interactions with female teachers than their male teachers, compared with girls. Einarsson and Granström (2002) suggest a rather speculative explanation: 'slight elements of sexual enticement could be at work' (p.125), but also other explanations are possible. Younger et al. (1999) found that girls at this age interact in more inquisitive ways.

The sex-invariant notion is the idea that motivation, volition, academic work, engagement and attainment do not vary as a function of teacher sex. It is the nature of pedagogy that is influential and not the sex of the teacher delivering the instruction. The teacher's professional role is to not express preferences for different students. Supporters of this hypothesis claim that there is only minor evidence to assert that a teacher's sex makes any difference to students' educational attitudes and attainment. Lahelma (2000, p.177) found that 'both for the 13-14 year-olds and for the 17-18 year-olds, it was not gender[4] that seemed to be important in young persons' reflections about teachers'. Martin and Marsh (2005) concluded that boys and girls are no more engaged in classes taught by males than they are in classes taught by females: 'the data support the gender-invariant model' (p. 330). Finally,

Ehrenberg et al. (1995) found that matching teachers and students by sex has little effect on achievement.

In our empirical investigation, we explore the extent to which different aspects of teaching qualities interact with the student's sex and the teacher's sex. The research that is cited above includes several age groups. A student's relation to the teacher will typically change throughout the years of formal schooling: 'The familial aspects of schooling are strongest at the primary level, where this transition from family to larger society begins' (Bryk and Schneider, 2002, p.185). For many students, school is a small step out of the intimacy of families over time, and gradually heads into unfamiliar territory. In high school the relationships change further: 'We might expect somewhat diminished salience for this dimension in forming reciprocal trust in high schools' (Bryk and Schneider, 2002, p.185). Research on motivation shows that students typically develop lower motivation for academic work in high school (Ryan and Patrick, 2001).

The conditions for exerting power and building reciprocal trust are dependent on shared social norms, societal values and beliefs. Norway ranks at the top of the sex empowerment measurement[5] among ninety-three countries (UNDP, 2007) and can be characterized as one of the most sex equal societies in the world. From this perspective, we find it of particular interest to study the influence of teachers' sex within Norwegian society, with highly empowered students, because a teacher's enforcement of power must likely be balanced in a considerate way so that it supports good relations with students.

A student's mental processes start with a motivational state. Research distinguishes motivational processes from volitional processes (Kuhl, 1985). This distinction is supported by experiments (Gollwitzer, 1999) and surveys (McCann and Turner, 2004). It is also assumed that the student takes a strategic position with respect to academic work. A student's use of learning strategies influences the learning process (Weinstein et al., 1988).

The concept of teacher behaviour needs to be nuanced. Additionally, governmental educational authority's expectations of teacher conduct have changed. Prior to the autumn of 2001, Norwegian school authorities emphasized a more distant role for teachers to act as guides for students to 'work with problems as they develop'. Current governmental signals point to how teachers should be 'clear', have 'clearly defined responsibilities', exert 'academic pressure to learn' and have 'high academic ambitions.' These explicitly expressed expectations (Ministry of Education, 2003) call for teachers to be able to demonstrate the will to exercise power in classroom interactions, i.e. unemotional responses. On the other hand, students in today's Norwegian schools will not tolerate unreasonable use of a teacher's power. For instance, a nationwide assessment implemented yearly in all high school classes asks the students whether they have been 'harassed by one or more teachers' (Udir, 2008), and this is likely to regulate the teachers'

exercise of power.[6] In addition, the nationwide assessment poses the question: 'Do you have teachers that inspire you to learn?'[7] This line of questioning indicates to students that the teacher's ability to build positive relations is critical to their own success as a student. The teacher has the difficult job of balancing the use of power, awakening students' interests, and building positive relations, while also allowing for student autonomy. The theoretical notions of teachers' conduct we apply in our empirical study are the exertion of the academic pressure to learn, and the exertion of classroom management, influencing achievement norms in the class and building reciprocal trust.

METHODS

The empirical research methodology is based on a cross-sectional survey about how Norwegian sixteen-year-old students evaluate the significance of teachers' behaviours in their own learning process. These constructs are connected to evaluations of individual mental states, such as motivation, volition/self-discipline and the use of learning strategies. In order to avoid a blending of impressions about several teachers, we asked students to evaluate these aspects with respect to one teacher in one school subject, science. We chose to connect our study to high school science, while Norwegian educational authorities have increased the effort to recruit girls to science studies at the university level. How students judged their teacher's abilities to create engagement and interest for the study of science is, therefore, especially interesting. Traditionally, science has been considered masculine, unwelcoming and discriminating to women (Harding, 2008; Rosser, 1990). Some fields of science have been alleged to lack feminine attributes (for instance physics), while topics of biology have more appeal to girls (Sjøberg and Schreiner, 2006). This also makes it of particular interest to study differential sex effects for science teachers. In the questionnaire, the students were also asked to give the grade they most likely will receive in science, based on the tests they had so far. The grades are used as a proxy for the students' achievement. The questionnaire also asked students to evaluate the importance of parental engagement in their schooling.

The survey was implemented in 2008 at seven high schools in the Norwegian capital, Oslo. The participating students had known their science teachers for six months. The students answered a questionnaire in paper format disseminated by a trained data collector.[8] In total, there were forty-eight participating classes taking the common compulsory science course in high school level 1. The students were in five different educational programs. A total of 1112 students took part. The response rate to the survey was close to 100 percent.

The starting high-school students grade score among the seven selected schools in 2007 was 40.9 (average). This is somewhat higher than the average for all high schools in Oslo (39.3). The average point score among the seven schools varies between 37.5 and 44.2. Among all high schools in Oslo, there is a variation between 29.8 and 47.1 in 2007. The selected high

schools do not cover the lowest level of performance, but rather covered the schools with mid- to high-level of performance.

Some classes in the vocational educational programs in our sample turned out to be all boy or girl classes. Therefore, we have chosen to focus on the thirty-three classes with *general academic studies* programs. Here we are talking about a total of 798 students. Within general academic studies programs, all classes are a combination of boys and girls, and hence no science teacher has only been exposed to one sex of students. The percentage of girls in the class varied between thirty and eighty percent.

In our sample, sixty percent of the students are taught by female science teachers and thirty-five percent by male teachers (five percent by both female and male). In Norway, approximately sixty percent of the science teachers in the first year of high schools are male, while there are equal numbers of men and women among all high school teachers (Turmo and Aamodt, 2009).

Instruments

The students responded to a survey that scored learning strategies; motivation/self-discipline; teacher conduct/class environment; teacher-student interactions; and parent engagement. In line with newer research about motivation, learning strategies and self-regulation (Boekaerts et al., 2006), we have focused on subject specific aspects connected to a school subject, in this case science: (1) classroom management (2) exertion of academic pressure to learn in the classroom (that Norwegian school authorities wish should characterize the learning situation). Classroom interaction also demands that the teacher (3) handles social relations so that reciprocal relational trust is established.

We have worked within the test theoretical paradigm (Crocker and Algina, 1986) where psychological constructs are measured by sets of individual questions (items) that are asked of the students. We report the constructs that have worked sufficiently well from psychometric quality criteria (De Jong and Westerhof, 2000). The questionnaire consisted partly of already established measurement instruments that were adjusted to a science subject context (Tangney et al., 2004; Midgley, 2000; Duncan and McKeachie, 2005), and partly of newly developed instruments based on a pilot study that was implemented in Fall 2006.

Students were asked to answer the items using the five-point Likert-scale with the following alternatives: Totally disagree (1), Disagree (2), Neither agree nor disagree (3), Agree (4), and Totally agree (5). The number values presented in the following result from calculated average sets for the individual items that enter into the construct. Table 1 shows the internal consistency of the constructs. The constructs are further supported by examples of individual questions that were posed. The table shows that all of

the reported constructs have a reliability that can be described as satisfactory.[9]

Table 1: Reliability of the constructs measured by Cronbach's alpha (see Crocker & Algina, 1986). N=798.

	Number of questions in construct	**Question samples**	**Cronbach's alpha**
Student engagement			
Copying strategies	2	I often copy homework from others.	0.65
Elaboration	7	I try to see the connections between what I learn in science and what I already know.	0.77
Active engagement	7	When I read a science book, I attempt to repeat to myself what I have learned until I remember it.	0.69
Mastery motivation	3	It is important to learn as much as possible in science this school year.	0.81
Interest enhancement	2	When the science content is boring, it helps to motivate myself by dreaming of the future when I will have an exciting career.	0.67
Perceived relevance of science	2	I think what we learn in science is important.	0.66
Volition	9	The teacher must pressure me so that I complete what is required.	0.79
The influence of teaching			
Exertion of academic pressure to learn	5	The science teacher demands a lot from students.	0.69
Exertion of classroom management	3	There is disorder and disruption when we have science.	0.71
Influencing achievement norms in the class	4	In our class getting good grades is one of the most important things.	0.72

Building reciprocal trust	5	It is ok to discuss feelings, worries, and frustrations with my science teacher.	0.66
Student responses			
Disengagement	4	When the science teacher requests that I work harder, I feel stressed.	0.67
Student commitment	7	The science teacher should tell students that they can perform better.	0.69
Student wants autonomy and empowerment	3	Students themselves should decide when and where they will work.	0.65
Parental influence			
General autonomy from parents	3	My parents allow me to choose my own path in life.	0.79
Parental involvement in schooling	5	My parents ensure that I complete my homework when I come home from school.	0.66

To explore the construct validity of the instruments, a one-way ANOVA was conducted. The ANOVA shows that 5-10 % of the variance lies between the school classes for the constructs in the categories 'Student engagement', 'Student responses' and 'Parental influence'. The corresponding value for the science grade is 10%. As expected, most of the corresponding values for the constructs belonging in the category 'Quality of teaching' are significantly higher. The observed inter-correlations between the constructs in Table 1 vary from -0.27 (between 'Volition' and 'Negative response to pressure') to 0.58 (between 'Active engagement' and 'Elaboration'). Furthermore, we find that the students' perception of the teachers' exertion of academic pressure to learn is not related to the self-reported learning outcomes in science, and the same is the case for the parental involvement in schooling. The strongest predictor of the learning outcomes is students' tendency to respond negatively when confronted with pressure to learn, and this significant relationship ($p<0.01$) is strongly negative (-0.33). But we find positive statistically significant relationships ($p<0.01$) between outcome and students' use of elaboration strategies (0.30), perceived relevance of science (0.28), volition (0.27), and mastery motivation (0.23).

EMPIRICAL RESULTS

Table 2 shows the average values for students being taught by their respective female or male science teachers. Separate values for girls and boys are given in each of these two groups. Sex differences are expressed in terms of effect sizes. Following Cohen (1992), effect sizes can generally be

defined as small (d = 0.2), medium (d = 0.5), and large (d = 0.8). The testing of statistical significance for the differences between the means for boys and girls in the two groups, respectively, is done by t-tests. Statistical significant differences are indicated by * ($p<0.05$) and ** ($p<0.01$). The statistical significance of the interactions between teacher and student sex are tested by two-way ANOVA (F-tests). Statistical significant interaction effects are indicated by * ($p<0.05$) and ** ($p<0.01$). Partial eta-square values from the two-way ANOVA are presented as a measure of effect size.

The results in Table 2 show that boys evaluate their own grade levels significantly higher than girls do in science.[10] However, the difference is correspondingly large within the two groups of students taught by female and male teachers, respectively. When it pertains to the constructs connected to student engagement, we find statistically significant sex differences in the groups for 6 of 14 tests. Regarding the construct of mastery motivation, there are no sex differences found in the group with female teachers, but there are, however, a significant difference in the group taught by male teachers. The comparison of values in the group with female science teachers shows that the values for girls taught by male teachers are somewhat higher, but they are somewhat lower for boys. In other words, we found indications of interactions between teacher and student sex along the lines of the sex-opposite notion. However, it is important to note that none of the interactions between teacher and student sex among the constructs in this category are statistically significant. One should, therefore, be very careful regarding the possibility of capitalising on chance when interpreting these findings.

Boys show tendencies to experience the teacher's exertion of classroom management more effectively with male teachers, while girls experience this aspect somewhat more positively with female science teachers. Furthermore, there are tendencies that girls experience a teacher's ability to build reciprocal trust more positively by female teachers, while boys experience male teachers more positively here. Here we find a significant interaction effect between teacher sex and student sex ($p<0.05$). This finding, in other words, supports the sex-stereotypic notion. The results for the construct *Disengagement* show that boys react significantly less negatively under pressure when relating to male science teachers. Here we find a statistically significant interaction effect between teacher and student sex ($p<0.05$). There is also a weak tendency for girls, to a larger degree, to want pressure to learn and control when they are taught by female science teachers, and boys responded correspondingly when they had male science teachers. The interactions in this category, in other words, point to the sex-stereotypic notion.

The last category of constructs deals with parental influence. As previously stated, it is naturally easier for students to distance themselves from their parents as they grow older. The results show that girls who are taught by male science teachers report a significantly greater involvement from parents than girls taught by female science teachers. For this construct we find a

statistically significant interaction effect between teacher and student sex ($p<0.01$). If we interpret this as compensatory behaviour displayed by parents and students, we have an example of sex-stereotypic notion. However, it has to be underlined that also other interpretations are possible regarding this point.

To summarise, we find support for the sex-invariant notion in most instances. However, the three statistically significant interaction effects between teacher and student sex are all in line with the sex-stereotypic notion. Furthermore, we find tendencies supporting the sex opposite notion in some instances (Mastery motivation, Influencing performance norms in class). However, these interactions between teacher and student sex are not statistically significant, and very careful interpretations are therefore needed.

*Table 2: Student's sex differences by science teacher's sex. Statistically significance indicated by * ($p<0.05$) and **($p<0.01$).*

Construct	**Female science teacher**			**Male science teacher**			**Interaction Teacher sex* student sex**
	Girls	Boys	*Cohen' s d (girls – boys)*	Girls	Boys	*Cohen's d (girls-boys)*	*Partial eta square*
	N=256	*N=234*		*N=152*	*N=127*		
Learning outcome							
Science mark (scale 1-6; 6= best, 1 = worst)	4.29	4.57	-0.31**	4.26	4.53	-0.33**	.000
Student engagement							
Copying strategies	3.03	3.03	0.00	3.12	3.09	0.05	.000
Elaboration	3.34	3.48	-0.22*	3.31	3.41	-0.15	.000
Active engagement	3.13	2.91	0.33**	3.10	2.91	0.29*	.001
Mastery motivation	3.87	3.85	0.02	3.98	3.75	0.28*	.004
Interest enhancement	3.14	3.11	0.03	3.04	3.01	0.03	.000
Perceived relevance of science	3.36	3.27	0.09	3.24	3.26	-0.02	.000
Volition (reversed)	3.09	2.91	0.24**	3.10	2.86	0.36**	.000
Quality of teaching							
Exertion of academic pressure to learn	3.34	3.28	0.08	3.29	3.31	-0.03	.000

Exertion of classroom management (reversed)	2.85	2.79	0.07	2.67	2.85	-0.20	.000
Influencing performance norms in the class	3.13	3.36	-0.28**	3.08	3.10	-0.02	.001
Building reciprocal trust	3.28	3.20	0.11	3.25	3.33	-0.13	.004*
Student responses							
Disengagement	3.05	2.99	0.06	2.98	2.76	0.31**	.006*
Student commitment	3.86	3.81	0.10	3.80	3.85	-0.10	.000
Student wants autonomy and empowerment	3.08	3.11	-0.03	2.87	2.84	0.03	.001
Parental influence							
Parental involvement in schooling	2.25	2.61	-0.49**	2.51	2.63	-0.17	.012**
General autonomy from parents	4.06	3.94	0.15	4.14	3.95	0.26*	.001

DISCUSSION

The way in which a teacher behaves in the classroom can have complex effects. Sex-specific patterns of interaction in the classroom are well documented (Jones and Dinia, 2004), yet we know little about how these patterns influence girls' and boys' levels of understanding and attitudes. However, in gender theory, weight is placed on the fact that gender is not necessarily connected to sex, and that the differences between people of same sex can be as meaningful as the differences between people of different sexes (Glasser and Smith, 2008). In our study, the focus has been on the sex of both the students and the science teachers. This reduces the complexity of the design, i.e. sex is easily observable, in contrast to gender. However, survey instruments that aim to tap core aspects of gender could also possibly be included in future studies. This may reveal interesting elaborations of the results reported in the present paper.

What is maintained by our empirical research is that some important sex interactions are found in school science, and this awareness has to be studied further. In our study, we found empirical support for the sex-stereotypic in some instances. However, in most instances statistical significant interactions between teacher sex and student sex were not established. In some cases, however, we find empirical indications supporting the sex-opposite notion. A further complexity is that students' responses to teachers may initially be based on their sex, but once they get to know their teacher, their response is based much more on how the teacher responds to them (which may or may not be gendered) and to the pedagogical quality of the teaching. The length

of time of student-teacher interaction may influence the gendered response. In conclusion, there are interesting nuances in the question of the influence of a teacher's sex that we need to understand better. Exclusive support for one of the three notions, as found in several earlier studies, is not established. The complexity of teacher-student interactions is rather overwhelming, where causes may interact to produce joint effects, and we want to emphasize the need to better understand this complexity. The way forward, as we see it, is more in depth investigations.

When discussing causation, it is important to search for variables that co-vary with the sex of the science teachers. However, available surveys of Norwegian high school teachers do not reveal important differences between female and males with respect to educational background, age or other potentially relevant variables. Furthermore, the three statistical significant partial eta squares effects established are in the range from .004-.012, and this must be regarded as weak effects. However, what is an *important* effect size is not a straight forward question. For example, Plucker (1997) points to the fact that an effect size of 0.001 in a large medical study may represent the saving of one person's life, even though the effect is very small. However, conceiving of such an ethically and morally serious scenario in the social sciences is difficult. It is argued that the best guide for interpretations of effect sizes is a review of similar studies to determine the range of effect sizes usually found. Also seen in relation to effect sizes typically reported in educational research, our interaction effects can be characterised as weak, however, statistically significant.

Initially, we find empirical support for the sex-stereotypic notion rather surprising in a country like Norway with a high degree of sex equality.[11] However, studies have shown that Norwegian students' interest profiles in science are highly gendered (Schreiner, 2006): in a postmodern society, boys can choose to be 'boyish' and girls to be 'girlish'. A person's identity is to a lesser extent inherited or handed down from traditions or family background, while sex remains an inborn quality. Consequently, young people may lean on, cling to and emphasize gender as an identity symbol. This leads to larger differences between the genders in highly modernized countries. Furthermore, Norway is among the countries in the modernized world with the most sex-segregated labour markets, even though sex equality in society in general is high. This has been called the Norwegian sex equity paradox (Birkelund and Petersen, 2003).

STUDY LIMITATIONS AND FURTHER RESEARCH DIRECTIONS

The results of this study should be regarded in light of several shortcomings. First, the data were gathered at one point in time. The cross-sectional nature of the data collection precluded causal analysis and inferences. However, a reverse causality (students' influences -> the sex of teacher) is impossible. Longitudinal or quasi-experimental studies are warranted to overcome this cross-sectional shortcoming. A second caution is the reliance on self-reported questionnaire data, causing concerns about biases. This study is also limited

by the fact that the data were obtained from students in one municipality in Norway. The results may only generalise to similar contexts (for instance Swedish and Danish high schools). The present study is limited in the number of schools examined. Further, we lacked measures for important concepts such as time on task, intelligence et cetera. We have only studied the responses of sixteen-year-olds: youngsters who are in transition to responsible adult life.

Much research shows that student motivation for school work changes from lower secondary school and onwards (for instance, Eccles et al., 1993). The positive emotional projections of primary-school students are often transformed during a school career into a greater emotional distancing between teacher and student. A student's relation to the teacher will typically change throughout the years of formal schooling. The teacher's sex matters in the primary classroom (Skelton et al., 2009), but later the potential influences change. In high school, the relationships change further.

The teacher's influence over what the student learns will depend on the logical-sequential structure of the subject. There are grounds to hypothesise that the more logical-sequential the structure of the subject, the greater is the influence of the quality of teaching over what the student learns (Stodolsky & Grossman, 1995). In science topics that are less logically-sequential (such as factual knowledge of species) the student can read up on knowledge more easily than on a topic such as mechanics (where the student will be more dependent on the teachers explaining difficult tasks and explaining methods). It is necessary to emphasis the need for more research in this respect. All these study limitations which are mentioned are areas for improvement in future research.

Our research revealed that boys have a higher tendency to be stressed when a female teacher challenges them to work harder (labelled Disengagement). We need more research to better understand why boys experience female science teachers in this way. Our conclusions are based on associations that project explanations through an interpretation of statistical variations. The statistical explanation relies on intuitions about plausible causation. Therefore, it is important to proceed with caution when attempting to clarify causation, although the direction of causation from sex to engagement cannot be denied.

We agree with Sabbe and Aelterman (2007) in saying that one cannot see the characteristics and effects of gender 'without considering the social and cultural context and the individuals' personal gender construction' (p. 527). Seeing that meaning is attributed to sensory data, it may be that our choice of the male and female science teacher categories conceals western aspects of gender construction. What is also important is how significant the question of teacher's sex and gender really is. Given the fact that 'favored variables can blind scientists to other theories and other variables that could compete for favor' (Scarr, 1985, p.499), we must be open to additional approaches to

gender. Therefore, we strongly emphasize that the discoveries we have presented here ought to be followed up with further research, so that we can better understand the significance of a teacher's sex. In a follow-up to the reported research study, we are planning to interview the teachers who scored the best in teaching quality, and their students, so that we can share in their own words what gives students energy to do high-quality work, and what kinds of strategies these teachers are employing to inspire them. We need more research to understand the mechanism behind how teachers can energize the students' learning processes.

Implications for practice

Despite its limitations, this study may have important implications for school practice. If the statistical associations between a teacher's sex and a range of variables relating to adolescent students' perceptions of their classroom engagement, quality of teaching and responses to their teacher, and their own achievements in science represent causal relationships, our findings may have implications for school practice. For instance, given the vital importance of relationship building, schools may use our findings to guide the selection of personal supervisors[12] in Norwegian high schools and the matching of supervisors and students.

CONCLUSION

This study contributes to the emerging literature that investigates the influences of the teacher's sex and gender by exploring how sex may interact in classrooms. In order to better understand the relationship more research is needed. An interesting avenue for future research can be to conduct similar studies with longitudinal designs to better understand the influence of experience: once students get to know their teacher, their response is based much more on how the teacher responds to them (which may or may not be gendered) and to the pedagogical quality of the teaching.

The main conclusion is that there seems to be interesting differences between female and male science teachers in high schools along some dimensions. However, our evidence in part supports the sex-stereotypic notion, and in part supports the sex-invariant notion. There are also empirical indications supporting the sex-opposite notion, however, these are not statistically significant. The conclusions are consequently more nuanced than what has been reported in earlier studies. We do not interpret our data to mean that, for example, girls should have female science teachers and boys ought to have male teachers, but rather that 'teachers need to be aware of their own patterns of interaction with male and female pupils and how this impacts them' (Drudy, 2008, p.312). Students should learn to be adaptable in school, since it ought to be preparing students for life. However, an important conclusion is to emphasize the importance of meaningful reciprocal trust, and that students can experience advantages from having a science teacher for whom they feel high levels of trust. When female teachers appear to succeed at building reciprocal trust with girls, and male teachers succeed in large part with reciprocal trust with respect to boys, we

see that a relationship to a teacher's awareness of reciprocal trust's potential importance can contribute to better practice. This is in accordance with the findings of Martin and Marsh (2005). Even though teachers, in large part, are aware that girls and boys perceive reciprocal trust differently, this is still an aspect that varies with the teacher's sex.

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NOTES

[1] The disorder and disruption scales were omitted from the recently published Norwegian PISA-results from 2003 and 2006.
[2] 5 hours of Science at school each week.
[3] Introjected regulation refers to taking in a regulation but not accepting it as one's own.
[4] Both Lahelma (2000) and Martin and Marsh (2005) use the term 'gender' when referring to a person's sex.
[5] This measure is composed by several factors: Seats in parliament held by women, percentage of female legislators, senior officials and managers, professionals and technical workers, as well as the ratio of estimated female to male earned income.
[6] 10.4 % of the Norwegian students claim that 'they are harassed by one or more teachers' (http://udir.no/upload/Brukerundersokelser/V09/EU-2009_Nasjonale%20tall_andel.pdf)
[7] 51 % of the students have teachers that inspire them in 'most or many subjects'.
[8] Apart from one class that sabotaged the survey (and therefore was not a part of our material), the following collected material was cross-checked with background information about classes.
[9] However, internal consistency measured via alpha does not provide *sufficient* evidence of uni-dimensionality. A discussion of this proposition is found in Gardner, 1996.
[10] These results are consistent with other sources (Jones and Jones, 1989; Skelton, 1997; Carrington et al., 2008; Francis, 2008; Dee, 2006; Jones and Myhill, 2004; Myhill and Jones, 2006; Skelton et al., 2009).
[11] The definition that we are using of equality is rather limited, in that it only refers to the representation of women in certain spheres of public life and does not appear to account for people's perceptions of equality in everyday life or their private experiences. We acknowledge the difficulties when we measure equality in this way, and we ask: Will such a measure ever be able to account for all of the different aspects of social life?
[12] Every student in Norwegian high-schools has 1 personal supervisor ('kontaktlærer')

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