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Chapter 3

ACADEMIC GRADES AND MOTIVATION IN HIGH SCHOOL SCIENCE CLASSROOMS AMONG MALE AND FEMALE STUDENTS: ASSOCIATIONS WITH TEACHERS' CHARACTERISTICS, BELIEFS, AND PRACTICES

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ABSTRACT

This study compared the academic performance, perceived competence, attitudes, and perceived level of momentary skill of 244 (n = 129 male, n = 115 female) high school students in science. While males and females did not differ from one another in their science grades, there were significant gender differences in factors that promote motivation and persistence in science. Female students reported lower perceived competence in science and more negative general science attitudes than male students. Males and females also differed systematically from one another in their perceived level of momentary skill while in science as measured by the Experience Sampling Method. We sought to understand more about the role that teachers' beliefs and practices may play in fostering these experiential and motivational differences. Students' high school science teachers (n=13) were interviewed about their beliefs pertaining to gender and science. Observational data from their classrooms also were coded and examined to describe teachers' interactions with male and female students. In general, teachers spent an average of 39% more time addressing male than female students, which was not explained by student initiation. In particular, teachers addressed males more often than females about content knowledge, elaboration of course content, and classroom management. Most teachers explicitly denied that there were gender differences in science performance, but their talk about males and females in their classrooms revealed

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implicit beliefs that suggested gender bias. Some consistency was found between the science teachers' implicit beliefs, teachers' practices, and the gendered motivational patterns of their students.

Several recent studies have found that the gender gap in mathematics and science achievement during adolescence has closed (AAUW, 2008; Hyde, Lindberg, Linn, Ellis & Williams, 2008; Xie & Shauman, 2003). In fact, a recent study of three large nationally representative data sets found that high school girls actually had slightly higher GPAs in science and mathematics than boys (Riegle-Crumb, King, Grodsky, & Muller, 2012). Further, that study found that the gender disparity in postsecondary STEM majors was not explained by prior academic performance measured by either grades or achievement test scores. As suggested by the disparity in STEM majors, gender gaps related to STEM motivation, which have been documented during adolescence over several decades (see DeBacker & Nelson, 2000; Freeman, 2004; Jones, Howe, & Rua, 2000; NCES, 2000a, 2000b; Preston, 2004), persist despite recent parity in STEM achievement (see Hill, Corbett & St. Rose, 2010 for a review; Zafar, 2009). Those motivational gaps include differences in interest, course-taking, and career aspirations favoring male over female students. In the current study, we compared high school students' science grades and motivation as revealed by their perceived competence and by their attitudes toward science.

While there are multiple possible explanations for gender differences in students' motivation in science, a likely influence is science teachers themselves. If teachers overtly or implicitly communicate beliefs about gender differences in science, students' attitudes will likely be affected. It is important to understand, then, how science teachers think and talk about gender and how they interact with both male and female students. This study addresses those issues.

MOTIVATIONAL PROCESSES AND GENDER IN HIGH SCHOOL SCIENCE CLASSES

Our recent research focused on adolescents' subjective experience during science class has demonstrated that male and female students experience high school science classes very differently, with females reporting lower science self-efficacy and lower engagement in response to challenge in science than males (Schmidt, Kackar & Strati, 2010; Schmidt & Shumow, 2012). In the present study, we expand the motivational outcomes we examined previously by comparing students' perceptions of competence, their attitudes toward science, as well as grades in science by gender. Perceiving oneself as competent is considered a basic human need in Self Determination Theory (Deci & Ryan, 1991), an influential theory of human motivation. Researchers have found that students who feel competent are more likely to choose to engage in that activity, persist when they experience setbacks and work harder, all ingredients needed to succeed in complex subjects like the sciences. Students' attitudes toward science, which are defined as psychological tendencies expressed through positive or negative evaluations (Eagly & Chaiken, 1993), influence behavior to a considerable degree (Reid, 2011). Students' attitudes are likely to impact the choices they make about course-

taking, post-secondary majors, and careers because people tend to prefer to engage in activities for which they have positive as opposed to negative attitudes.

TEACHER BELIEFS ABOUT GENDER AND SCIENCE

Despite numerous scholarly arguments about a gender gap in science (Riegler-Crumb, King, Grodsky, & Muller, 2012) and the evidence that females are less motivated than males to pursue science, many educators currently believe that gender differences in science have been successfully addressed and no longer exist (Sadker, Sadker, & Zittleman, 2009; Sanders, 2010). On the one hand, educators might base their assessment that gender differences in science have been redressed on positive changes that have taken place in practice (see for example Corra, 2007) and by the equivalence in grades noted previously. On the other hand, they might not notice gender differences because they are concentrating on other more immediate issues during their hectic teaching day (Sanders, 2010). It is also possible that teachers think that expressing beliefs about gender differences is socially undesirable and tantamount to endorsing inequality. We investigate high school science teachers' beliefs about and interactions with male and female students, and how those beliefs and behaviors are related to each other and to the performance and motivation of students in their classrooms.

Few U.S. adults openly express stereotypes about gender and STEM fields (Schmader, Johns & Barquissau, 2004; Hyde et al, 1990). There is considerable evidence, however, that people who do not explicitly endorse stereotyped views nevertheless do reveal implicit beliefs and act in concert with these stereotypes. This pattern is observed with stereotypes in general, and in relation to gender and science in particular. Such implicit beliefs are related to student performance in STEM during the eighth grade (Nosek et al, 2009). Thus, a study of teacher beliefs about gender should be designed to tap into teachers' implicit (likely subconscious) beliefs in addition to their explicitly stated beliefs, a strategy which we adopt here.

TEACHERS' INTERACTION PATTERNS WITH MALE AND FEMALE STUDENTS

One way that teachers have historically enacted stereotypes about gender and science in the classroom is through the way that they talk to, interact with, and respond to students. Trends in general gender-bias in classrooms emerge from discussions with and observations of teachers. Research across a variety of subjects has documented some gender biases in classrooms. For instance, physically active males are often viewed as troublemakers, and, because females are often viewed as compliant, they receive less teacher attention than male students (Ruble, Martin & Berenbaum, 2006; DeZolt & Hull, 2001). Many studies which have examined interaction patterns in science classes were conducted a generation ago (Altermatt, Jovanovic, & Perry, 1998; Jones & Wheatley, 1990; Kahle, 1990; Wilkinson & Marrett, 1985). Those studies showed that teachers called on males more than females, interacted with males more than females about procedures and behavior in class, and communicated higher expectations to males than females. Gender gaps in high school course-

taking and achievement have closed in the period since these studies were conducted, though large gaps in post-secondary science interest and persistence remain. Given that the landscape of gender and science has changed somewhat in recent decades, exploring possible teacher gender bias in contemporary science classrooms is important.

Of course, observed gender differences in teachers' beliefs and behavior may not manifest bias but rather reflect real differences in male and female students' engagement and interest in science. Altermatt, Jovanovic, and Perry (1998) found, for example, that teachers called on boys more than girls but that was in direct proportion to the fact that more boys raised their hands to participate in science class. For decades, feminist scholars have suggested that individuals differ in stable and reliable ways with regard to how they approach knowledge and learning (Baxter-Magolda, 1992; Belenky, et al., 1986; Galotti et al., 1999; Knight et al., 2000). However, some evidence suggests that the degree to which gender stereotypes are made salient in classrooms impacts whether or not there are gender differences in approaches to learning. Ryan and David (2003) discovered gender differences in students' approaches to knowing only when gender stereotypes were made salient: In situations where they were not made salient, no gender differences in approaches to knowing were evident. Given that many norms and stereotypes of "scientists" are strongly gendered, it is important to explore the degree to which gender appears salient among the teachers of tomorrow's scientists.

McLaughlin and Talbert (2001) argue that the patterns of practice high school teachers pursue in their classrooms "fundamentally shape students' classroom experiences" (p. 32). In order to better understand the experiences of male and female students in high school science classes a descriptive account of what is happening in science classrooms is needed. Two decades ago, Tobin and colleagues observed high school science classrooms in the United States and Australia, and found that females participated less than males during whole class instruction and that whole class instruction accounted for about 70% of instructional time in high school science classrooms (Gallagher, 1985; Tobin & Gallagher, 1987; Tobin & Garnett, 1987; Tobin et al., 1987). The researchers further found that a "typical" high school science lesson included the teacher providing some factual information during whole class instruction and the students completing seatwork consisting of fact oriented worksheets using the textbook as a reference; girls were observed to be more diligent than boys during seatwork. Typically, rote learning was emphasized, questions posed by the teacher were low-level questions, requiring only a yes or no answer. More recent research suggests that whole class instruction, particularly lecture remains the predominant instructional practice in high school science classrooms and that seatwork is common (McLaughlin & Talbert, 2001; Shernoff, Knauth & Makris, 2000) yet there has been considerable emphasis on reforming science education to emphasize activity and thinking. It is not clear however, whether contemporary teachers interact differently with female and male students in terms of content knowledge, thinking, directives, and behavior management as has been observed in the past. Thus, we consider those teacher interactions patterns with students by gender in this study.

Teacher Beliefs and Practices

We expect teachers' implicit beliefs to influence their classroom practice, and that these beliefs and practices will shed light on the results of our study of students' subjective learning

experiences in high school science classrooms. Teachers' beliefs about learning and motivation impact their practices (Turner, Christensen, & Meyer, 2009) and teachers' beliefs and practices have been demonstrated to impact student performance in high school science classrooms (McNeill, Pimental, & Strauss, 2010) but studies have rarely focused on teacher beliefs and behavior as potential contributors to student beliefs about themselves as learners in science classrooms. As research on gender and science moves forward, we must understand the many ways that students' beliefs might be shaped by people and experiences.

The lack of women role models has been offered as an explanation for female students' disinterest and lack of aspirations in science (Bickenstaff, 2005; Weinburgh, 1995). Because women have been underrepresented in science, role models including female science teachers have been scarce for female students interested in science. However, this "women-science-teachers-as-role-models" line of inquiry may not be fruitful theoretically or practically as it suffers from a "chicken-and-egg" problem: are there few female role models because girls aren't interested in science, or are girls not interested because they have few female role models? This study goes beyond the simple consideration of teacher gender, and focuses instead on teachers' beliefs about gender and science as they are reflected both in their discussion of teaching science and in their everyday actions and interactions with high school students in their classrooms.

Study Goals

We examine the degree to which contemporary high school science teachers appear to hold gender-related stereotypes regarding science. In order to investigate teachers' instructional practices and their interactions with male and female students, we have analyzed approximately 100 hours of classroom instruction and interviews with high school science teachers in order to address the following research questions:

1. Is there gender disparity in science grades, attitude toward science, global perceived competence, and momentary perceived competence in science among high school students?
2. What explicit general beliefs do teachers express about gender and science learning, and are these explicit beliefs consistent with implicit beliefs revealed through discussions of specific students in their classrooms?
3. Do high school science teachers interact with male and female students in similar ways in terms of the frequency with which students are addressed, the function or purpose of the verbal interaction, and the degree to which higher level thinking is fostered?
4. Are teachers' interactions aligned with male and female students' initiation of verbal exchanges with their science teacher, observed participation in class activities, and observed display of confidence in science tasks?
5. Do teachers' explicit or implicit beliefs align with behavior observed in the classroom and what does observed behavior tell us about teachers' implicit beliefs?

METHOD

Context

The study was conducted in regular track science classrooms in a large public high school (9th - 12th grades; enrollment = 3,323) serving students from a diverse community. Overall, 33% of the student body came from low-income families. The school graduation rate was reported to be 86%. The school's science department had 28 faculty members (16 female, 12 male) offering a total of 23 different courses in AP, honors, regular, applied, and vocational tracks. All science faculty members were white. Three science teachers from each of the regular track general science, biology, chemistry and physics classes participated in the research project. In the regular track science classes, there was no gender gap in science course taking and science test achievement. The science department chairperson reported that an inquiry approach was used throughout the department.

Participants

Students

In total, 244 students participated in the study. The overall student participation rate across all classrooms was 91%, with half of the classrooms studied having 100% participation. The sample was 53% male and 47% female. The student sample was 42% White, 37% Latino, 12% African American, 2% Asian, 1% Native American, and 6% multi-racial. According to school records, 43% of students in the sample were eligible to receive free or reduced lunch. Approximately one-third of the students reported that at least one parent had a college degree.

Teachers

Thirteen teachers in twelve classrooms participated in the study (in one of the general science classrooms, a new teacher was assigned to the class in the spring semester as a result of staffing changes elsewhere in the department). Six of the teachers were male and 7 were female. It is noteworthy that all of the biology teachers were female and all of the physics teachers were male, while the general science and chemistry classrooms studied had both male and female teachers. As is the case in the science department as a whole, all participant teachers were white. The teachers in the study had an average of 8.6 years of teaching experience, and the average age was 35.6. Three teacher participants (n=1 biology, n = 1 chemistry, and n = 1 physics) had earned National Board Certification in Science.

Data Collection and Measures

Student Outcomes

Science achievement was measured using students' end of year grades in the science course in which we observed them. A measure of *global perceived competence in science* was gathered through the survey administered at the outset of the study using the Perceived

Competence for Learning Scale developed by Williams & Deci (1996). This is the mean of 4 items (on a scale of 1-7) measuring students' perceptions of their capability to learn course material and perform well ($M=5.01$, $SD=1.40$, Cronbach's $\alpha=.93$). Students' *momentary perceived competence* in science was computed using data from the Experience Sampling Method (ESM; see Hektner et al, 2007). Students were signaled with vibrating pagers twice per class for 10 days to report on their experience. When signaled, they were asked to report how skilled they felt on a scale from 0-3. For each student, mean momentary skill ratings were computed, so that each student had an average rating that represented as many as 20 individual responses ($M=1.4$, $SD=.57$). General *attitude toward science* was measured using Gogolin & Swartz's (1992) 20-item Attitudes toward Science Inventory, which is computed by taking the sum of all items on a 4 point scale (scale range 20-80, mean=51.74, Cronbach's $\alpha=.87$). In this scale, higher numbers indicate a more positive attitude toward science.

Teacher Student Interactions

Observational data were collected along with the ESM in each classroom on five consecutive days in both the fall and spring semesters. During each day, three researchers were present in the classrooms. One researcher was a videographer who was positioned in the back of the classroom to record the teachers' activities as unobtrusively as possible.

All class sessions were video-recorded, with a focus on the teachers' activities. After each recorded class session the teacher rated on a 5-point scale how typical the class period was. For each teacher, we selected 2 days (1 from fall, 1 from spring) they rated as "most typical" (ratings of 4 or 5) for detailed coding of *teachers' verbal interactions* with students. The video data were coded using the NVivo8 software, which enables direct coding of video data. In total, 20 hours of video representing 24 different 50-minute class sessions from 13 different science teachers were coded in this manner. Classroom video data were coded at the level of teacher "utterances." A teacher's statement was considered a single utterance so long as it had a consistency in the person being addressed and the function of the statement. The end of one utterance and the beginning of the next utterance was defined in terms of a shift in the person(s) being addressed or in the function or purpose of the statement. Teacher utterances could be very short (e.g. "everyone take out your homework") or, in rare cases, much longer (e.g. a two-minute mini-lecture on the differences between exothermic and endothermic reactions). The fifty-minute class sessions observed in this study typically contained 250 – 400 teacher utterances. As one can infer from the large number of utterances, most utterances lasted just a few seconds.

For the purpose of this study, each utterance was coded on the following dimensions: (1) who was addressed by the utterance (whole class, mixed male/female group; males individually or in a group; and females individually or in a group); (2) who initiated the utterance (teacher or student); (3) whether or not the utterance fostered student thinking (an utterance was coded as fostering thinking if the student was included intellectually, e.g., "What does that tell you?" or "Suppose it looks like this" or "So, how does that work?" etc.); and (4) the function or purpose of the utterance. Following procedures previously used by King, Shumow, and Leitz (2001) the function of each utterance was categorized as either a) content (presenting declaratory knowledge about science); b) sequential flow (moving the lesson forward by focusing on what has to happen next, but no content presented); c) elaboration (focus on explanation, conceptual understanding, meaning making); d) classroom management; and e) irrelevant. Ten percent of the videos were coded by two independent

coders who had not read the teacher interviews. Reliability was within acceptable limits, with inter-rater agreement ranging from 85% to 100%. Duration and frequency of utterances were accessed from the NVivo8 software.

The “who was addressed” utterances were used to create variables that enabled comparison by gender. First the utterances addressed to all male small groups and those addressed to individual males were combined into an “addresses males” variable; the same procedure was used for females. The distribution of males and females in each class was not half and half. Therefore, in order to make fair estimates of the teachers interactions with students by gender, the “addresses males” variable was divided by the number of males in the class to yield an estimate of how often the teacher addressed each male in the class; the same procedure was used to estimate how often the teacher addressed each female in the class.

For each of the 120 class periods that was observed, observers completed *in-class global-observational ratings*. Observers rated whether certain behaviors were equally distributed between male and female students (M=F) or occurred more frequently with one gender (M>F or F>M) including: (a) teacher engagement of students, (b) student participation in class, (c) teacher behavior management, (d) student cooperation, (e) teacher messages of competence, and (f) student display of competence/confidence. The percent of days that fell into each observed category was calculated. Inter-rater reliabilities were conducted for more than 25% of the in-class observations; percent agreement on specific items ranged from 76% to 87%. Disagreements were resolved by using the rating of the senior coders who developed the coding scheme and who achieved very high reliability (> 90%) both with each other and with actual counts from video data.

Teacher Beliefs

All science teachers participated in a semi-structured interview during the week following data collection. They were asked directly about their observations and beliefs pertaining to gender differences in science. For example, they were asked whether they noticed student gender differences in science interest, ability, aptitude, or behavior. Socially desirable responses indicating few gender differences were expected. So, more implicit beliefs about gender were tapped by first asking teachers to identify a particular student in their class who had the greatest potential for a science career and their reasons for choosing that student. Student gender and the reasons given for selection were noted. Second, teachers identified the highest and lowest achieving male and female student in their class and were asked to compare and contrast them.

RESULTS

Gender Comparisons on Science-related Outcomes

While males and females did not differ from one another in their science course grades, there were significant gender differences in perceived competence in science and general science attitudes. Males and females also differed systematically from one another in their perceived level of momentary competence (skill) while in science as measured by the ESM. Means comparisons for each of these variables are presented in the table below.

Table 1. Mean Comparisons of Possible Gender Differences in Student Outcomes in Science

	Males (n=129)	Females (n=115)	t-value
End-of-year science grades	1.93	2.09	-.96
Global perceived science competence	5.2	4.7	2.7**
Momentary perceived science competence	1.65	1.37	3.91***
General science attitude	53.33	49.96	2.86**

Teacher Beliefs

Explicit Beliefs about Gender

Six of 13 teachers professed the belief that no gender differences existed in students' science experiences; three said they did not know, and four (2 males, 2 females) indicated that they had noticed gender differences in the way their students responded to science. Teachers who were uncertain and those who expressed the belief that there were no gender differences made comments such as: "It's not a gender thing" or "I don't think it exists much, not as compared to when I was in high school." One female teacher who acknowledged gender differences commented: "Well I think, you know, anybody that wants to be honest will definitely tell you that there are differences in gender and in the science field, if they tell you there is not then they're just either unaware or they're lying, uhm, cause there clearly are. I tell people I'm a teacher, one of the first questions out of their mouth is 'oh do you teach English?'" All four teachers who expressed a belief in gender differences indicated that, in their experience, males are more interested and "catch on" faster to science. Two teachers said males participated more while the other two said females participated more in science class.

Implicit Beliefs about Gender

Asking teachers to identify and compare specific students can uncover deeply held implicit beliefs about how teachers think about gender and achievement. For example, although few teachers expressed a belief of general gender differences in students' interest or aptitude for science, when asked to identify a student who might have a future science career, only three out of 13 identified a female. When pressed about whether there were any female students in the class we studied who might pursue science, most could name one and provide a reason why. It is notable, however, that several teachers had difficulty even remembering the name of any of their female students during our interview.

Teachers' comparisons of the characteristics of their highest and lowest achieving male and female students provided additional insight into their implicit beliefs. According to many teachers, high achieving male and female students were both "good workers." However, the high achieving males were more often described as having intellectual capacity (e.g. "smart" "a natural" "curious" "a deep thinker") whereas the females were simply harder workers ("not smarter," as one said) and more motivated by grades than males. Multiple teachers described how females were conscientious in their completion of homework assignments, commenting on their ability to follow directions and the neatness of their work. Interestingly, none of the four teachers who expressed an explicit belief in gender differences made this

intellectual/worker distinction. Rather it was the teachers who denied there were gender differences or “didn’t know” whose responses suggested this gendered pattern.

Comparing the higher and lower achieving males with one another, one teacher specifically said the high and low achieving male had the same “potential” but two others described the higher achieving male as smarter. Comparing the higher and lower achieving females, not one teacher said the higher achieving female was more intellectually capable, but two teachers said both were “able”. Overall, female achievement was attributed to females’ extrinsic motivation, attendance, and assignment completion. Teachers identified problems with work habits, attendance, and motivation as commonalities of low-achieving males and females.

Observations of Classroom Practices

Observation Rating Indicators

In the majority of the class sessions we observed, observers indicated no gender differences on the global ratings of teachers’ engagement of students, classroom management or direct messages about competence (see Table 2). Nevertheless, while they were not the norm, some gender differences in teachers’ more global interaction patterns were present. Fairly consistent patterns emerged when gender inequities were observed such that teachers engaged males more often than females and focused more on managing male behavior. Teachers tended to send messages of competence equally but more messages of lower competence were sent to female students. Males participated and displayed confidence/competence more than girls. Females cooperated more with the teacher.

Who Teachers Talked to and with What Purpose

Because it is always possible that classroom ratings might be influenced by the researcher’s expectations, we also coded all the teacher’s verbal interactions with students. These are counts made by viewing the video record of the teacher student interactions that occurred during each class; the duration of each instance is also marked. In a typical 50 minute class period, teachers spent an average of 27 minutes speaking with students: For the remaining 23 minutes, students were talking or the classroom was silent (as in the case of independent seatwork, for example). About 56% of teachers’ total classroom talk time was spent addressing the whole class (about 15 min/day), with the remaining 12 min/day spent addressing individual students or small groups of students. In general, science teachers spent 39% more class time talking to their male students than their female students. While this figure represents a difference of only a few minutes per day, over the course of a month this means that teachers will have spent close to 40 more minutes (nearly an entire class period) talking with their male students compared with their female students.

When we examined gender differences in the function of teacher utterances, we found that teachers spent more time addressing males than females in every one of the function categories we coded. In other words, teachers spent more time talking with males than females with the purpose of conveying basic content, moving the lesson along (sequential flow), elaborating on content, managing behavior, and discussing irrelevant material like sporting events and weekend plans.

Table 2. Global Observation Rating Frequencies for 120 Class Periods

	Equally	M>F	F>M
Teacher Attempts to Engage	96	19	5
Student Participation	70	39	11
Teacher Behavior Management Focus	82	34	4
Student Cooperation	101	4	15
Teacher Messages of Low Competence	110	3	7
Student Display of low Competence/confidence	76	8	36

Note: Frequency of class periods receiving this rating is entered in the table.

As shown in Table 3, gender gaps were smallest in utterances characterized as sequential flow (only 15% more time addressing males than females), but were much larger in all other categories, with males receiving 31% - 66% more talk time than females.

Even though teachers spent more time speaking to males than females, they spent twice as much time addressing comments and questions that fostered higher order thinking to female students compared to males. The reader should note, however, that such fostering thinking utterances were extremely rare, amounting to less than 1 minute of class time per week for either gender, on average.

Table 3. Time Teachers Spend Talking with Different Functions

	Min/Wk addressing Male Students	Min/Wk addressing Female Students	Min/Wk addressing all students (whole class, groups or individuals)
Functions			
Content knowledge	3.3	2.3	27.5
Sequential Flow	16.9	14.4	79.0
Elaboration	0.7	0.2	6.5
Beh. Management	7.1	3.5	16
Irrelevant	2.5	1.3	6.5
Fostering thinking ^a	0.3	0.6	3
Total of all Functions	30.5	21.7	135.5

^a The fostering thinking code was applied separately from the function codes, thus the fostering thinking counts are not included in the total for all functions figure.

Initiators of Verbal Interaction

Not surprisingly, the vast majority of teachers' verbal interaction (80%) was initiated by the teacher. A greater proportion of student-initiated verbal interaction was initiated by male students, however. Teachers spent about 27% more time in male-initiated verbal interaction than female-initiated verbal interaction.

Table 4. Explicit Beliefs about Participation and Observational Ratings of **Teacher Engaging and Student Participation in Individual Classes by Gender**

T ID	Subject	Explicit T Belief about Participation by Gender	Rating of Student Participation by Gender: # of Days		Mean N of Daily T Verbal Interactions per Enrolled Female & Male Student			Alignment	
			M>F	F>M	M	F	Summary	Explicit Belief & Student Participation	Student Participation & T Interaction
1 ^a	General	Equal	1/5	0/5	7.8	5.8	M>F	Mismatch	Match
2 ^b	General	Equal	0/5	0/5	9.1	8.8	M~F	Match	Match
3	General	Equal	2/10	0/10	13.1	10.3	M>F	Mismatch	Match
4	General	Equal	4/10	1/10	17.4	9.8	M>F	Mismatch	Match
5	Biology	Equal	0/10	1/10	2.3	4.1	F>M	Mismatch	Match
6	Biology	M>F	5/10	0/10	10.1	9.9	M~F	Match	Mismatch
7	Biology	M>F	5/10	0/10	9.3	6.4	M>F	Match	Match
8	Chemistry	Equal	3/10	0/10	6.8	6.1	M>F	Mismatch	Match
9	Chemistry	Equal	6/10	0/10	6.8	5.0	M>F	Mismatch	Match
10	Chemistry	F>M	5/10	0/10	16.3	13.9	M>F	Mismatch	Match
11	Physics	Equal	5/10	0/10	7.1	7.2	M~F	Mismatch	Mismatch
12	Physics	F>M	1/10	5/10	9.9	8.7	M>F	Match	Mismatch
13	Physics	Equal	2/10	4/10	4.1	9.1	F>M	Mismatch	Match

^a Observed spring only (5 days); ^b observed fall only (5 days).

Table 5. Global Beliefs about “Catching on” and Observational Ratings of Teacher Messages of Competence and Student Display of Confidence in Individual Classes by Gender

T ID	Subject	Explicit T Belief about Students “catching on” by Gender	Observational Rating: Teacher Messages of Lower Competence		Observational Rating: Student Displays of Confidence		Alignment Between Explicit Belief & Messages of Competence
			M>F	F>M	M>F	F>M	
1 ^a	General	M>F	0/5	1/5	1/5	1/5	Match
2 ^b	General	Equal	0/5	1/5	2/5	0/5	Mismatch
3	General	Equal	1/10	0/10	3/10	0/10	Mismatch
4	General	Equal	1/10	1/10	1/10	0/10	Match
5	Biology	Equal	0/10	0/10	1/10	2/10	Match
6	Biology	Equal	1/10	0/10	2/10	0/10	Mismatch
7	Biology	Equal	0/10	0/10	4/10	0/10	Match
8	Chemistry	Equal	0/10	0/10	4/10	0/10	Match
9	Chemistry	Equal	0/10	0/10	5/10	0/10	Match
10	Chemistry	Equal	0/10	1/10	5/10	1/10	Mismatch
11	Physics	Don’t Know	0/10	1/10	5/10	1/10	Mismatch
12	Physics	Equal	0/10	0/10	0/10	1/10	Match
13	Physics	M>F	0/10	2/10	3/10	2/10	Match

^a Observed spring only (5 days); ^b observed fall only (5 days).

Alignment of Beliefs and Practices

As discussed previously, most teachers explicitly stated the belief that males and females participated equally in science class. This stated belief generally does not align with our observations of actual student participation in each classroom. Table 3 compares each teacher's explicit beliefs and our observations of their classroom and coding of lessons for the number of utterances addressed directly to males or females in a typical day (frequencies were adjusted for the number of male or females enrolled in the class).

Generally speaking, we observed greater participation of male students across all science classrooms. The exception is two physics classes in which we observed greater participation among females (in the interviews one of these teachers described a pattern of participation consistent with our observations, while the other believed participation was equal).

Results presented in Table 4 suggest that teacher interaction with students and ratings of student's actual participation tend to be aligned with one another in all subjects except physics, whereas teachers' beliefs about student participation in class tend to be somewhat inconsistent with the observations. We investigated the discrepancy between student participation and the counts of interactions in physics classes and found in two cases the frequency counts and duration of the interactions did not match (as they did in other cases). Teacher 2 actually spent much more time talking to boys than girls and teacher 3 actually spent considerably more time talking to girls than boys, which aligned with the student participation ratings.

We also investigated alignment between teacher beliefs about "catching on", their messages of competence, and student display of competence/confidence by gender. As shown in Table 5, ten teachers say females and males are equal in "catching on". Although teachers were not observed to send lower messages of competence often, five did send messages of lower competence to females more often than males. In sum, females got messages of lower competence during 9 class periods compared to 3 class periods when males did. Gender differences were evident in students' actual display of confidence/competence. Males displayed greater confidence/competence in ten classrooms (total, 37 class periods). Again, we detect some mismatch between teachers' professed beliefs about student competence, and what we observe in their classrooms.

DISCUSSION

Like other recent studies, we found no gender gap in high school students' performance as measured by grades in science suggesting that female students were as prepared to continue studying science as male students. Yet, these female students who actually demonstrated equivalent competence felt less competent than male students both in their global evaluation of their own science competence and in their momentary reports during science class. Their attitudes toward science were also more negative than the attitudes of the male students. It would not be surprising, then, to find that the female students would be less likely to choose STEM majors or careers than the male students. Why is this so?

Evidence from a host of studies demonstrates that teachers' beliefs about ability are connected to students' achievement and motivation in science and mathematics. The finding

that few teachers held explicit beliefs about gender differences in science was not surprising given recent similar findings (Sadker, Sadker, & Zittleman, 2009; Sanders, 2010). This finding is a matter for serious concern because the explicitly stated beliefs tended to be inconsistent with teachers' implicit beliefs that emerged in more nuanced discussion of specific male and female students. The implicit view of males as scientific intellectuals and females as hard workers motivated by grades was generally more aligned with teacher practices, which also revealed some gender inequity. The discrepancy between teachers' explicit and implicit beliefs points to the need to help teachers assess and reflect on their beliefs about gender. The method used in this study, which entailed asking teachers to compare and contrast exemplars they chose was more successful at revealing their operational ideas about gender and science ability than was asking them directly.

The fact that teachers do not consciously recognize or acknowledge bias is both good and bad news. Presumably, they do not endorse the idea of gender differences in science because they recognize that this view is not positive or desirable, which suggests that they might be open to redressing the inequities. On the other hand, they are unlikely to seek to address the problem on their own if they think there are no differences or inequities. Certainly, then, it is important, at the very least, for science teacher educators to communicate to preservice teachers that gender inequities persist in science classrooms. Anecdotally, in professional development conferences with teachers, we have found that asking teachers to mentally answer the questions we posed in the interview and then asking them to examine their answers elicited surprise and consternation among many teachers who seemed stunned that their implicit beliefs favored male students. We are currently developing teacher self study materials that include this exercise, and will be formally evaluating these materials in the near future.

Teachers' implicit beliefs about gender and science appear to be reflected in differences in the ways that high school science teachers interact with their male and female students in the classroom. Across all examined subject areas, teachers spent more time talking to males than females about science content and matters related to science instruction; the teachers tried to engage males more than females in class activities and interacted with males considerably more than females. When males receive more attention than females in science class, females may very well be getting the message, whether intentionally or not, that males are more capable and suitable for science work than females (Amelink, 2009). Furthermore, a meta-analysis which investigated the impact of instructional strategies in science classrooms found that students were advantaged when teachers varied their interaction patterns with them during lessons by asking different types and levels of questions (Schroeder, Scott, Huang, Tolson, & Lee, 2007). The current study demonstrated that males received more attention than females in almost every type of verbal interaction during class.

Our findings of gender inequities in student interactions with teachers in science classrooms may have important implications for students' perceptions of their abilities in science and in their longer-term interest and persistence in science fields. In fact, data gathered from students in the larger study revealed clear and abiding perceptions among the female students that they were not competent in science whereas the male students felt competent (Schmidt, Kackar & Strati, 2010). These differences are extremely important in light of recent analyses of NELS by Legewie and Di Prete (2012) that demonstrated that a positive orientation toward female students in science at the local school level considerably

narrowed the gender gap in STEM undergraduate degrees among students who had attended such high schools.

The knowledge gained by this descriptive study can inform science teacher education programs by suggesting science curricula and instructional practices that could effectively meet the needs of both males and females. Not surprisingly, in most cases any imbalance in verbal interactions with students by gender matched the greater participation of either males or females in the class. Since, in most classes, males participated more than females, males tended to get more attention from the teachers. This suggests that teachers need to find a way to make class participation an expectation and a norm by establishing routines in which students are called on to participate with some system (like drawing names or round robin) that promotes gender blind participation in class. Teachers will need to be convinced of the need for this approach as the vast majority believed there was equal participation.

The greater participation of female students in physics was an interesting finding. Perhaps the teachers called on females more often (in two of the physics classes) because they were anticipating that the girls would answer more readily and enthusiastically, a common practice (Tobin & Garnett, 1987). Another explanation might rest on the fact that in this school physics is an elective course and is not a graduation requirement. Students seeking science credits for college entrance were able to select from several alternatives. So, the female students in physics might be different from female students who enrolled only in required courses, or from those who chose to take other science electives.

Observed trends in teachers' classroom practices aligned well with teachers' implicit beliefs about gender differences in science ability. In the interviews the teachers described males as more "able" students and females as more conscientious students in science. Further, the greater differences in teachers' interactions with males and females in the classroom suggest that teachers communicated their implicit beliefs to their students during instruction, thus reinforcing gender stereotypes. An alarming message that the students likely receive is that science ability is a fixed quality that males inheritably possess and females do not. Years of research in cognitive psychology have shown convincing evidence that all cognitive abilities will improve with learning and practice (Halpern, et al, 2007). It is this message that the teachers need to explicitly and implicitly convey to students to help close the achievement gap in science education.

Of course this study was conducted with a relatively small number of teachers so caution must be used in generalizing the results. Yet, the results do match the observations of other researchers currently (AAUW, 2008; Hyde, Lindberg, Linn, Ellis & Williams, 2008; Rieggle-Crumb, King, Grodsky, & Muller, 2012) and from the past (Altermatt, Jovanovic, & Perry, 1998; Jones & Wheatley, 1990; Kahle, 1990; Wilkinson & Marrett, 1985). It is also important to note that teachers are not the only but are likely one of many influences on students' motivation and engagement. Teachers may be more accessible and amenable to change than mass media or families so it is worth pursuing approaches to impact their implicit beliefs and interaction patterns with students.

In conclusion, this study suggests some inconsistency between science teachers' stated beliefs about gender equity in their classrooms and actual observations of their classrooms. Observations suggest that students may receive some (albeit probably unintended) messages about gender and science. Given that many norms and stereotypes of "scientists" are strongly gendered, it was important to explore the degree to which gender appears salient among the

teachers of tomorrow's scientists. Our findings suggest that efforts need to be made to address the implicit beliefs and behaviors of science teachers regarding gender.

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