JOURNAL OF RESEARCH IN SCIENCE TEACHING VOL. 55, NO. 2, PP. 271–298 (2018)

Research Article

Supporting Girls' and Boys' Engagement in Math and Science Learning: A Mixed Methods Study

Jennifer A. Fredricks,[1] Tara Hofkens,[2] Ming-Te Wang,[2] Elizabeth Mortenson,[2] and Paul Scott[2]

[1]*Union College, 807 Union Street, Schenectady, New York*
[2]*University of Pittsburgh, Pittsburgh, Pennsylvania*

Received 7 August 2016; Accepted 20 July 2017

Abstract: This study uses a mixed method sequential exploratory design to examine motivational and contextual influences on boys' and girls' engagement in math and science, paying particular attention to similarities and differences in the patterns by gender. First, interviews were conducted with 38 middle and high school students who varied in their level of math and science engagement about their perceptions of the motivational and contextual factors influencing their level of engagement. Both boys and girls discussed how their engagement was higher in classrooms with more student-centered instructional practices and in classrooms with highly engaged peers. Girls were more likely to discuss teacher support and personally relevant instruction as being important to their engagement in math and science. In contrast, boys reported being more engaged in math and science when they were interested in pursuing a STEM-related career. From these interviews, we identified factors that students described as important to their engagement and tested whether these factors were statistically significant in a socioeconomic and racially diverse sample of 3,833 middle and high school students. Specifically, we tested the associations between adolescents' motivational beliefs (e.g., utility value, attainment value, and expectancy beliefs), social support from teachers and peers, and student-centered and relevant instructional practices with engagement (e.g., cognitive, behavioral, emotional, and social) in math and science, paying particular attention to main effects and gender as a moderator. In the majority of the models, the motivational and contextual factors were significantly related to engagement and had comparable effects for girls and boys. We documented a few significant interactions by gender that tended to mirror the patterns found in the qualitative interviews. Implications of these findings for developing interventions to increase girls' participation in math and science are discussed. © 2017 Wiley Periodicals, Inc. J Res Sci Teach 55: 271–298, 2018
Keywords: engagement; motivation; student-centered instruction; gender; mixed methods

Adolescents' engagement in math and science coursework is critical for developing the preparation and persistence necessary to pursue college majors and careers in science, technology, engineering, and mathematics (STEM) fields (Maltese & Tai, 2010). Unfortunately, American adolescents' engagement in math and science declines over the middle and high school years, particularly for female and minority students (Martin, Way, Bobis, & Anderson, 2015;

Contract grant sponsor: National Science Foundation; Contract grant number: 1503181.
Correspondence to: J. A. Fredricks; E-mail: jfred@conncoll.edu
DOI 10.1002/tea.21419
Published online 9 September 2017 in Wiley Online Library (wileyonlinelibrary.com).

Wigfield et al., 2015). As a result, many American youth fail to attain the fundamental math and science skills that would enable them to successfully participate in the workforce (Baldi et al., 2007; Evan, Gray, & Olchefske, 2006), and even fewer attain the advanced knowledge and abilities needed to pursue STEM careers (National Science Foundation, 2015). Furthermore, female adolescents who are academically successful in their math and science coursework are less likely to choose a STEM career than their male peers (Clewell & Campbell, 2002; Wang, Eccles, & Kenny, 2013), resulting in fewer qualified and motivated individuals to fill the growing need for STEM professionals and an underrepresentation of females in certain STEM courses, majors, and careers (National Science Foundation, 2015).

Increasing student engagement has been an explicit goal of many school improvement efforts that address problems of student boredom, alienation, and low achievement in math and science (National Research Council, 2004). The term *student engagement* refers to the quality of a student's involvement in academic settings and learning activities (Eccles & Wang, 2012; Skinner, Kindermann, Connell, & Wellborn, 2009) and is conceptualized as consisting of at least three distinct, yet interrelated dimensions: behavioral, emotional/affective, and cognitive (Fredricks, Blumenfeld, & Paris, 2004). *Behavioral engagement* refers to student participation, effort, attention, persistence, positive conduct, and the absence of disruptive behavior (Fredricks et al., 2004). *Emotional engagement* focuses on the extent of positive (and negative) reactions to teachers, peers, and classroom activities, as well as interest in and value of learning (Finn, 1989; Voelkl, 1997). *Cognitive engagement* refers to students' self-regulated learning, use of deep learning strategies, and exerting the necessary effort for comprehension of complex ideas (Fredricks et al., 2004; Meece, Blumenfeld, & Hoyle, 1988). In addition to the traditional tri-dimensional conceptualization of student engagement, some scholars have recently added a fourth dimension, *social engagement*, which has been defined in terms of the quality of social interactions and the social forms of engagement around classroom tasks (Linnenbrink-Garcia, Rogat, & Koleskey, 2011; Rimm-Kaufman, Baroody, Larsen, Curby, & Abruy, 2015; Wang, Fredricks, Ye, Hofkens, & Schall, 2016).

In order to increase the number and diversity of students who pursue STEM careers, we need to better understand how to support both males' and females' engagement in math and science coursework. Motivational theorists posit that contextual factors—such as teachers, peers, and learning task—influence student engagement in math and science, which, in turn, influences their educational and occupational choices (Wang & Degol, 2013). The majority of research on gender and STEM education has used quantitative techniques to test hypotheses about the predictive associations between motivation, context, and engagement. A handful of studies have tested whether these relations differ by gender (e.g., Simpkins, Davis-Kean, & Eccles, 2006; Simpkins, Fredricks, & Eccles, 2015; Watt et al., 2012), though more research is necessary to determine which of these influences are shared and which are more salient to female or male students.

Although this quantitative research has provided important insight into the factors that are associated with engagement, we still know very little about how both male and female students make meaning of their experiences in math and science classrooms, which contextual factors are most salient to their engagement, and how these experiences relate to how they engage in math and science. Qualitative methods can supplement the quantitative data by providing in-depth information on context and engagement to help address questions about "how," or the ways that individuals make meaning of their engagement and "why," or the process by which contextual and motivational factors influence engagement over time (Johnson & Onwuegbuzie, 2004; Tolan & Deutsch, 2015). We address this gap in the literature by using a mixed method, sequential exploratory design to examine similarities and differences in the motivational and contextual influence on boys' and girls' engagement in math and science (Creswell, Plano Clark, Gutman, & Hanson, 2003).

Theoretical and Empirical Frameworks

Expectancy-Value Theory

In this paper, we use expectancy-value theory as an overriding framework to examine how engagement is shaped by both motivational and contextual factors. According to expectancy-value theory, engagement is most directly influenced by two motivational factors: (a) expectancy beliefs and (b) subjective task value (Eccles et al., 1983; Wigfield & Eccles, 2000). Expectancy beliefs refer to students' beliefs about how well they can expect to do on academic tasks or in an academic subject area in the immediate or distant future (Eccles et al., 1983). Task value is a function of four distinct components: intrinsic and interest value (i.e., the enjoyment of an activity), attainment value (i.e., the importance of doing well on a task to confirm aspects of one's self-schema), utility value (i.e., usefulness of a task for future goals), and cost (i.e., negative aspects of engaging in a task). In general, individuals are more likely to participate in math and science learning activities when they have high perceptions of their chances of being successful and view these domains as interesting, important, and compatible with one's self-schema (Eccles, 2009). Gender differences in these competence and task beliefs are one explanation for why girls are less likely to choose STEM-related courses and careers. Expectancy-value theory also links individual and gender differences in motivational beliefs to the experiences that individuals have in social contexts. Specifically, expectancy beliefs and task value are shaped by teachers' beliefs and behaviors, social contexts, individual perceptions of tasks, and cultural beliefs about gender roles and STEM courses and careers (Eccles, 2009).

Teacher Support. Research has shown how teacher support (e.g., teacher caring, involvement, and encouragement) is predictive of behavioral, emotional, and cognitive engagement indicators (Pianta, Hamre, & Allen, 2012; Roorda, Komen, Split, & Oort, 2011; Wang & Eccles, 2012; Wang & Holcombe, 2010). Some research has suggested gender differences in the quality of teachers' relationships with their students. Teachers are more likely to stereotype math as a masculine domain and believe that girls gain less from additional effort and that math is more difficult for girls than for boys (Keller, 2001; Tiedemann, 2002). Teachers have also been found to have more interactions with male than with female students, and these interaction patterns are more pronounced in stereotypically male domains, such as math and science classrooms (Meece, Glienke, & Burke, 2006).

Peer Support. During adolescence, youth spend more time with and place greater emphasis on the expectations of their peers, and as a result are more motivated by belongingness and positive peer regard (Brown & Larson, 2009). Students who perceive that their peers support and care for them have been found to be more behaviorally and emotionally engaged in learning (Garcia-Reid, 2007; Wang & Eccles, 2012; Wentzel, 2005). As female students tend to place greater emphasis on building and maintaining relationships, this peer support may be particularly important to girls' engagement, especially in non-traditional domains like math and science (Crosnoe, Riegle-Crumb, Field, Franks, & Muller, 2008; Giordano, 2003). Unfortunately, there is also some evidence that girls receive less peer support and encouragement in science courses than do their male counterparts (Kelly, 1988).

Instructional Approaches. The goal of current math and science reforms has been to include more student-centered instructional techniques, a pedagogical approach where students collaborate with their peers on real-world tasks that promote higher order thinking (Meece, 2003; Resnick & Nelson-Le Gall, 1997). These reforms place a greater emphasis on group work, complex problem solving, quantitative data analysis, abstract reasoning, and argumentation (e.g., Common Core State Standards, 2015; National Research Council, 2012). A student-centered instructional environment differs from a teacher-centered instructional environments, which maintains the teacher as the focus and intellectual authority of the classroom, and has a greater focus on procedural than on conceptual understanding (Stein, Kinder, Silbert, & Carnine, 2005).

Scholars have suggested that student engagement is higher in classrooms where tasks are hands-on, relevant, and authentic (Bransford, Brown, & Cocking, 1999) and where students have opportunities to work with and discuss ideas with their peers (O'Donnell & Hmelo Silver, 2013; Ryan & Patrick, 2001), though empirical research testing the associations between instructional style (i.e., student versus teacher directed) and student engagement is limited. Some scholars have suggested that instruction that is hands-on, relevant, and emphasizes applied learning may be particularly beneficial for girls (Baker & Leary, 1995; Geist & King, 2008; Lee & Burkam, 1996), though other work suggests that the benefits of student-centered instruction extend to both genders (Brotman & Moore, 2008). Furthermore, some have argued that girls may especially benefit from learning environments that foster greater connection and affiliation because these environments are more cooperative and relationally driven (Gilligan, 1982; Wang, 2012; Zohar, 2006). In contrast, boys are assumed to take a more competitive approach to learning, though more research is necessary to evaluate this claim (Daniels, Creese, Hey, Leonard, & Smith, 2001; Wang, 2012).

Disciplinary Differences

Math and science coursework can overlap and relate in a number of ways. Science is considered a quantitative discipline and there are several shared practices across mathematics and science (see CCSRI, 2015). As a result, there has been a recent emphasis on strengthening the alignment between math and science coursework (National Research Council, 2013). Moreover, some studies show that student engagement and understanding is improved in coursework that integrates these subjects (Czerniak & Johnson, 2014; Venville, Rennie, & Wallace, 2004). However, despite the potential overlap and integration of math and science, it is important to acknowledge disciplinary differences that may influence how students engage in these classrooms.

In most schools, mathematics and science are treated as separate content areas whose learning goals, curriculum, instruction, and assessment practices can vary significantly throughout secondary school (McConachie & Petrosky, 2010). Math instruction tends to focus on teaching a well-defined sequence of concepts and procedures (Sherin, Mendez & Louis, 2004). Mathematics instruction also emphasizes the repeated practice of procedural skills and frequent and timed assessments (Boaler, 2015; Henningsen & Stein, 1997; Stein, Engle, Smith, & Hughes, 2008). This has resulted in many teachers expecting students to memorize and apply procedures with speed and accuracy as opposed to focusing on meaning and understanding (Boaler, 2015). The math curriculum also tends to be more theoretical and abstract than science. In contrast, science instruction tends to more connected to real world issues and has a greater focus on the how and why of learning than does mathematics (Duschl, 2008). Science classrooms also focus more on inquiry-based instructional approaches where students develop a knowledge and understanding of scientific ideas and how scientists conduct their work (Bartos & Lederman, 2014; National Research Council, 2000; Sandoval, 2005). The hands-on experiences in science may make it more appealing than math for youth with interests in applied careers and real-world problem-solving skills (Maltese & Tai, 2011).

These disciplinary differences can influence girls' and boys' engagement in mathematics and science in complex ways. On the one hand, the emphasis on timed assessment has been linked to the development of mathematics anxiety (Boaler, 2015), which is more prevalent among female students (Lau & Roeser, 2002). The emphasis on students' performance on discrete tasks in mathematics may also undermine cognitive engagement by hindering students' ability to develop a deeper understanding of what they are studying (Boaler, 2015). Although the opportunity to engage in hands-on learning and scientific inquiry could contribute to higher quality and more sustained emotional engagement in science coursework, the less frequent assessments in science could also potentially lead students to be less consistently behaviorally and cognitively engaged in this domain.

Mathematics and science educators also experience different constraints in the ways in which they can adapt their courses to support student engagement. Mathematics performs a gate-keeping function for students who aspire to STEM careers (Li, Shavelson, Kupermintz, & Ruiz-Primo, 2002). Math teachers also feel more constrained by the curriculum and feel less autonomy in making adaptions to the course content and their instructional practices than do teachers in other domains (Stodolsky & Groosman, 1995). In contrast, science departments tend to offer more discrete and specialized courses, and as a result teachers feel greater freedom in determining the content of their courses than do math teachers (Siskin, 1994: Stodolsky & Groosman, 1995). Given the differences in how mathematics and science is taught in secondary schools and potential differences in motivation to pursue STEM careers, it is important to examine how these differences contribute to boys' and girls' engagement in this coursework.

Gender and Engagement

Until recently, much of the research on engagement in math and science learning has focused on mean-level gender differences in motivation, engagement, and contextual factors. Although girls and boys have similar math and science course grades, several studies have shown that girls have lower perceptions of their abilities in these domains than do boys (Andre, Wingham, Hendrickson, & Chambers, 1999; Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005; Watt et al., 2012). Additionally, there is evidence that girls have less positive attitudes toward science, less interest in the domain, and are more likely to perceive science as difficult (Brotman & Moore, 2008; Jones, Howe, & Rua, 2000; Miller, Blessing, & Schwartz, 2006; Wang, 2012). Other studies have indicated that boys report greater interest in math in high school (Frenzel, Goetz, Pekrun, & Watt, 2010; Hyde, Fennema, Ryan, Frost, & Hopp, 1990) and rate the importance of math higher than girls do (Andre et al., 1999).

Research on mean-level differences can provide important insight into whether boys or girls, on average, are more likely to engage in certain activities or hold different motivational beliefs. However, if policymakers and practitioners want to increase girls' and boys' engagement in math and science, they also need to know whether the nature of the associations among constructs are similar or different by gender. Relatively few studies have tested gender as a moderator. One exception is research by Watt et al. (2012) which found that utility value (i.e., perceptions of usefulness) in math had a stronger impact on females' than males' careers choices. In contrast, other studies have failed to show gender differences in the associations between motivational beliefs and participation in mathematics (Simpkins et al., 2006, 2015).

Although there is some suggestion that certain instructional environments are more beneficial for girls, more research is clearly necessary to evaluate this claim. Additionally, while some studies suggest that girls receive less social support from teachers and peers than do boys, we know little about whether teacher support influences engagement in math or science differently for boys and girls. A better understanding of which influences are shared across genders and which influences are stronger for one gender over another has important theoretical and practical implications for designing interventions that enhance participation in math and science courses and careers for all students.

Mixed Methods

This study used a mixed method sequential, exploratory design to examine contextual and motivational influences on boys' and girls' engagement in math and science (Creswell et al., 2003). Combining qualitative and quantitative methods enhances the validity of findings by (a) triangulating results across different methods that examine the same phenomenon, (b) expanding and elaborating on findings, and (c) uncovering contradictions that can result from the use of different methods (Creswell & Plano, 2011; Greene, Caracelli, & Graham, 1989; Tolan & Deutsch, 2015). First, we interviewed female and male students with varying levels of engagement in the subjects of math and science about their engagement and experiences in these particular classrooms. The purpose of the qualitative study was to explore the question, "what are students' perceptions of the motivational and contextual factors influencing their engagement, and do these differences vary by gender"? From these interviews, we identified motivational and contextual factors that students perceived influencing their math and science engagement. The themes identified in the interviews were used to select constructs from a larger survey of motivation, context, and engagement. We then quantitatively tested the relations among these constructs with a larger sample of middle and high school students. Specifically, these analyses explored the question, "are the motivational and contextual factors identified in the interviews predictive of behavioral, cognitive, emotional, and social engagement, and do these associations differ by gender?"

Qualitative Study

Sample

The qualitative sample included 38 students (middle school [$N = 10$, 2 in 7th grade and 8 in 8th grade] and high school [$N = 28$, 13 in 9th grade, 5 in 10th grade, 4 in 11th grade, and 6 in 12th grade]). The sample had a slightly larger percentage of female students (female [$N = 20$], male [$N = 17$], unidentified gender [$N = 1$]). The sample was predominately Caucasian/White ($N = 24$), with a smaller number of African American ($N = 6$), multiracial ($N = 4$), and Asian American students ($N = 4$)]. Approximately one-fourth of the sample qualified for free- or reduced-lunch ($N = 9$).

All participants were recruited from six different school districts in Western Pennsylvania. These schools were selected because of their interest in promoting student engagement in math and science as well as their diverse student populations. These schools represented a range of school types and are diverse in terms of socioeconomic status and race. Specifically, the sample includes students from eight regular public secondary schools, eight public charter secondary schools, and one private secondary school, each of which vary in the size of the student population (247 to 1,404 students), racial composition (6–85% minority), and the socioeconomic status of students (10–82% economically disadvantaged students).

We asked school administrators and participating teachers to identify racially diverse students in the 6th through 12th grades from each of their schools who were currently enrolled in math and science classes and who varied in their level of engagement and achievement (i.e., students whose level of engagement and achievement in math and science ranged from low, medium, and high). Administrators and teachers sent consent forms home with students who were identified to participate. Any student who returned a consent form was eligible to participate.

Method

We used semi-structured interviews to gather data from students. The interview questions were organized around the following areas: (a) what does engagement and disengagement mean to you? (b) what do students do when they are engaged in math and science? and (c) what influences student engagement and disengagement in math and science? First, we wanted to see how participants thought about engagement and disengagement with little prompting from interviewers. After eliciting unprompted information about engagement and disengagement in math and science, we asked students to provide specific examples of times when either they or their peers were engaged or disengaged in these subjects, and prompted them to describe what they were doing, feeling, and thinking at that time. Additionally, we asked students a general question about what influenced their engagement and disengagement in math and science. We then followed with specific questions about how socializers (i.e., teachers and peers) and the task influenced their level of engagement in these subjects. The interview is available by contacting the first author.

Interviews were conducted by the project coordinator, three doctoral students (one white females, one African-American female, and one Asian-American female), and the first author. To increase comparability across interviews and interviewers, we used a detailed interview protocol that outlined specific issues to attend to and suggested potential follow-up probes (see Supplementary Materials for list of questions and probes). However, in order to fully explore the perspective of students, we also allowed participants' answers to help guide the direction taken during individual interviews. All interviewers completed mock interviews prior to interviewing participants to ensure that all were asking protocol questions and probing for additional information in similar ways. Following this initial training period, interviewers listened to others' recorded interviews to review and discuss any differences, suggest new questions that should be explored, and ensure consistency among the interviewers. The research team met weekly to discuss the substance, format, and facilitation of interviews, as well as theoretical observations regarding themes that were emerging in the interviews.

Data Analysis

We used a combination of induction, deduction, and verification techniques to analyze the interviews (Miles, Huberman, & Saldana, 2014; Saldana, 2009). All interview transcripts were first coded using Dedoose, a computer program for coding qualitative interview data. All transcripts were coded for indicators of engagement and disengagement (e.g., behavioral, emotional, cognitive, and social), external influences (e.g., teacher, peer, and task/instruction), and internal influences (e.g., competence, values, and expectations for success). The research team met weekly during the coding process to discuss the definition of each code and to settle any disagreements that arose about the best way to code some of the indicators. These discussions resulted in minor refinements and an elaboration of the coding framework.

After all of the interviews were coded, printed reports generated by Dedoose were examined in order to begin compiling a list of themes across each code. Next, all transcripts were divided among three members of the research team for a holistic review of each interview. We created a list of themes across both contextual (e.g., instruction, teacher support, peers) and motivational (e.g., competence, challenge, value, and interest) factors for each transcript. The summaries were then exchanged with another team member to verify the conclusions. During this stage, the research team met on several occasions to reach *consensus* on some of the emerging themes.

In the next step, two researchers separately calculated the percentage of students who mentioned the theme at least once during the interview. We documented a 97.8% agreement between these two raters. When discussing gender differences in the frequency of themes, we noted the percentage of males and females who mentioned the theme at least once. However, in comparing the frequency of these themes, it is important to acknowledge variability in the degree of probing and the depth of responses. Because it was a semi-structured interview format, not all participants were asked about all of the influences. Additionally, the frequencies were impacted by differences in the context (e.g., type of class, level of class, and school) and individual differences in how students engage.

Qualitative Results

Instructional Methods. There were many similarities by gender in students' perceptions of how the instructional method and type of task influenced their math and science engagement. Most students thought that their engagement was higher when they were in a more student-centered instructional environment where they were working on labs and/or hands-on activities ($N = 29/38$, 76%). This type of instruction was more characteristics of science than of math classrooms. Both males and females thought these environments were more engaging because they were active, solving problems that were more connected to the real world, and discussing ideas with their peers. The following quotes illustrate this theme:

> I liked being able to watch what was happening rather than just read it off of a piece of paper. (White female high school student)

> Instead of being told about the science, you were like 'oh, this is how it's working', and then you were actually able to see how it happens without realizing that you were beginning to understand. (Asian male high school student)

Although the majority of students thought that a student-centered environment was more engaging, two students did note some problems with hands-on activities in science classrooms because the topics were boring and their directions were unclear.

On the other hand, the majority of students reported that they were more likely to be disengaged during teacher-directed instructional environments, when the teacher was lecturing and they were working on problems alone ($N = 26/38$, 68%). These types of instructional environments were more characteristics of their mathematics than of science classrooms. Students reported feeling more disengaged in these environments because they were passive and not able to construct their own knowledge. As stated by one youth:

> Engaging is actually using your hands and doing something, not just sitting there just listening or just taking notes the whole time because that's not engaging and that's just how kids fall asleep in school all day. You're using your brain, you're using your body to actually do something instead of just sitting there being a robot and just recording or listening. (White male high school student)

Many of the students also felt that their engagement was higher when instruction was personally relevant and when they had the opportunity to apply the content to real-world issues. This was more characteristics of the science than of the math classrooms. This theme was also more likely to be mentioned by female ($N = 14/20$, 70%) than by male students ($N = 9/17$, 53%). The following quotes illustrate this theme:

> It's more interesting to me if I can connect it to something in my life. (White female high school student)

> It's a real world project that makes it better. . .Applying what you learn to something, like building something, is definitely a very advanced form of engagement for students. (Black male high school student)

Peer Dynamics

The peer dynamics in the classroom were also important to engagement. Almost all of the students thought that their engagement was higher when they had the opportunity to work with their peers and discuss ideas ($N = 35/38$, 89%). They reported that working in pairs and small groups was more engaging because it was fun, helped in dividing the workload, gave them opportunities to explain ideas and help their peers, and gave them the opportunity to hear other perspectives and expand on their own thinking. The following quotes illustrate how peers influence engagement:

> I'm a person who people would come to for help. And so that helps me understand it a lot better when I have to explain it to someone else. And I find out things that I'm not sure about when I'm like 'you do this I think' and then I can be like 'oh, you did this for sure'. . . I really enjoy doing that when we first learn something because · · ·I can ask them questions and we can both learn something. And then solidify new concepts. (White female high school student)

> With math, I think talking about it with your peers and being able to go up to the board, that's engaging. . .with math and science I think it's easier to have a conversation with someone about it to understand it. . . It's just hearing other people's opinions or how to do it helps spark something. It helps me process information better. (White female high school student)

However, many of the students did report some challenges with collaborative work, especially when either they or their peers were not engaged and did not care about learning. This theme was more likely to be mentioned by male ($N = 10/17$, 58%) than by female students ($N = 7/20$, 35%).

> I can't stand it when I'm working with someone who the whole time they're just like "oh I don't even care about this it doesn't matter" and I'm like "oh it kind of does", so their attitude affects my attitude. It's just really irritating to the people who do care and who do want to learn this because they're disrupting the class and they're taking time away from stuff. (White female high school student)

> I am a very social person so I get sidetracked because I'm usually with like somebody, so I'll start talking about something that's completely irrelevant to what the whole class is about. (White male high school student)

For both genders, the engagement level of their peers appeared to relate to the participant's own engagement. Several of the participants talked about how it was important to surround themselves with peers who were also interested in learning because these peers were more likely to participate, support their learning, and help them when they had difficulties ($N = 21/38$, 55%).

> If people who are really engaged surround you then people are more likely to be engaged. Definitely helps learning something with others versus on your own because then you can just, like I said, help each other along in the process. (White female high school student)

Relationships With Teachers. Almost all of the students reported that they were more engaged when their teachers monitored their engagement and level of understanding, provided scaffolding and encouragement, demonstrated passion, and set up a challenging and engaging environment ($N = 36/38$, 95%). In contrast, when a teacher was disorganized, boring, and did not seem to care about students' level of engagement or what they were teaching, they reported becoming more disengaged. The following quotes illustrate the different ways teachers support students' engagement in math and science:

> They (teachers) make the class interesting. Like not just the subject, the class itself. . .. Or if they take the extra step to show where something can be applied or why it's significant, that makes it better too. (White female high school student)

> If I see the teacher actually like wanting to be here and being engaged, and wanting to make it enjoyable I'll kind of do the same, like I'll be engaged, I'll want to make it enjoyable and respect them and really, but if it's like, they're gonna fall asleep in class I might as well just do the same thing. (Asian male high school student)

Female students ($N = 7/20$, 35%) were more likely to report that developing a personal relationship with their teacher was a critical factor in their engagement. Only two of male students reported this theme. Developed a positive relationship with their teacher appeared to help these female students feel more comfortable participating in class and made them less afraid to seek out additional help when they did not understand the content. The following quotes illustrate this point:

> My teacher, she helps me a lot to feel comfortable and be able to speak out. (White female high school student)

> I like it when I feel comfortable around my teacher. . . Being comfortable in class is much better for my studies because they don't like, usually when I'm stressed out I can't get as good of grades, and usually if I'm stressed I can't answer the question as right. (Asian female middle school student)

Teacher support was especially important to students who were having academic difficulty and to those indicating a less positive experience during the previous year. This theme was more likely to be mentioned by female students ($N = 10/20$, 50%). Only two male students discussed this theme.

> With me and math, it depends on if I have a good teacher. And so last year I struggled the whole way through and this year it kind of just makes more sense. So that's exciting for me. (Black female high school student)

Students thought it was easier to develop these types of relationships with their teachers in classrooms where there were fewer students because it was easier to ask questions and instruction could be more individualized.

Expectancy Beliefs. Expectancy beliefs were also important to engaging in math and science. The majority of the students reported that perceiving and demonstrating that they had ability to their teachers and peers was important to their enjoyment, participation, and persistence in math and science ($N = 33/38$, 87%). The following quotes from students illustrate this theme:

> In math I'm really engaged because if we're like, if we do like a worksheet and then I know how to do one of the problems I'll like want to share out and stuff, because I know what's going. (White female high school student)

> I mean when you understand like the material, you feel really confident, you feel really good about yourself so I guess that kind of gets people to engage too, like, hey I understand what's going on, this is pretty cool. (Asian male high school student)

Many of the students also reported that difficult and challenging content was more engaging. They talked about how they had to pay attention, work harder, and use variety of strategies to try and figure out challenging problems ($N = 23/38$, 61%).

> It's difficult, but once you get it, like once I start understanding it, after so often, like, I feel better about myself. I feel like I have done more work and I've worked towards something instead of like just giving up. (White male high school student)

> I'm probably more interested this year cause it's more of a challenge for me... I need to work harder to do better, which means I need to engage myself more and allow myself to be engaged and attentive. (Female high school student)

However, girls ($N = 10/20$, 50%) were more likely than boys ($N = 3/17$, 18%) to discuss signs of disengagement (e.g., being frustrated, giving up) when they thought the content was too difficult. This was more common in math than in science classrooms.

> I find something challenging I tend to engage less, cause I don't like things being challenging, I don't like asking for help, I don't, I don't like asking for anything. (Multiracial male high school student)

> It's hard or you don't understand the material. And then you get frustrated and just sometimes you just stop...Like you're sitting there like I don't know what to do I don't know how to do it and I don't want to do it because I don't know how to do it. (Black female middle school student)

Additionally, some of the students talked about how they were less likely to participate because of fears of getting it wrong or looking dumb. This theme was more common among female ($N = 9/20$, 45%) than among male students ($N = 5/17$, 29%).

> You get lost. But then you don't want to ask the question because you don't want to feel dumb. Cause everyone else get it but you. (Black female middle school student)

> There is always a barrier to raising your hand and saying, I don't understand, because you're in front of your peers and if you're someone who your peers regard as smart, then it can be embarrassing at times. (Asian male middle school student)

Value Beliefs. Boys ($N = 7/17$, 41%) were more likely than girls ($N = 5/20$, 25%) to report that they perceived that math and science was useful for college and future careers. More of the boys ($N = 9/17$, 53%) than girls ($N = 3/20$, 18%) reported that they were engaged in math and science because they were interested in pursuing STEM-related careers, such as medicine and engineering. The following quotes illustrates this point:

> As of now something in the medical field. . .We did like the whole like cells and the different like organ systems. . .I found that to be pretty interesting because it like directly reflects the sort of medical field and it really makes much more of a difference than it does to how you see it. More than just a chapter, but something possibly to use in your future. (White male high school student)

> I'm almost out of high school, I need to start thinking of a career that I'm not going to be completely miserable to go every day, and that I'm actually gonna make decent money in, so I started looking into that. And I figure math is one of my stronger suits and math and science and all that, and I can't stand English so, figured engineering seemed pretty cool. (Asian male high school student)

In contrast, some of the girls talked about how they had a hard time seeing how math or science was useful or relevant to their future ($N = 7/20$, 35%). This theme was not mentioned by any of the boys. The following two quotes illustrate this theme.

> In science it would sometimes like this isn't gonna help me in any time in my life so why would I do it now. (Black female high school student)

> I don't really understand how biology will be helpful later on, unless I want to be a scientist or like a mathematician or something. But I don't, so it's kind of hard to [pause] keep in mind why this will be important later on. (white female high school student)

Girls' lower perception of the task value of math and science resulted in girls being less likely to report an interest in a math and science career or a desire to learn about math and science outside of school.

A few students discussed how their perceptions of math and science ability and the value of participating in the domain influenced their math and science identity, which in turn influenced their engagement in these domains ($N = 7/38$, 18%). Four of the girls described their math and science identity in terms of "not being a math and science person" and not wanting to be seen as the "dumb math girl." For these girls, being engaged in math and science appeared to be incompatible with their developing identity. They felt that they were not good at math, did not value it, and did not feel that engagement in this domain fit with who they were and who they wanted to become. In contrast, two of the boys and one of the girls talked about how they were "math and science oriented person" or "good with numbers", and how this identity positively influenced their engagement in math and science.

Study 2: Quantitative Study

The qualitative interviews informed the selection of constructs from the larger quantitative survey of motivation, context, and engagement, as well as the choice of specific constructs from this larger survey that we included in the quantitative analyses. Specifically, the qualitative interviews were used to develop the scales of behavioral, emotional, cognitive, and social engagement in math and science (see Fredricks et al., 2016, for more description), as well as to inform the selection of the other constructs (e.g., context and motivation) included in the larger quantitative survey. The constructs in the larger survey were initially chosen based on a review of the prior literature. To verify the inclusion in the survey, we compared this list of constructs against the motivational and contextual factors discussed in the interviews. From this larger list of constructs, we then chose specific scales to test in the quantitative analyses that emerged from the themes in the interviews.

Based on our qualitative analysis, we chose scales to measure expectancy beliefs, value beliefs, teacher support, peer support, student-centered instruction, and fostering relevance and understanding to include in the quantitative analyses. For example, expectancy beliefs were included in the quantitative analyses because of the large number of students who talked in their interviews about how their perceptions of their ability and expectancies for success in math and science were important to their engagement. Additionally, we included two scales for value beliefs because some students discussed how they were more engaged when they felt that math and science was relevant to their future (e.g., utility value) and when participating in math and science fit with their self-schema (e.g., attainment value). Furthermore, scales assessing both teacher and peer support were included in the quantitative analyses because students discussed the importance of having academic support (i.e., help when they were having difficulty) and social support (i.e., caring about how they were feeling) from both their teachers and peers. Additionally, we included a scale assessing student-centered instruction because many students talked about how their engagement was higher when they had the opportunity to work on meaningful and challenging tasks, when their teachers were flexible and responsive to their needs, and when their teachers provided scaffolds and supports. Finally, fostering relevance and understanding was included to reflect the theme that students were more engaged when tasks were personally relevant and applicable to life outside of school. We then tested the associations between scales assessing motivational beliefs (e.g., expectancy beliefs, utility value, attainment value), social support (e.g., peer support, teacher support), and instructional practices (e.g., student-centered instruction and fostering relevance and understanding) and engagement in math and science (e.g., behavioral, emotional, cognitive, and social engagement), paying particular attention to potential differences in the pattern of associations by gender.

Sample

Participants were middle and high school students recruited from three of the six school districts included in the qualitative study. The sample included 3,833 students in 6th through 12th grades (17.5% 6th graders, 18.8% 7th graders, 19.4% 8th grade, 12.9% 9th graders, 10.9% 10th graders, 11.2% 11th graders, and 9.3% 12th graders). Approximately 52.1% of the sample was female; 66.1% was Caucasian/White, 23.8% was African American, and 10.1% identified as another race or ethnicity. The sample was economically diverse, with 35.2% of the sample qualifying for a free- or reduced-price lunch. Students were nested within 356 math classrooms, with an average class size of 10.6 students per class, and 313 science classrooms with an average class size of 9.6 students per class.

Procedure

All participants were invited to participate in the study using school-based recruitment during the fall semester of the 2014–2015 school year. With math and science teachers' help, the research team distributed letters about the project to students in their math or science classes and asked permission for the students to participate in the study. Informational forms were sent home that described the study purpose and procedures and provided a place where parents and/or students could sign in order to opt out of the study. In order to increase the number of teachers participating in the large study, surveys were administered in either a math or science classroom. The most common science courses included general science courses, chemistry, biology, physics, and astronomy, and the most common mathematics courses included general mathematics, algebra, geometry, calculus, trigonometry, and statistics.

Regardless of which class the survey was administered in, all students responded to questions about both their math and science classes. Students whose parents did not opt them out and who agreed to participate were provided with a computer-based survey that they completed during a full period of either their math or science class. Research staff was available to answer questions about survey items. Student surveys were anonymous aside from being linked to the students' math and science classes.

Measures

Students responded to survey items concerning their math and science classes using a 5-point Likert scale. Negative items were reverse coded and scale scores were obtained by averaging items such that higher scores indicated higher levels in the construct of interest. The list of items in each scale are available in the supplementary materials. Descriptive statistics and cronbach's alphas for each scale are presented in Table 1.

Student Engagement. We assessed behavioral, emotional, cognitive, and social engagement, with the *Math and Science Engagement Scales* (Wang et al., 2016). The indicators of students' cognitive, behavioral, emotional, and social engagement in math and science were measured with items that were initially developed from the qualitative interviews (see Fredricks et al., 2016, for more discussion). Specifically, we were interested in how students and teachers conceptualized engagement and disengagement, and used these responses to develop items in the *Math and Science Engagement Scale.* Because there were few differences in the indicators that teachers and students reported as indicative of engagement in math and science, we created one scale to assess engagement in math and science for both subject areas. Having one measure for math and science engagement has the benefit of being appropriate in STEM coursework that is math-intensive and non-math intensive. Wang et al. (2016) examined the validity of this newly developed measure in an ethnically and economically diverse sample, and found support for the construct validity, predictive validity, and measurement invariance of the four engagement scales.

The cognitive engagement scales included eight items about students' use of deep learning strategies and self-regulated learning in math and science (e.g., "I go through the work that I do for math/science class and make sure that it is right"). The behavioral engagement scales included eight items about students' involvement and investment in classroom activities in math and science (e.g., "I put effort into math/science"). The emotional engagement scales included ten items about students' positive and negative reactions to and value of classroom learning and activities in math and science (e.g., "I enjoy learning new things about math/science"). The social engagement scales included seven items about students' willingness to value and consider others' perspectives and the quality of students' interactions in math and science class (e.g., "I build on others' ideas"). All items were on a scale indicating how closely the student identified with the item, with results ranging from 1 (*not at all like me*) to 5 (*very much like me*).

Student Motivational Beliefs. Students responded to questions about utility value, attainment value, and expectancy beliefs in math and science (Trautwein et al., 2012). The utility value scale included three items about how useful math and science is to their lives or their future (e.g., "I will need good math/science skills for my daily life outside of school"). The attainment value scale included three items about the importance of math and science (e.g., "Science is important to me personally"). The expectancy belief scale included three items about how likely they feel that they are to succeed in math and science (e.g., "I am good at math/science"). The response scale for all motivational belief scales ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). Trautwein et al. (2012) found evidence that the expectancy and value beliefs of adolescents from a number of different schools are domain specific and predictive of academic achievement.

Table 1
Descriptive statistics of the sample for the quantitative study and of the main study variables (n = 3,883 secondary school students)

Variable	*M*	SD	Percent (%)	Cronbach's α	Intra-Class Correlation
Female			52.12		
Minority			33.94		
Free lunch			35.15		
Previous GPA					
Cognitive engagement	2.45	1.39			
Math	3.74	.68		.74	.10
Science	3.68	.69		.75	.08
Behavioral engagement					
Math	4.41	.82		.82	.17
Science	4.44	.80		.80	.14
Emotional engagement					
Math	3.67	.90		.88	.17
Science	3.82	.84		.88	.12
Social engagement					
Math	3.77	.70		.73	.05
Science	3.80	.69		.73	.05
Utility value					
Math	4.21	.78		.77	
Science	4.02	.82		.75	
Attainment value					
Math	3.76	1.00		.85	
Science	3.75	1.03		.86	
Expectancy beliefs					
Math	3.71	1.04		.90	
Science	3.62	.99		.88	
Teacher social support					
Math	3.76	1.07		.81	
Science	3.77	1.03		.84	
Peer social support					
Math	3.65	.99		.82	
Science	3.65	.99		.82	
Fostering relevance and understanding					
Math	3.56	.99		.81	
Science	3.67	.92		.79	
Student-centered instruction					
Math	3.77	.81		.85	
Science	3.68	.79		.86	

Social Support. We measured perception of social support from teachers and peers with scales adapted from the *Classroom Life Measure* (Patrick, Ryan, & Kaplan, 2007). The teacher scale included three items about the extent to which students feel that the teacher cares about them as people (e.g., "Can you count on your math/science teacher for help when you need it?"). Student responses indicated frequency and ranged from 1 (*almost never*) to 5 (*almost always*). The peer social support scale included similar items (e.g., "I can count on other students for help when I need it") as well as a fourth item that asked students if other classmates care about their feelings. Students responded on a scale of 1 (*not at all true*) to 5 (*very true*). Patrick and Ryan (2005) documented evidence of the construct validity, predictive validity, and reliability across different samples of adolescents.

Fostering Relevance and Understanding. We assessed teacher practices that foster relevance with four items from a well-validated scale that assess the extent to which the teacher explains why it is important to study certain subjects in school (e.g., "My teacher applies the subject to problems and situations in life outside of school") (Assor, Kaplan, & Roth, 2002). Students' responses ranged from 1 (*not at all true*) to 5 (*very true*). Assor et al. (2002) found that early adolescents can distinguish teacher behaviors that emphasize relevance and understanding, and that these behaviors have unique positive associations with adolescents' feelings about learning and cognitive engagement.

Student-Centered Instruction. We used the *Math Instruction Scale* to assess student-centered instruction. This scale was developed for the larger quantitative study based on indicators of student-centered instruction outlined by Stein (2000) and Stein, Engle, Smith, and Hughs (2008). The scale included six items that focused on conceptual understanding (e.g., "My math/science teachers ask us to explain and justify our method for solving a problem") and supported cognitive challenge and students' intellectual authority (e.g. "My math/science teacher shows me how to solve problems by myself"). Item responses were on a 5-point Likert scale ranging from 1 (*almost never* or *not true at all*) to 5 (*often* or *very often true*). Exploratory and confirmatory factor analyses supported the construct validity of this scale.

Control Variables. Covariates included students' gender, grade point average from the prior academic year, and eligibility for free- or reduced price school lunch as indicated by school records. Racial minority was also constructed based on students' reports of being any race or ethnicity other than Caucasian, including African American, Asian or Pacific Islander, Native American, Hispanic, or Latino/a. These variables were included because students' previous grades, race, and socioeconomic status have been linked to students' engagement in math and science domains (Johnson, Crosnoe, & Elder, 2001; Riegle-Crumb, 2006; Wang & Degol, 2013).

Quantitative Analyses

In order to examine whether students' motivational beliefs, social support, and teacher practices predicted cognitive, behavioral, emotional, and social engagement in math and science, we used multiple regression models in Stata 14.0 (Stata Corp, 2015). These multiple regression models tested the main effects of the predictor variables when controlling for gender, socioeconomic status, previous achievement, and minority status for each dimension of engagement in math and science. In addition, we tested the moderating effect of gender on each main predictor variable in the models, as well as the main effect of gender on engagement in each model. To improve interpretability, coefficients were reported in standardized form, and continuous predictors were centered around their grand-means. We addressed the clustering nature of the data by adjusting the mixed-effect linear model with a level-2 random effect for intercept variance, thereby achieving robust standard errors (Raudenbush & Bryk, 2002).

The amount of missing data on the key predictors and outcomes ranged from 3.5% to 12.7%. The vast majority of missing data had a monotonic pattern with increasing amounts of missing values toward the end of the surveys. Missingness in the outcomes was not dependent upon the predictor variables as indicated by Little's (1995) covariate-dependent missingness test, $\chi^2(72) = 15.826$, $p = 1.00$, and $\chi^2(72) = 15.497$, $p = 1.00$ for math and science, respectively. All of the missing and non-missing cases did not significantly differ from one another in terms of their values on the variables in the model. We dealt with the missing data through full-information maximum likelihood estimation, allowing us to include all available data and identifying the parameter values that have the highest probability of producing the sample data (Baraldi & Enders, 2010).

Quantitative Results

Table 2 includes results from the hierarchical regression models run for each dimension of engagement. Regarding gender differences in each dimension of engagement, girls were more engaged in math and science overall. Specifically, girls were more cognitively engaged in math ($\beta = .209$, $p < .001$) and science ($\beta = .214$, $p < .001$); more behaviorally engaged in math ($\beta = .144$, $p < .001$) and science ($\beta = .177$, $p < .001$); and more socially engaged in math ($\beta = .099$, $p < .001$) and science ($\beta = .095$, $p < .05$). The only area in which girls exhibited significantly less engagement than boys was their emotional engagement in science ($\beta = -.054$, $p < .05$).

The majority of the predictors were significantly related to engagement and had comparable effects for girls and boys. The motivational variables were significant in the majority of the models. For example, attainment value predicted all dimensions of engagement for both girls and boys in math and science (β ranges from .175 to .354, $p < .001$). Utility value predicted behavioral engagement in math ($\beta = .127$, $p < .001$) and science ($\beta = .116$, $p < .001$) and cognitive engagement in science ($\beta = .105$, $p < .001$) and social engagement in science ($\beta = .079$, $p < .05$). Expectancy beliefs predicted behavioral engagement in math ($\beta = .196$, $p < .001$) and science ($\beta = .213$, $p < .001$), emotional engagement in math ($\beta = .295$, $p < .001$) and science ($\beta = .309$, $p < .001$), and cognitive engagement in science ($\beta = .225$, $p < .001$).

Among the social support predictors, teacher support was significantly related to all of the dimensions of engagement for boys and girls (β ranges from .081 to .165). Peer support predicted behavioral engagement in math ($\beta = .064$, $p < .05$) and science ($\beta = .050$, $p < .05$), cognitive engagement in math ($\beta = .065$), $p < .05$), and social engagement in math ($\beta = .259$, $p < .001$) and science ($\beta = .240$, $p < .001$). In terms of instruction, student-centered teaching practices were significantly associated with behavioral engagement in math ($\beta = .077$, $p < .05$), emotional engagement in math ($\beta = .107$, $p < .001$) and science ($\beta = .060$, $p < .05$), and social engagement in science ($\beta = .082$, $p < .05$). After adjusting for other variables in the model, fostering relevance was not significantly related to either girls' or boys' engagement in any of the models.

There were a few predictors that had differential associations for girls and boys. In particular, utility value had a stronger association with boys' behavioral engagement in math ($\beta = -.067$, $p < .05$) and science ($\beta = -.076$, $p < .05$). Interestingly, expectancy beliefs had a stronger association with boys' cognitive engagement in science ($\beta = -.104$, $p < .05$), but a stronger association with girls' emotional engagement in math ($\beta = .066$, $p < .05$). Among the social support variables, when there was a moderating effect, it was mainly for girls. For example, teacher social support was associated with an increase in girls' behavioral engagement in math ($\beta = .065$, $p < .05$) and peers social support was associated with an increase in girls' cognitive ($\beta = .050$, $p < .05$) and social ($\beta = .060$, $p < .05$) engagement in science. Finally, teachers' efforts to support student understanding and to make math and science class relevant to students had a stronger association with girls' emotional engagement in science ($\beta = .057$, $p < .05$).

Discussion of Qualitative and Quantitative Findings

This study uses both qualitative and quantitative methods to expand our understanding of the associations between gender, motivation, contextual factors, and math and science engagement. Although mixed approaches are increasingly being advocated in developmental and educational research (Johnson & Onwuegbuzie, 2004; Tolan & Deutsch, 2015; Yoshkawa, Weisner, Kalil, & Way, 2013), the integration of both quantitative and qualitative techniques is still relatively rare in the literature. To our knowledge, this is the first study to use both thematic analysis from in-depth interviews and inferential statistics in a large sample of students to test the factors associated with

Table 2
Hierarchical multiple linear regression analyses predicting secondary school students' cognitive, behavioral, emotional, and social engagement in math and science and testing for the main and moderating effects of student gender (n = 3,883)

Predictor	Math Engagement Cognitive β (SE)	Math Engagement Behavioral β (SE)	Math Engagement Emotional β (SE)	Math Engagement Social β (SE)	Science Engagement Cognitive β (SE)	Science Engagement Behavioral β (SE)	Science Engagement Emotional β (SE)	Science Engagement Social β (SE)
Constant	5.49** (.078)	5.381** (.081)	4.115** (.056)	5.354** (.066)	5.346** (.074)	5.507** (.089)	4.459**	5.472** (.067)
Student demographics								
Female	.209** (.033)	.144** (.031)		.099** (.028)	.214** (.036)	.177** (.034)	−.054* (.035)	.095* (.030)
Free lunch	−.111* (.045)	−.184** (.041)			−.184** (.047)	−.254** (.044)	(.048)	
Minority	−.124* (.044)	−.142** (.039)		−.087* (.037)	−.165** (.046)	−.200** (.044)	−.067* (.048)	−.080* (.039)
Previous GPA	.082** (.017)	.040* (.016)	−.073** (.013)		.098** (.019)	.095** (.018)	−.039* (.019)	
Motivation								
Utility value		.127** (.031)			.105* (.039)	.116** (.037)		.079* (.033)
Utility value × female		−.067* (.030)				−.076* (.035)		
Attainment value	.258** (.041)	.233** (.037)	.352** (.031)	.232** (.037)	.202** (.037)	.235** (.044)	.354** (.037)	.175** (.039)
Attainment value × female								
Expectancy beliefs		.196** (.031)	.295** (.026)		.225** (.039)	.213** (.037)	.309** (.046)	(.033)
Expectancy beliefs × female			.066* (.026)		−.104* (.038)			
Social support								
Teacher support	.098* (.032)	.095* (.029)	.165** (.025)	.129** (.029)	.130** (.035)	.127** (.033)	.157** (.036)	.081* (.030)
Teacher support × female		.065* (.030)						
Peer support	.065* (.027)	.064* (.025)		.259** (.023)		.050* (.027)		.240** (.024)
Peer support × female					.050* (.029)			.060* (.024)
Instruction fostering relevance								
Fostering relevance × female							.057* (.040)	
Student-centered instruction		.077* (.034)	.107** (.030)				.060* (.044)	.082* (.037)
Student-centered × female								
R^2	.321	.448	.620	.298	.362	.494	.602	.301

$^{*}p < .05$.
$^{**}p < .001$.

variations in math and science engagement, and how these relations may differ by gender. The use of both quantitative and qualitative techniques enhanced the validity of our findings by showing how expectancy and value beliefs, teacher and peer support, and student-centered instruction were positively related to engagement in math and science, and how these findings were both similar and different for male and female students. Additionally, the qualitative methods offered in-depth insight into some of the mechanisms that can help to explain the positive relations between motivation, context, and engagement identified in the quantitative analyses.

Motivational Beliefs. Both the quantitative and qualitative results demonstrate the influence of motivational beliefs on math and science engagement and support the tenets of expectancy-value theory (Eccles et al., 1983). Consistent with prior research (e.g., Wang, 2012; Wigfield et al., 2015), students who reported higher perceptions of their ability (e.g., expectancy beliefs) and value of participating in math and science (e.g., utility value) also had higher levels of behavioral, emotional, and cognitive engagement. The interview study expanded on this previous research by showing the reasons for the positive associations between expectancy and value beliefs and engagement. Participants reported feeling more engaged when they were able to demonstrate this ability to their teachers and peers, when they perceived that they had the skills to solve challenging problems, and when they felt could be successful in their current and future math and science classes. Additionally, students were more likely to discuss being engaged when they saw the relevance of math and science for their lives outside of the classroom and for achieving their future career goals.

For a few of the female students, their engagement in math and science appeared to be lower because they did not see doing well in math and science as compatible with their goals, values, and identity. Their future goals, values, and identities were shaped by prevailing stereotypes of math and science as a white masculine domain, and fit with a growing body of research exploring the role that these intersecting identities play in math and science engagement (Carlone & Johnson, 2007; Cobb, Gresfaldi, & Hodge, 2009; Nassir, 2002). This finding also supports expectancy-value theory, and specifically the hypothesis that attainment value (i.e., importance of doing well in an activity for confirming one's self-schema) influences ones' behavioral choices (Eccles, 2009). School and afterschool contexts that help students think of themselves as math and science learners, feel successful, and build a sense of community have been found to help to facilitate positive math and science identities among female students (Calabrese Barton et al., 2013; Cobb et al., 2009).

Teacher and Peer Support. Both the quantitative and qualitative results demonstrate the influence of teacher and peer support on engagement in math and science. Consistent with prior research (Crosnoe et al., 2008; Roorda et al., 2011; Wang & Holcombe, 2010), teacher and peer support was positively associated with behavioral, emotional, cognitive, and social engagement.

The interviews provided additional insight into how teachers and peers positively influence engagement. For example, the majority of the students talked about how both their teachers and peers increased their perceptions of their ability and, in turn, their level of engagement, by providing encouragement and extra academic assistance when they were having difficulty, and by scaffolding their learning through modeling, asking questioning, and giving time for them to discuss ideas. These findings support the tenets of expectancy-value theory, which assumes that socializers' beliefs, attitudes, and behaviors influence students' self-and task beliefs, which in turn, influences their level of engagement (Eccles, 2009; Martin & Dowson, 2009). Participants also talked about how important it was to have teachers and peers that were engaged and cared about learning for their engagement, and how having a teacher that lacked passion and being with peers that were disengaged resulted in them being less engaged in math and science.

The use of mixed methods expanded on prior research by helping us to identify potential mechanisms by which these socializers may influence engagement in math and science. For example, in their interviews, some of the girls talked about how important it was to have a positive relationship with their teacher and how this relationship made them feel more comfortable to ask questions and to participate in class. This may help to explain the significant relationship between teacher social support and girls' behavioral engagement in math. In addition, some of the boys discussed how they are more likely to shift their attention away from their classwork, an indicator of behavioral engagement, to spending time goofing off with friends. The problems that emerged in group work for some boys could help to explain why and how peer social support was a less significant predictor of boys' cognitive and social engagement in science.

Instructional Approaches. The findings from both the qualitative and quantitative analysis expand our understanding of the benefits of student-centered instructional techniques on engagement. In the interviews, students discussed being more engaged when they were working with their peers on hands-on and personally relevant tasks, which was more characteristic of science than of math classrooms. In contrast, participants reported feeling less engaged in a more teacher-directed environment where the instructor was primarily lecturing, which was more characteristics of their math classrooms. These findings support expectancy-value theory, which assumes that individuals' expectancy beliefs, task value, and engagement are shaped over time by interactions with tasks and their subjective interpretation of these experiences (Eccles, 2009).

Although several scholars have argued that student-centered instructional environments are more motivating (Blumenfeld et al., 1991; Meece, 2003), few studies have talked directly to male and female students about how task characteristics influence their engagement in math and science classrooms. Additionally, our study expands the literature by empirically demonstrating the positive association between student-centered instruction and behavioral, emotional, and cognitive engagement. To date, few studies have empirically tested these associations in a large sample of students. These finding are important given that key aspects of math and science reforms outlined in both the Common Core State Standards (CCSI, 2015) and Framework for Science Education (National Research Council, 2012) call for teachers to use more student-centered instructional practices that emphasize conceptual understanding, collaboration, and honoring and reflecting students' voices.

Gender and Engagement. Although the pattern of association was similar in the majority of models, we did document a few differences in the strength of association by gender. For example, there was evidence in both the qualitative and quantitative analyses to suggest that strong relationships with adults and with peers are more important for girls' engagement in math and science than for boys. This finding supports prior work suggesting that girls' preferred way of learning emphasizes collaboration and connection (Wang, 2012; Zohar, 2006) and prior quantitative research which finds that peer support is particularly important for girls' engagement in math and science (Crosnoe et al., 2008; Riegle-Crumb et al., 2006). Additionally, female students were more likely to discuss the importance of relevant instruction that had application to the real world and to their lives in influencing their engagement. This finding was confirmed on the quantitative analyses which showed that relevant teaching practices were more significantly associated with girls' emotional engagement in science. The qualitative and quantitative findings both support feminist pedagogical approaches to teaching science, which emphasize the doing and knowing of science, the grounding of science in lived experience, and the societal values of science (Brotman & Moore, 2008; Howes, 2002).

Lastly, our results reveal that the same motivational beliefs may shape boys' and girls' engagement in math and science differently. To date, there has been limited research that has tested gender as a moderator (see Watt et al., 2012, for an exception). We expand this limited work by showing that expectancy beliefs were more strongly linked to boys' cognitive engagement in science, but were a stronger predictor of girls' emotional engagement in math. Insight from the qualitative interviews may help to explain these differential relations. For girls, reactions to math was strongly influenced by their expectancy beliefs, and whether they thought they understood the content and could be successful in the domain. Girls were more likely to report getting frustrated and giving up when the material was challenging. In contrast, for boys, perceiving that they were competent made it more likely that they would persist and use deep learning strategies.

Limitations and Future Directions

Our findings have to be interpreted in light of the following methodological decisions. One limitation was the composition of our interview sample. We selected this sample by asking teachers and administrators to identify racially and economically diverse students that varied in their engagement levels. However, the students who ultimately returned consent forms were more likely to be Caucasian/White and reported higher achievement and engagement in their math and science classroom than their peers. Another limitation was the reliance on self-report methodologies. There are concerns about the reliability and validity of survey responses because of recall and response biases (e.g., social desirability and inaccurate memory) (Azvedo, 2015).

Although there are disciplinary differences between math and science that can influence how students engage in these domains, in our sample math and science curriculum and instruction varied across (and in some cases within) the participating schools. This made it difficult to assess disciplinary differences in this study in a systematic way. For example, a subset of schools offered integrated math and science coursework in the middle school grades to all students, some schools integrated math and science concepts into literacy classes, some high schools offered integrated math and science courses to high achieving students, and other schools offered separate math and science courses throughout secondary school.

We administered surveys in both math and science classrooms in an effort to encourage teachers from both subject areas to participate in the larger study. Although all students responded to questions about their involvement in both math and science classrooms, we do not know whether, and if so, how the class in which the survey was administered shaped their responses. Future research should explore whether student responses vary by which course they were in when they took the survey. For example, future studies should test whether there are gender differences in engagement by math topic (i.e., calculus versus algebra versus geometry) and by subject-specific science classes (i.e., biology versus physics versus chemistry) (see Bressoud, 2015, for one example).

Another limitation is that we only collected survey data at only one point in time. This limits our ability to identify and test the predictors and mechanisms related to girls' and boys' math and science engagement over time. Future research should model the complex and dynamic relationships between contextual and motivational influences and engagement and explore how longitudinal associations between these variables contribute to the development of STEM-related aspirations. For example, in a longitudinal study of science aspirations in the United Kingdom, researchers found that female students have lower science aspirations and were less likely to see science as compatible with their interests or identities (Aspire, 2014). Recently, it has been suggested that instead of focusing on gender differences in math and science engagement and aspirations, it may be more interesting and useful to understand the processes by which math and science aspirations develop in both genders over time (Watt et al., 2012). In order to increase the number and diversity of individuals in math and science and other STEM-related fields, future research should examine how motivational beliefs, engagement, and aspirations contribute to educational and career choices among girls and boys from secondary school into postsecondary school and beyond. These lines of inquiry should especially focus on girls, for whom engaging and succeeding in math and science coursework is necessary, but not sufficient for pursuing or staying in a STEM field throughout or after college.

Finally, our study controlled for race and an indicator of socioeconomic status (free- or reduced-price lunch eligibility), but did not explore their role in gender similarities or differences in math and science engagement. In most of our models, being a member of a minority group and being eligible for free- or reduced-price lunch was a negative predictor of engagement, especially in science. Future research should explore how minority status and/or socioeconomic status may interact with gender to influence math and science engagement and aspirations for STEM careers.

Conclusions and Implications

The results of this study have implications for efforts to improve middle and high school math and science education. Both girls and boys felt they were more engaged in more student-centered classrooms with hands-on learning, group work, and problem-solving activities. In contrast, they reported being more disengaged in classrooms with traditional teacher-directed instructional methods and when they were passive recipients of knowledge. These perceptions fit with the new teaching standards in math and science that include a greater emphasis on student-centered instructional techniques where they had opportunities to work in groups on complex problem solving tasks (CCSI, 2015; NRC, 2012). Our research suggests that collaborative environments that emphasize student-centered and authentic instruction may be particularly beneficial for girls' engagement.

It is important to acknowledge the disciplinary differences between math and science that can influence the implementation of these instructional reforms. For example, our findings point to some of the challenges with implementing hands-on activities, complex problem solving, and group work in mathematics, as students were less likely to report student-centered learning opportunities in this domain. Math teachers may be more likely to feel that they need to cover the curriculum sequentially and in a standardized manner, and as a result feel less freedom to make instructional changes in this domain (Grossman & Stodolsky, 1995). In contrast, it may be easier to implement student-centered instructional reforms in science because these techniques are more closely aligned with the tenets of the scientific method and scientific inquiry.

Our findings also have implications for designing interventions to increase females' participation in math- and science-related careers. For example, several of the girls did not see the link between what they were learning in math and science and the careers they were planning. Teachers should provide all students, but especially female students, with messages about the relevance of math and science to their lives outside of the classroom and with information on the diverse career options that are related to math and science. Messages about how math and science careers can have a beneficial impact on society and often involve working with people may be particularly beneficial for female students, who are more likely to report a preference for people-oriented careers (Wang & Degol, 2013).

Interventions should also address girls' lower emotional engagement in science, lower expectancy beliefs, and how girls conceptualize math and science. It is important to help girls to see that they have the skills and supports to be successful in math and science classrooms and that engagement and achievement in these domains can be compatible with their developing identity. Exposing female students to successful female mathematicians and scientists has been shown to lead to increases in self-efficacy and more positive attitudes toward math and science careers (Wang & Degol, 2013). Our results also highlight the benefit of developing relationally based interventions to increase females' engagement and expectancy beliefs, as girls reported feeling more comfortable and confident in smaller classes when they had the opportunity to interact with and discuss ideas with their teachers and a smaller group of peers.

Finally, the teacher can play a key role in encouraging their female students to engage in math and science by holding high expectations for success, providing encouragement, and offering additional supports when students are having difficulty with the material. Teachers should work to validate the voices and experiences of all students, but especially their female students, challenge the idea that math and science are masculine domains, and empower students to recognize the role that these disciplines can play in their lives. Training teachers on how to recognize and prevent gender-stereotypes and how to implement more student-centered instructional practices and collaborative learning environments will increase the likelihood that they can create classroom environments that support the engagement of both their male and female students.

References

Andre, T., Whigham, M., Hendrickson, A., & Chambers, S. (1999). Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects. Journal of Research in Science Teaching, 36, 719–747. https://doi.org/10.1002/(SICI)1098-2736(199908)36:6%3C719::AID-TEA8%3E3.0.CO;2-R

(2014). Aspire: Young people's science and career aspirations: Ages 10–14. Department of Educational and Professional Studies: Kings College of London. Retrieved at www.kcl.ac.uk/sspp/departments/education/research/aspires/aspires-final-report-december-2013.pdf

Assor, A., Kaplan, H., & Roth, G. (2002). Choice is good, but relevance is excellent: Autonomy-enhancing and suppressing teacher behaviours predicting students' engagement in schoolwork. British Journal of Educational Psychology, 72, 261–278. https://doi.org/10.1348/000709902158883

Azvedo, R. (2015). Defining and measuring engagement and learning in science: Conceptual, theoretical, methodological, and analytical issues. Educational Psychologist, 50, 84–94. https://doi.org/10.1080/00461520.2015.1004069

Baker, D., & Leary, R. (1995). Letting girls speak out about science. Journal of Research in Science Teaching, 32, 3–27. https://doi.org/10.1002/tea.3660320104

Baldi, S., Jin, Y., Skemer, M., Green, P. J., Herget, D., & Xie, H. (2007). Highlights from PISA 2006: Performance of U.S. 15-year-old students in science and mathematics literacy in an international context. Washington, DC: U.S. Department of Education.

Baraldi, A. M., & Enders, C. K. (2010). An introduction to modern missing data analyses. Journal of School Psychology, 48, 5–37. https://doi.org/10.1016/j.jsp.2009.10.001

Bartos, S. A., & Lederman, N. G. (2014). Teachers' knowledge structures for nature of science and scientific inquiry: Conceptions and classroom practice. Journal of Research in Science Teaching, 51, 1150–1184. https://doi.org/10.1002/tea.21168

Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. Educational Psychologist, 26, 369–398. https://doi.org/10.1207/s15326985ep2603&4_8

Boaler, J. (2015). The math-class paradox: Mastering the subject has become less about learning and more about performance. The Atlantic. Retrieved from: https://www.theatlantic.com/education/archive/2015/12/math-class-performing/421710/

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.).(1999). How people learn. Washington, DC: National Academy Press.

Bressoud, D. (2015). Insights from the MAA National study of college calculus. Mathematics Teacher, 109, 179–185.

Brotman, J., & Moore, J. (2008). Girls and science: A review of four themes in the science education literature. Journal of Research in Science Teaching, 45, 971–1002. https://doi.org/10.1002/tea.20241

Brown, B. B., & Larson, J. (2009). Peer relationships in adolescence. In R. M. Lerner & L. Steinberg (Eds.), The handbook of adolescent psychology: Vol. 2. Contextual influences on adolescent development (3rd ed., pp. 74–103). Hoboken, NJ: John Wiley & Sons Inc.

Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2013). Crafting a future in science: Tracing middle school girls' identity work over time and space. American Educational Research Journal, 50, 37–75. https://doi.org/10.3102/0002831212458142

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. Journal of Research in Science Teaching, 44, 1187–1218. https://doi.org/10.1002/tea.20237

Clewell, B. C., & Campbell, P. B. (2002). Taking stock: Where we've been, where we are, where we're going. Journal of Women and Minorities in Science and Engineering, 8, 20–50. https://doi.org/10.1615/JWomenMinorScienEng.v8.i3-4.20

Cobb, P., Gresalfi, M., & Hodge, L. L. (2009). An interpretive scheme for analyzing the identities that students develop in mathematics classrooms. Journal for Research in Mathematics Education, 40, 40–68.

Common Core State Standards Initiative. (2015). Mathematics standards. Retrieved from http://www.corestandards.org

Creswell, J. W., Plano Clark, V. L., Gutmann, M. L., & Hanson, W. E. (2003). Advanced mixed methods research design. In A. Tashakkori & C. Teddlie (Eds.), Handbook of mixed methods in social and behavioral research (pp. 209–240). Thousand Oaks, CA: Sage.

Creswell, J., & Plano, C. V. (2011). Designing and conducting mixed methods research (2nd ed.). Thousand Oaks: Sage Publications.

Crosnoe, R., Riegle-Crumb, C., Field, S., Frank, K., & Muller, C. (2008). Peer group contexts of girls' and boys' academic experiences. Child Development, 79, 139–155. https://doi.org/10.1111/j.1467-8624.2007.01116.x

Czerniak, C. M., & Johnson, C. C. (2014). Interdisciplinary science teaching. In N. G. Lederman & S. K. Abell (Eds.), Handbook of research on science education (Vol. 2, pp. 395–411). New York, NY: Routledge.

Daniels, J., Creese, A., Hey, V., Leonard, D., & Smith, M. (2001). Gender and learning: Equity, equality, and pedagogy. Support for Learning, 16, 112–116. https://doi.org/10.1111/1467-9604.00201

Duschl, R. (2008). Science Education in 3-part Harmony: Balancing conceptual, epistemic, and social learning goals. In J. Green, A. Luke, & G. Kelly (Eds.), Review of research in education (pp. 268–291). Washington, DC: AERA.

Eccles, J. S. (2009). Who am I and what am I going to do with my life? Personal and collecting identities as motivators of action. Educational Psychologist, 44, 78–89. https://doi.org/10.1080/00461520902832368

Eccles [Parsons], J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectations, values and academic behaviors. In J. T. Spence (Ed.), Achievement and achievement motivation (pp. 75–146). San Francisco: W. H. Freeman.

Eccles, J. S., & Wang, M. (2012). Part I commentary: Part I commentary: So what is student engagement anyway. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), Handbook of research on student engagement (pp. 133–145). New York: Springer Sciences.

Evan, A., Gray, T., & Olchefske, J. (2006). The gateway to student success in mathematics and science. Washington, DC: American Institutes for Research.

Finn, J. D. (1989). Withdrawing from school. Review of Educational Research, 59, 117–142. https://doi.org/10.1080/00461520.2015.1004069

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. Review of Educational Research, 74, 59–109. https://doi.org/10.3102/00346543074001059

Fredricks, J. A., Wang, M., Schall, J., Hokfkens, T., Snug, H., Parr, A., & Allerton, J. (2016). Using qualitative methods to develop a survey of math and science engagement. Learning and Instruction, 43, 5–15. https://doi.org/10.1016/j.learninstruc.2016.01.009

Frenzel, A. C., Goetz, T., Pekrun, R., & Watt, H. M. G. (2010). Development of mathematics interest in adolescence: Influences of gender, family, and school context. Journal of Research on Adolescence, 20, 507–537. https://doi.org/10.1111/j.1532-7795.2010.00645.x

Garcia-Reid, P. (2007). Examining social capital as a mechanism for improving school engagement among low income Hispanic girls. Youth and Society, 39, 164–181. https://doi.org/10.1177/0044118×07303263

Geist, E. A., & King, M. (2008). Different, not better: Gender differences in mathematics learning and achievement. Journal of Instructional Psychology, 35, 43–52.

Gilligan, C. (1982). In a different voice: Psychological theory and women's development. Cambridge, MA: Harvard University Press.

Giordano, P. C. (2003). Relationships in adolescence. Annual Review of Sociology, 29, 257–281. https://doi.org/10.1146/annurev.soc.29.010202.100047

Greene, J. C., Caracelli, V. J., & Graham, W. (1989). Toward a conceptual framework for mixed methods evaluation design. Educational Evaluation and Policy Analysis, 11, 255–274. https://doi.org/10.3102/01623737011003255

Grossman, P. L., & Stodolsky, S. S. (1995). Content as context: The role of school subjects in secondary school teaching. Educational Researcher, 14, 5–23. https://doi.org/10.3102/0013189X024008005

Henningsen, M., & Stein, M. K. (1997). Mathematics tasks and student cognition: Classroom based factors that inhibit high-level mathematical thinking and reasoning. Journal of Research in Mathematics Education, 28, 524–549. https://doi.org/10.2307/749690

Howes, E. V. (2002). Connecting girls and science: Constructivism, feminism, and science education reform. New York: Teachers College Press.

Hyde, J. S., Fennema, E., Ryan, M., Frost, C. A., & Hopp, C. (1990). Gender comparisons of mathematics attitudes and affect. Psychology of Women Quarterly, 14, 299–324. https://doi.org/10.1111/j.1471-6402.1990.tb00022.x

Johnson, M. K., Crosnoe, R., & Elder, G. (2001). Students' attachment and academic engagement: The role of the race and ethnicity. Sociology of Education, 74, 318–340. https://doi.org/10.2307/2673138

Johnson, R. W., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. Educational Researcher, 33, 14–26.

Jones, M. G., Howe, A., & Rua, M. J. (2000). Gender differences in students' experiences, interests, and attitudes toward science and scientists. Science Education, 84, 180–192. https://doi.org/10.1002/(SICI)1098-237X(200003)84:2%3C180::AID-SCE3%3E3.0.CO;2-X

Keller, C. (2001). Effects of teachers' stereotyping of mathematics as a male domain. Journal of Social Psychology, 141, 165–173. https://doi.org/10.1080/00224540109600544

Kelly, A. (1988). Option choice for girls and boys. Research in Science and Technological Education, 6, 5–23.

Lau, S., & Roeser, R. W. (2002). Cognitive abilities and motivational processes in high school students' situational engagement and achievement in science. Educational Assessment, 8, 139–162.

Lee, V. E., & Burkam, D. T. (1996). Gender differences in middle grade science achievement: Subject domain, ability level, and course emphasis. Science Education, 80, 613–650. https://doi.org/10.1002/(SICI)1098-237X(199611)80:6%3C613::AID-SCE1%3E3.0.CO;2-M

Li, M., Shavelson, R. J., Kupermintz, H., & Ruiz-Primo, M. A. (2002). On the relationship between mathematics and science achievement in the United States. In D. F. Robitaille & A. E. Beaton (Eds.), Secondary analysis of the TIMSS data (pp. 233–249). The Netherlands: Springer.

Linnenbrink-Garcia, L., Rogat, T., & Koskey, K. (2011). Affect and engagement during small group instruction. Contemporary Educational Psychology, 36, 13–24. https://doi.org/10.1016/j.cedpsych.2010.09.001

Little, R. J. A. (1995). Modeling the drop-out mechanism in repeated-measures studies. Journal of the American Statistical Association, 90, 1112–1121.

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. Science Education, 95, 1–31.

Maltese, A. V., & Tai, R. H. (2010). Eyeballs in the fridge: Sources of early interest in science. International Journal of Science Education, 32, 669–685. https://doi.org/10.1080/09500690902792385

Marsh, H. W., Trautwein, U., Lüdtke, O., Köller, O., & Baumert, J. (2005). Academic self-concept, interest, grades and standardized test scores: Reciprocal effects models of causal ordering. Child Development, 76, 297–416. https://doi.org/10.1111/j.1467-8624.2005.00853.x

Martin, A. J., Way, J., Bobis, J., & Anderson, J. (2015). Exploring the ups and downs of mathematics engagement in the middle school years. Journal of Early Adolescence, 35, 199–244. https://doi.org/10.1177/0272431614529365

Martin, A. J., & Dowson, M. (2009). Interpersonal relationships, motivation, engagement, and achievement: Yields for theory, current issues, and educational practice. Review of Educational Research, 79, 327–365. https://doi.org/10.3102/0034654308325583

McConachie, S. M., & Petrosky, T. (2010). Content matters: A disciplinary literacy approach to improving student learning (1st ed.). San Francisco: Jossey-Bass.

Meece, J (2003). Applying learner-center principles to middle school education. Theory Into Practice, 42, 109–116. https://doi.org/10.1207/s15430421tip4202_4

Meece, J., Blumenfeld, P. C., & Hoyle, R. H. (1988). Students' goal orientation and cognitive engagement in classroom activities. Journal of Educational Psychology, 80, 514–523. https://doi.org/10.1037/0022-0663.80.4.514

Meece, J. L., Glienke, B. B., & Burg, S. (2006). Gender and motivation. Journal of School Psychology, 44, 351–373. https://doi.org/10.1016/j.jsp.2006.04.004

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). Qualitative data analysis: A method sourcebook. Thousand Oaks, CA: SAGE Publications Incorporated.

Miller, P. H., Blessing, J. S., & Schwartz, S. (2006). Gender differences in high-school students' views about science. International Journal of Science Education, 28, 363–381. https://doi.org/10.1080/09500690500277664

Nassir, N. S (2002). Identity, goals, and learning: Mathematics in cultural practice. Mathematical Thinking and Learning, 4, 213–248. https://doi.org/10.1207/S15327833MTL04023_6

National Research Council (NRC). (2000). Inquiry and the national science education standards: A guide for teaching and learning. Washington, DC: National Academy Press.

National Research Council (NRC). (2004). Engaging schools: Fostering high school students' motivation to learn. Washington, DC: National Academy Press.

National Research Council (NRC). (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC: National Academy Press.

National Research Council (NRC) (2013). Next generation science standards: For states, by states. Washington, DC: The National Academies Press.

National Science Foundation (2015). Women, minorities, and persons with disabilities in science and engineering: 2011. Arlington, VA.: Author.

O'Donnell, A., & Hmelo Silver, C. E. (2013). What is collaborative learning: An overview. In C. E. Hmelo Silver & C. A. Chinn (Eds.), The international journal of collaborative learning (pp. 1–13). New York: Routledge.

Patrick, H., & Ryan, A. (2005). Identifying adaptive classrooms: Dimensions of the classroom social environment. In K. A. Moore & L. H. Lippman (Eds.), What do children need to flourish: Conceptualizing and measuring indicators of positive development (pp. 271–285). New York: Springer.

Patrick, H., Ryan, A. M., & Kaplan, A. (2007). Early adolescents' perceptions of the classroom social environment, motivational beliefs, and engagement. Journal of Educational Psychology, 99, 83–98. https://doi.org/10.1037/0022-0663.99.1.83

Pianta, R., C., Hamre, B. K., & Allen, J. P. (2012). Teacher-student relationships and engagement: Conceptualizing, measuring, and improving the capacity of classroom interactions. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), Handbook of research on student engagement (pp. 365–388). New York: Springer Sciences.

Raudenbush, S. W., & Bryk, A. S. (2002). Hierarchical linear models: Applications and data analysis methods (2nd ed.). Newbury Park, CA: Sage.

Resnick, L. B., & Nelson-Le Gall, S. (1997). Socializing intelligence. In L. Smith, J. Dockrell, & P. Tomlinson (Eds.), Piaget, Vygotsky and beyond (pp. 145–158). London: Routledge.

Riegle-Crumb, C. (2006). The path through math: Course sequences and academic performance at the intersection of race-ethnicity and gender. American Journal of Education, 113, 101–122.

Riegle-Crumb, C., Farkas, G., & Muller, C. (2006). The role of gender and friendship in advanced course taking. Sociology of Education, 79, 1017–1045. https://doi.org/10.1177/003804070607900302

Rimm-Kaufman, S. E., Baroody, A. E., Larsen, R. A. A., Curby, T. W., & Abruy, T. (2015). To what extent do teacher-student interaction quality and student gender contribution to fifth graders' engagement in mathematics learning? Journal of Educational Psychology, 107, 170–185. https://doi.org/10.1037/a0037252

Roorda, D. L, Koomen, H. M., Spilt, J. L., & Oort, F. (2011). The influence of affective teacher-student relationships on students' school engagement and achievement: A meta-analytic approach. Review of Educational Research, 81, 493–529. https://doi.org/10.3102/0034654311421793

Ryan, A. M., & Patrick, H. (2001). The classroom social environment and changes in adolescents' motivation and engagement during middle school. American Educational Research Journal, 28, 437–460. https://doi.org/10.3102/00028312038002437

Saldana, J. (2009). An introduction to codes and coding. The coding manual for qualitative researchers. Thousand Oaks, CA: Sage Publications.

Sandoval, W. A. (2005). Understanding students' practical epistemologies and their influence on learning through inquiry. Science Education, 89(4), 634–656. https://doi.org/10.1002/sce.20065

Sherin, M. G., Mendez, E. P., & Louis, D. A. (2004). A discipline apart: The challenge of fostering a community of learners in a mathematics classroom. Journal of Curriculum Studies, 36, 307–332. https://doi.org/10.1080/0022027032000142519

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of links between choices and beliefs. Developmental Psychology, 42, 70–83. https://doi.org/10.1037/0012-1649.42.1.70

Simpkins, S., Fredricks, J. A., & Eccles, J. S. (2015). Parent beliefs to youth choices in academics and leisure: Mapping the sequence of predictors from childhood to adolescence. Monographs of the Society for Research in Child Development, 2, 1–151. https://doi.org/10.1111/mono.12164

Siskin, L. S. (1994). Realms of knowledge: Academic departments in secondary schools. London: Falmer.

Skinner, E. A., Kindermann, T. A., Connell, J. P., & Wellborn, J. G. (2009). Organizational constructs in the dynamics of motivational development. In K. Wentzel & A. Wigfield (Eds.), Handbook of motivation at school (pp. 223–246). New York: Routledge.

Stata Corp. (2015). Stata statistical software: Release 14. College Station, TX: StataCorp LP.

Stein, M. K. (Ed.). (2000). Implementing standards-based mathematics instruction: A casebook for professional development. New York: Teachers College Press.

Stein, M. K., Engle, R. A., Smith, M. S., & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. Mathematical Thinking and Learning, 10, 313–340. https://doi.org/10.1080/10986060802229675

Stein, M., Kinder, D., Silbert, J., & Carnine, D. W. (2005). Designing effective math instruction: A direct instruction approach (4th ed.). New York: Prentice Hall.

Stodolsky, S., & Groosman, P. (1995). The impact of subject matter on curricular activity: An analysis of five academic subjects. American Educational Research Journal, 32, 227–249. https://doi.org/10.3102/00028312032002227

Tiedemann, J. (2002). Teachers' gender stereotypes as determinants of teacher perceptions in elementary school mathematics. Educational Studies in Mathematics, 50, 49–62. https://doi.org/10.1023/A:1020518104346

Tolan, P. H., & Deutsch, N. L. (2015). Mixed methods in developmental science. In W. F. Overton & P. C. Molenaar (Eds.), Handbook of child psychology and developmental science, Vol. 1: Theory and method (7th ed., Vol. 1, pp. 713–757). New York: Wiley.

Trautwein, U., Marsh, H. W., Nagengast, B., Lüdtke, O., Nagy, G., & Jonkmann, K. (2012). Probing for the multiplicative term in modern expectancy-value theory: A latent interaction modeling study. Journal of Educational Psychology, 104, 763–777. https://doi.org/10.1037/a0027470

Venville, G., Rennie, L., & Wallace, J. (2004). Decision making and sources of knowledge: How students tackle integrated tasks in science, technology and mathematics. Research in Science Education, 34, 115–135.

Voelkl, K. E. (1997). Identification with school. American Journal of Education, 105, 204–319. https://doi.org/10.1086/444158

Wang, M. T. (2012). Educational and career interests in math: A longitudinal examination of the links between perceived classroom environment, motivational beliefs, and interests. Developmental Psychology, 48, 1643–1657. https://doi.org/10.1037/a0027247

Wang, M. T., & Degol, J (2013). Motivational pathways to STEM career choices: Using expectancy-value perspectives to understand individual and gender differences in STEM. Developmental Review, 33, 304–340. https://doi.org/10.1016/j.dr.2013.08.001

Wang, M. T., & Eccles, J. S. (2012). Social support matters: Longitudinal effects of social support on three dimensions of school engagement from middle to high school. Child Development, 83, 877–895. https://doi.org/10.1111/j.1467-8624.2012.01745.x

Wang, M. T., Eccles, J. S., & Kenny, S. (2013). Not lack of ability but more choice: Individual and gender differences in STEM career choice. Psychological Science, 24, 770–775. https://doi.org/10.1177/0956797612458937

Wang, M. T., Fredricks, J. A., Ye, F., Hofkens, T., & Schall, J. (2016). The math science engagement scale: Development, validation, and psychometric properties. Learning and Instruction, 43, 16–26. https://doi.org/10.1016/j.learninstruc.2016.01.008

Wang, M. T., & Holcombe, R. (2010). Adolescents' perceptions of classroom environment, school engagement, and academic achievement. American Educational Research Journal, 47, 633–662. https://doi.org/10.3102/0002831209361209

Watt, H. M, Morris, Z., Shapka, J. D., Durik, A., Keating, D. P., & Eccles, J. (2012). Gendered motivational processes affecting high school mathematics participation, educational aspirations, and career plans: A comparison of samples from Australia, Canada, and the United States. Developmental Psychology, 48, 1594–1611. https://doi.org/10.1037/a00278

Wentzel, K. R. (2005). Peer relationships, motivation, and academic performance at school. In A. Elliot & C. Dweck (Eds.), Handbook of competence and motivation (pp. 279–296). New York: Guilford Press.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. Contemporary Educational Psychology, 25, 68–81. https://doi.org/10.1006/ceps.1999.1015

Wigfield, A., Eccles, J. S., Fredricks, J. A., Roeser, R., Schiefele, U., & Simpkins, S. (2015). Development of achievement motivation and engagement. In R. Lerner (Series Ed.), C. Garcia Coll, & M. Lamb (Volume Eds.), Handbook of child psychology, 7th ed. Vol. 3, Social, and emotional development (pp. 657–699). New York: John Wiley.

Yoshikawa, H., Weisner, T., Kalil, A., & Way, N. (2013). Mixing qualitative and quantitative research in developmental science: Uses and methodological choices. Qualitative Psychology, 1, 3–18. https://doi.org/10.1037/2326-3598.1.S.3

Zohar, A. (2006). Connected knowledge in science and mathematics education. International Journal of Science Education, 28, 1579–1599. https://doi.org/10.1080/095006905004

Supporting Information

Additional Supporting Information may be found in the online version of this article.