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Original Paper

The Interaction of Gender and Pedagogy on Learning Motivations in a Secondary PBL Mathematics Classroom

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Abstract

The purpose of this study was to investigate the interactive effects of gender, learning motivations, and pedagogy (Project-Based Learning [PBL] and conventional) on secondary mathematics learning. In order to measure their academic achievement and learning motivations, 165 secondary students were given a state standardized mathematics test and the Motivated Strategies for Learning Questionnaire. Study results indicated that pedagogy and gender had no impact on academic achievement. Pedagogy played a stronger role in rehearsal, peer learning, and task value. Gender played a stronger role in test anxiety, organization, help seeking, and control of learning. PBL students seemed to value and actively engage in the mathematics more than did the conventional students.

Keywords

PBL, mathematics, gender, motivation, academic, achievement

1. Introduction

Project Based Learning (PBL) is a pedagogical approach that employs inquiry-based, real-world problem-solving explorations with cooperative learning techniques (Brown, Lawless, & Boyer, 2013). It is characterized by students working collaboratively on tasks that "involve students in problem-solving, decision-making, and investigative activities; give students the opportunity to work relatively autonomously over extended periods of time designing solutions for authentic and meaningful problems that culminate in realistic products or presentations" (Thomas, 2000, p. 1; Gijbels, Dochy, Vanden Bossche, & Segers, 2005; Petrosino, 2004). Typically, in a mathematics PBL setting, groups of students use mathematics as a tool to solve reality-based problems that will be disseminated to an authentic audience. Through the process of solving the given problem, students construct new understandings of the necessary content, which can then be transferred to new situations. As a result of the PBL process, students acquire personally meaningful mathematical concepts or knowledge (Holmes & Hwang, in press). The teacher's role in a PBL mathematics classroom is that of facilitator in students' knowledge-construction process by providing scaffolding. The ultimate mathematical authority is not the teacher, but the plethora of resources garnered by the student, who then becomes the "expert" (Belland, Glazewski, & Richardson, 2008; Branson & Thomson, 2013; Fatokun & Fatokun, 2013).

Compared to PBL, the conventional mathematics teaching and learning approach is characterized by the development of the ability to follow rules and execute procedures/algorithms, as well as the memorization of facts. The teacher's role is to "provide clear, step-by-step demonstrations of each procedure, restate steps in response to student questions, provide adequate opportunities for students to practice the procedures, and offer specific corrective support when necessary". Research suggests that by convention, in a traditional mathematics classroom much time is spent on lower-level thinking skills, where students are able to excel as they absorb, accumulate, and reiterate memorized information (Battista, 1994; Brandy, 1999; Hiebert, 2003; Nesmith, 2008). "The ultimate mathematical authority is the textbook, from whence-the answers to most mathematical problems are known and found" (Smith, 1996, pp. 390-391).

Research shows that both pedagogical approaches (PBL and conventional) can facilitate mathematical-content learning; however, differences emerge when looking at learning motivational characteristics. For example, Myer, Turner and Spencer (1997) demonstrated that PBL fostered challenge-seekers instead of challenge-avoiders in students' mathematics learning.

Students in the PBL environment have qualitatively different motivations for learning (e.g., higher intrinsic motivation, higher self-efficacy, or less anxiety) (Han, Capraro, & Capraro, 2014; Holmes & Hwang, in press; Rotgans & Schmidt, 2012). Learner demographics also have an impact on learning and motivation. Several studies have shown that learner demographics (e.g., ethnicity, SES, and/or academic performance-level) interact differently within varied pedagogical approaches. For instance, one study found that low-performing secondary students, regardless of race, benefitted more than high- and middle-performing students in the PBL pedagogical environment (Han, Capraro, & Capraro, 2014). Research also shows that, for a variety of reasons, white students perform better than black and Latino students in conventional secondary classrooms (NAEP, 2011; Holmes & Hwang, in press). Nevertheless, in regard to the learner demographic of gender, few empirical studies have focused on the interactive effects of pedagogical approach and gender differences in mathematics. (Anderson, 2005; Han, Capraro, & Capraro, 2014; Holmes & Hwang, 2015; Selkirk et al., 2011). In other words, not many studies have compared how males and females fare within the conventional and PBL mathematics environments.

Notwithstanding, current literature does provide valuable information on the overall effect of gender on mathematics learning. Research has shown that, despite gender stereotypes (e.g., males are better at mathematics and science, etc.), there is no statistical significant difference between the abilities of males and females to learn and apply mathematical concepts (Hyde, 2014; Hong, Hwang, Wong, Lin, & Yau, 2012; Khan & Sobani, 2012; Lindberg, Hyde, Petersen, & Linn, 2010; Scafidi & Bui, 2010; Watt, Shapka, Morris, Durik, Keating, & Eccles, 2012). Anxiety is likely another factor contributing to gender differences in math performance. Research indicates that females have greater anxiety during math tests, which overloaded their working memory and lead them to underperform on the test (Ganley & Vasilyeva, 2014).

However, there are differences among the aspects of mathematics in which males and females excel. Specifically, males perform higher than females in problem solving (Battista, 1990; Lindberg et al., 2010), spatial visualization (Battista, 1994), and mathematical application problems (Vermeer, Boekaerts, & Seegers, 2000). Females perform better in basic mathematics computation and conceptual understanding. There is no gender difference, however, in logical reasoning (Boekaerts & Seegers, 2000; Lindberg et al., 2010; Scafidi & Bui, 2010, Vermeer, Boekaerts, & Seegers, 2000).

In regards to learning motivational factors (e.g., self-efficacy, intrinsic motivation, and test anxiety), there are gender differences in how they are exhibited in the mathematics classroom. For example, female and male students explain differently the varied sources of their successes and failures. In particular, studies in attribution theory show that males tend to attribute their successes to internal factors (e.g., ability), while they attribute their failures to external factors outside of their control (e.g., exam difficulty). Females, however, tend to attribute the causes in a reverse manner: failures are caused by internal factors (e.g., effort), successes by external factors (e.g., luck) (Dweck, Mangels, & Good, 2004; Vermeer, Boekaerts, & Seegers, 2000). These differences in attributions can either positively or negatively impact their mathematics learning (Banks & Woolfson, 2008; Sukariyah & Assaad, 2015). While these studies aid in our understanding of gender and motivation in general, they have not included the interactive effects of gender, motivation, and pedagogy in the mathematics classroom. Hence, the exploration of academic and motivational factors within gender and pedagogy can provide insight into mathematics learning, especially when integrated with gender.

Research suggests that learning is a dynamic interaction of skill (i.e., academic and cognitive factors) and will (i.e., learning motivational factors) (Leutwyler, 2009; Pintrich, 2004).

In other words, like cognitive factors, many learning motivational factors (i.e., will) are found to affect students' learning. Such motivational factors can be classified into two subgroups: *learning motivations* and *learning strategies*. Learning motivation is defined as a force that initiates, energizes, and sustains learning behaviors (Ormrod, 2014; Schunk & Meece Pintrich, 2013). Research suggests the fifteen motivational learning constructs encapsulated in *learning motivations* and *learning strategies* are pivotal in understanding and assessing learners' motivational beliefs and behaviors in classroom learning, which includes learning mathematics. These factors have been validated in motivational research throughout the U.S. and other countries (Cho & Summers, 2012; Pintrich, Smith, Garcia, & McKeachie, 1993; Stoffa, Kush, & Heo, 2010). In terms of mathematics, learning motivations are beliefs and drives that enable students to successfully acquire the mathematical concepts taught, whereas learning strategies are techniques that learners employ to enhance their learning effectiveness (Hwang & Levin, 2002). These fifteen motivational learning factors also appear to play a significant role in classroom learning and are described below:

1.1 Learning Motivations and Study Strategies

1.1.1 Learning Motivations

Learning motivational factors include intrinsic or extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, and test anxiety. *Intrinsic goal orientation*, or intrinsic motivation "is defined as the doing of an activity for its inherent satisfaction rather than for some separable consequence" (Ryan & Deci, 2000, p. 60), whereas *extrinsic goal orientation*, or extrinsic motivation, "is a construct that pertains whenever an activity is done in order to attain a different outcome" (Ryan & Deci, 2000, p. 60). The results of studies on intrinsic and extrinsic motivational factors in mathematics differ greatly. Some studies show that male students tend to have higher intrinsic motivation in mathematics (Skaalvik & Skaalvik, 2004), while other studies show that there are no gender differences (Rusillo & Arias, 2004; Wigfield & Eccles, 2002). However, one recommendation for motivating female students and other underserved, underachieving students in the mathematics classroom is to implement instructional strategies, such as project-based and Problem-Based Learning (PBL), that allow them to feel a sense of belonging in mathematics (Boaler, 2016; Schettino, 2016).

Task value is defined as the magnitude of learners' appreciation, interest, perceived importance, and/or usefulness of a given task. Studies show that task value declines as female students transition to higher grade levels (Koller, Baumert, & Schnabel, 2001; Wang, Degol, & Fey, 2015), while some studies show no gender differences (Meece, Glienke, & Burg, 2006; Wigfield & Eccles, 2002; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006).

Control of learning measures the extent to which learners believe effort is a more important factor in success than is ability. As presented earlier, research suggests that males and females attribute their success and failure to different sources (e.g., ability, exam difficulty, effort, and luck) (Banks & Woolfson, 2008; Dweck, Mangels, & Good, 2004; Sukariyah & Assaad, 2015; Vermeer, Boekaerts, & Seegers, 2000).

Self-efficacy for learning and performance measures learners' belief that they can successfully execute and complete a task. Although contemporary studies show inconclusive results, in general, male students tend to have higher self-efficacy in mathematics (Baker & White, 2003; Huang, 2012; Meece, Glienke, & Burg, 2006).

Test anxiety is manifested as the negative cognitive, physical, and emotional reactions to a test. Students who experience mathematics anxiety seem to have similar negative cognitive, physical, and emotional reactions (Selkirk, Bouchey, & Eccles, 2011; Taylor & Frasier, 2013); though whether there are gender differences is inconclusive (Cooper & Robinson, 1991; Marsh & Tapia, 2004; Selkirk et al., 2011). However, some studies show that secondary females tend to have higher test anxiety than do secondary males (Devine, Fawcett, Szűcs, & Dowker, 2012; Fritts & Marszalek, 2010; Lowe & Lee, 2008; Osborne, 2006; Putwain & Daly, 2014), while other studies show that there are no gender differences in test anxiety (e.g., Selkirk, Bouchey, & Eccles, 2011).

1.1.2 Learning Strategies.

The second sub-category, learning strategies, includes rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time/study-environment management, effort regulation, peer learning, and help seeking. Few studies have focused on these constructs in a mathematics-learning context, and fewer still have related gender and mathematics to these constructs.

Three commonly used techniques, *rehearsal, elaboration, and organization,* are study strategies. *Rehearsal* is employed by memorizing given information through repetition. *Elaboration* is applied by connecting prior knowledge to new information. *Organization* facilitates learning by arranging study materials in meaningful ways to highlight important facts or concepts. Studies in mathematics-learning strategies by gender found that females tend to report higher use of rehearsal and organization than do males (Bidjerano, 2005). In addition, *time/study-environment management* measures ability to appropriately choose a time and place to study. Females demonstrate higher efficiency in arranging a suitable study environment than do males (Bidjerano, 2005).

Critical thinking measures the ability to analyze and assess given information (Paul & Elder, 2003). Studies show that there is little gender difference in critical thinking (Bidjerano, 2005; American Psychological Association, 2014).

Metacognitive self-regulation measures the extent of learners’ knowledge and understanding of their own cognitive process in performing a task and their ability to mediate the situation to promote leaning. Generally, studies show that while female students may demonstrate more developed metacognitive self-regulatory skills in learning than do male students, these differences do not affect academic success (Bidjerano, 2005; Matthews, Ponitz, & Morrison, 2009; Pajares, 2002). Other studies indicate slight, but not statistically significant, gender metacognition differences in STEM classrooms (Sharma & Bewes, 2011; Velayutham, Aldridge, & Fraser, 2012). In addition, *effort regulation* measures the degree to which learners self-regulate learning behaviors. Research shows that gifted female students exhibit a higher degree of effort regulation than do their male counterparts (Tang & Neber, 2008). Very few empirical studies have measured the effect of metacognitive skills and effort-regulation behaviors in learning secondary mathematics.

Some of the motivational beliefs and behaviors are manifested through social interactions. Peer learning and help seeking are two such constructs. *Peer learning* measures how much learners gain their cognitive and social knowledge through other learners. *Help seeking* measures learners’ ability to positively utilize people resources. One study found that there are no statistically significant gender differences in respect to studying with peers and help seeking (Bidjerano, 2005, p. 6). However, research on moral development shows that females are more care-oriented and males more justice-oriented in their moral reasoning processes. This can be translated as a characteristic that encourages females to participate in group activities and care more for their group members. Hence, females are more apt to be involved socially in peer learning and help seeking (Gump, Baker, & Roll, 2000; Ryan, David, & Reynolds, 2004).

Learning motivation can be a better predictor of students' long-term mathematics achievement than can academic or intelligence scores (Murayama, Pekrun, Lichtenfeld, & Vom Hofe; Watt et al., 2012). When looking at gender in mathematics learning, both academic achievement and motivational factors need to be addressed.

In sum, two important facts are gleaned from the research. One, to truly comprehend the impact of pedagogical differences (PBL and conventional approach) in mathematics learning, both academic achievement and learning motivations need to be investigated. Two, there is a dearth of knowledge pertaining to the interactive effects of mathematical pedagogies on gender. Thus, this paper focuses on the interaction effects of two different pedagogical approaches (PBL and conventional) and gender in learning secondary mathematics. It not only assesses gender interaction on mathematics content learning, but also the interaction effects of gender on learning motivational factors. The research question for this study is *what is the three way interactive effect of pedagogy, gender, and motivation on secondary students' mathematics learning?* Specifically, we were interested in how cognitive (academic achievement) and motivational factors manifested between genders within the two mathematics pedagogical learning environments.

2. Method

2.1 Participants

As we sought to understand the interactive effects of pedagogy and gender on learning and motivations among secondary-mathematics students, we looked at primary data from two pedagogically different high schools (i.e., Project-Based Learning (PBL) and conventional high school). The standardized mathematics test scores of these students were obtained, and the Motivated Strategies for Learning Questionnaire (MSLQ) survey was administered to all 532 students (PBL=88; conventional=444). Because of the disparate sample sizes, we used a stratified, random sample to construct a subset group; this insured comparable percentages of gender and racial make-up of the two groups. Thus, out of the total population of 532, 165 students (PBL=26; conventional=139) were randomly selected for comparison of the two pedagogies. These students were from middle- to lower-middle-class neighborhoods, with a racial make-up of predominately Caucasian (51%) and Latino (32%). Among the participants, approximately 46% were females and 54% were males.

2.2 Materials & Procedure

2.2.1 Content Learning-Standardized Assessment

In order to assess mathematics-content learning, we utilized scores from state standardized (i.e., ACT-based) tests that included algebraic, geometric, and statistical content areas. Grade-appropriate general topics included math reasoning, logic and proof, algebraic expressions, equations and functions, relationships, properties and geometric transformations of figures, and statistical univariate/bivariate data (MDE, 2010). Overall, Cronbach's alpha for reliability for the state standardized tests ranged from .87 to .88 (MDE, 2012). Because the school district had adopted this test for its construct validity based on curriculum standards, and both schools used it, we determined that this was an appropriate instrument for the study. Hence, overall mathematics scores on the state standardized tests for both the PBL and conventional schools (i.e., representing the two pedagogies) were contrasted for gender differences. Specifically, descriptive statistics were used to generally describe proportional and mean differences among the pedagogy and gender groups. ANOVA and Tukey post-hoc tests were run to determine statistical significance among and between the groups. As explained earlier, because of the large sample-size difference between the two pedagogical approaches (PBL vs. conventional), we utilized a randomized boot-strapping method to mitigate its effects. All stipulations for the tests of significance were met.

In order to determine any preexisting mathematics achievement-level differences between the PBL and conventional pedagogical groups *prior to* this study, we compared earlier mathematics standardized scores for both groups. An independent t-test showed that, though the PBL score was 10% lower, the difference between the two groups was not statistically significant ($p=.065$). Therefore, the initial mathematics-content learning of the two pedagogical groups was comparable.

2.2.2 Learning Motivation-Student Surveys

To measure students' motivational factors, we administered an online adaptive version of the MSLQ Learning Inventory by VanderStoep and Pintrich (1991 & 2008) (Holmes & Hwang, in press). The reliability (Cronbach's $\text{alpha}_{PBL}=.96$; Cronbach's $\text{alpha}_{conventional}=.94$.) and validity of the MSLQ survey is well-established and has been used by the professional community (Artino, 2005; Credé & Phillips, 2011; Rotgans & Schmidt, 2012). The MSLQ survey has been used in many mathematics and science education research studies (Doll, Zucker, & Brehm, 2004; Feiz, Hooman, & Kooshki, 2013; Karadeniz, Büyüköztürk, Akgün, Çakmak, & Demirel, 2008; and Milner, 2011).

The MSLQ 7-point, Likert-scaled survey is comprised of sixteen sub-categories, including demographics. These sub-categories are rehearsal (4 items), elaboration (6 items), organization (3 items), critical thinking (5 items), metacognitive self-regulation (12 items), intrinsic goal orientation (4 items), extrinsic goal orientation (4 items), task value (6 items), control of learning beliefs (4 items), self-efficacy (8 items), test anxiety (5 items), time and study environment (8 items), effort-regulation (4 items), peer learning (3 items), and help seeking (4 items). The fifteen cognitive and motivational factor constructs are summarized in Table 1 (Holmes and Hwang, in press).

In this study the MSLQ survey was used to analyze interactive effects among gender, pedagogy (PBL vs. conventional), and motivational factors on secondary-mathematics students. Chi-square and t-tests were run to determine statistical significance of motivational factors as they pertained to gender and pedagogy. All stipulations for the tests of significance were met. The motivational constructs were analyzed and reported by gender within and between pedagogies in mathematics learning; both standardized statistics and probability values were reported.

3. Results

The purpose of the study was to investigate qualitative gender differences in learning mathematics within two pedagogical approaches (PBL and Conventional Environments). Specifically, we were interested in how cognitive (academic achievement) and motivational factors manifested between genders within the mathematics-learning environments. In the following, mathematics-content learning and learning motivation results are reported in the context of gender differences. Then learning-motivational constructs disaggregated between gender and pedagogy are reported. For example, test anxiety is reported in three ways: *between gender and pedagogy*, e.g., female and male students' test anxiety in PBL vs. conventional pedagogies; *between pedagogies*, e.g., female students' test anxiety between PBL and conventional pedagogies; and *gender within pedagogy*, e.g., test anxiety of female vs. male students in PBL.

3.1 Content Learning

3.1.1 Standardized Mathematics Test

The results showed that there were no statistically significant differences between gender and pedagogy ($p=.96$; standardized effect size=.335). In other words, as indicated by the standardized assessment scores, mathematics achievement of PBL females and males was equal to that of conventional females and males. This is consistent with previous research on gender and mathematics achievement. This additional pedagogical factor did not alter the results. Pedagogy was not associated with the level of secondary-mathematics learning among females and males.

3.2 Learning Motivation

An average response to each of the survey's fifteen motivational constructs (e.g., test anxiety, peer learning, metacognition, etc.) was calculated. Regarding pedagogical differences, results showed that gender impacted only seven motivational constructs: test anxiety, rehearsal, organization, control of learning, task value, peer learning, and help seeking. First, we report these seven constructs between same genders in the two pedagogical approaches (e.g., female PBL vs. female conventional). We then report the gender differences among the statistically significant six out of the seven constructs in two pedagogies (e.g., female PBL vs. male conventional). Finally, we report the difference between genders within each of the two pedagogical approaches (e.g., female PBL vs. male PBL). Statistically significant differences are summarized in the tables.

3.2.1 Between Pedagogical Differences: PBL vs Conventional

3.2.1.1 Female to Female

The results show that female students in PBL mathematics classes showed a higher propensity to appreciate peer learning than did their conventional-classroom counterparts (t=2.44, p=.01). These students used more organization (t=2.27, p=.023) and rehearsal (t=2.2546, p=.011) strategies. They also showed more appreciation of mathematics than did those taught in the conventional approach (i.e., Task Value, t=2.17, p=.03). For females, PBL impacted peer learning the most and task value the least among the seven statistically significant constructs. Female students from conventional mathematics classes did not exhibit statistically significantly higher responses than did female students from PBL classes in any motivational constructs. Table 2 (above) shows the magnitude of statistically significant differences in female groups between pedagogies.

3.2.1.2 Male to Male

Compared to the male students in the conventional environment, the PBL male students used more rehearsal strategies (t=4.736, p<.001), and they also appreciated peer learning to a higher degree (t=2.006, p=.045). However, conventional male students showed higher test anxiety (t=2.564, p=.01) than did their PBL counterparts. Table 2 (above) shows the magnitude of statistically significant male-to-male differences in motivational constructs between pedagogies.

3.2.1.3 Interaction: Gender to Pedagogy

The results on interaction effects of gender and pedagogy showed that PBL male mathematics students used statistically significantly higher rehearsal strategies (t=4.871, p=.001) than did conventional female students. These PBL male students also exhibited higher control of learning (t=2.375, p=.018) and higher appreciation of peer learning (t=2.146, p=.032) than did the conventional female students. Conversely, conventional females showed statistically significantly higher test anxiety (t=3.121, p=.0018) than did PBL males. Additionally, PBL males showed higher intrinsic motivation, which was approaching statistically significance (p=.09).

PBL females used statistically significantly higher organization (t=2.55, p=.011) and rehearsal (t=2.404, p=.016) and showed more appreciation of peer learning (t=2.3, p=.021) than did conventional males. Table 3 (above) shows the interaction effects of gender within pedagogy on motivational constructs.

3.2.2 Within-Pedagogy Differences: PBL (Female vs. Male) and Conventional (Female vs. Male).

Within PBL, females and males experienced benefits of the pedagogical approach differently. Male students were statistically significantly higher in using rehearsal strategies (t=2.406, p=.015) than were female students. Male students also exhibited stronger beliefs in control of learning (t=2.23, p=.026) than did female students. On the other hand, PBL female students showed statistically significantly higher test anxiety (t=3.4, p=.00067), used more organization strategies (t=2.41, p=.016), and utilized more help seeking (t=1.979, p=.048) than did PBL male students. In the conventional classroom, there were no statistically significant gender differences in learning motivations. Table 4 (above) shows the magnitude of statistically significant differences within pedagogy in motivational constructs.

4. Discussion

4.1 Learning Mathematics and Gender

The purpose of this study was to determine the interactive effects of pedagogy and gender on content learning and learning motivations among secondary mathematics students. First, we found that gender and pedagogy are not associated with mathematics content learning. Supporting earlier findings, there were no statistically significant differences in females' and males' mathematics achievement, and performance was not affected by. This underscores the fact that gender differences in performance, especially in secondary school, are based on cognitive factors.

Then one may wonder why general sentiment is that STEM is a male field, and male students tend to take more advanced mathematics classes and pursue STEM-related majors and careers (Hill, Corbett, & St. Rose, 2010). One popular explanation is a gender-socialization pattern and sociological images in this culture (Lindberg, Hyde, Petersen, & Linn, 2010; Thoman, Arizaga, Smith, Story, & Soncuya, 2014). Also, social and cultural factors, such as gender expectations usually intensify during high school and college. Some researchers argue that, to encourage women to enter STEM majors and fields, STEM classrooms need to adapt to females' motivational patterns (e.g., females' peer learning and help seeking) (Smith, Lewis, Hawthorne, & Hodges, 2013), while other researchers argue that gender gap can be decreased simply by eliminating gender inequality (Lindberg et al., 2010).

Explanations of why females are not thriving in mathematics and mathematics-related fields generally fall into three categories. One is based on gender disposition, and the other two are based on gender-socialization factors in this culture. First, mathematics pedagogy was constructed based on male students' learning style and experiences throughout history. Therefore, the current practices in mathematics classrooms are disconnected from, and may not be conducive to, female students' learning and motivational styles, and so female students may not fit in. For example, according to one mathematics-education professor's description of her experiences in teaching pre-service secondary mathematics teachers, typically, in the beginning of the semester, her male students incorporate more lecture, competition, and quizzing in their lesson plans, while her female students incorporate more social activities, such as a discussion, group work, performance, and inquiry-style assessments. Therefore, she has to structure her class to combat this tendency by pairing male and female students and asking them to include various types of pedagogical approaches. Her intentions are to help male students utilize female-oriented learning activities to encourage all types of learners and facilitate learning in the future (interview July 2015). Current mathematics-teaching practices may be a deterrent to females' fitting into, and thus pursuing, mathematics and mathematics-related fields. If this is an accurate explanation for fewer females' exploring mathematics, then a solution may be to restructure mathematics-classroom pedagogy.

The second two explanations are based on socialization factors. Specifically, society holds certain gender stereotypes, which in turn impact academic fields by classifying subjects as female- or male-oriented. Individuals (or children) are influenced (and prejudiced) by these perceptions and beliefs, consciously and/or unconsciously, while growing up. The effect of these social norms predisposes people to believe and behave accordingly. Hence, the first explanation is that females buy into the stereotypes that they acquired through developmental experiences and believe that mathematics is not innately for them. Thus, they don't fit in, or they feel unattractive, when participating in the male-dominant subject. For example, females feel uncomfortable or even dumb when asking questions in mathematics classes, or they start to dress mannishly in order to fit in. The other explanation is similar, but now society itself imposes the implicit gender biases and discourages females' involvement in male-dominated domains. For example, professors tend to call on male students more, while asking female students superficial mathematics questions or commenting on their looks or personality. Advisors surreptitiously dissuade females from pursuing mathematics by suggesting less mathematics-oriented alternatives, such as English, psychology, or nursing. As noted, both of these explanations are based on gender socialization factors. However, the first explanation involves self-perception and internal pressure, whereas the second involves society perception and external pressure. If these explanations are plausible, then a possible solution is to educate the population to be aware of and eliminate gender stereotypes. In other words, gender stereotype pressure, whether internal or external, can be dissipated by exposing the fallacies therein. Whatever the explanation, finding solutions to mitigate gender biases regarding mathematics is imperative. Further study in this area is needed in order to provide more gender equality.

4.2 Gender, Learning Motivation, and Pedagogy

We found that the main differences in gender and pedagogy are centered on seven motivational constructs: test anxiety, task value, rehearsal, organization, control of learning, peer learning, and help seeking. Our interpretation of the learning motivation results are structured within and between pedagogy and gender differences.

4.2.1 Within Pedagogy

4.2.1.1 PBL Females and Males

Results show that there is an interaction effect between gender and PBL mathematics pedagogy on learning motivations. Female students seemed to be affected differently than were male students by the PBL mathematics-learning environment. Specifically, females tended to be organized, seek help, and have high test anxiety, while male students tended to believe their learning was within their control.

PBL females showed that they used more effective study strategies, such as organization, whereas PBL males used more rehearsal strategies for studying. Rehearsal tends to be less effective in studying mathematics content, as it is based on rote memorization. Additionally, female students showed a sign of self-regulation by seeking more help than did male students. At the same time, female students exhibited higher test anxiety than did their male counterparts, which helps clarify current understanding of certain gender differences in mathematics learning. These results may correspond with common beliefs about the pattern of gender socialization. For example, research shows that, when taking on a task, women tend to be more task-oriented and organized and to ask for help. Our results parallel the common attributes that women have higher organization, help seeking, and test anxiety than do their male counterparts, whereas males demonstrate higher control of learning beliefs. According to attribution-research findings, males tend to show higher confidence in themselves than females and attribute their success to their own abilities rather than to their effort. Despite its positive effects, the PBL environment did not mitigate the female tendency of being anxious in an academic context.

The results of this study germinated the question *what in the PBL pedagogy accounts for these different patterns of motivation*. One reason why male and female PBL students demonstrated distinctive motivational strengths may lie in the defining characteristics of PBL itself. The two distinctive characteristics of the PBL environment, group work and students' active participation in their learning, that help explain our findings (i.e., the pattern of gender socialization) may possibly stimulate students to play out stereotypical gender roles socialized within the culture (Pajares & Valiante, 2002; Zeldin, Britner, & Pajares, 2008). PBL's project-oriented tasks reflect the reality of the larger society and culture, which the students then unconsciously emulate in learning mathematics.

The above discussion posits the social aspects of group work as a possible explanation of the manifested stereotypical gender characteristics. The nature of group work divides roles (e.g., scribe, task master, etc.) among group members, which facilitates ownership of individual and collective responsibilities. A consequence of students owning their learning process is that they become more active learners (Downing, Kwong, Chan, Lam, & Downing, 2009; Goodnough & Cashion, 2006). In the process, they unconsciously begin to exhibit some of their socialized characteristics. In other words, students became responsible for being the "expert," each gender tended to respond according to its traditional roles.

While we are not claiming that conventional female/male stereotypes are true or healthy, students in the PBL environment may have more readily fallen into those roles. It must be stressed that PBL does not teach or reinforce gender roles; it simply provides the platform for them to be exposed, because it is a microcosm of the culture around it.

A further cause of these distinctive motivational differences may lie in the context of the subject matter itself. Since mathematics is stereotypically a male domain, perhaps it predisposes these high school students to comply with their conventional roles. We may have seen different results in an English class. This aspect of the stereotypical-gender hypothesis warrants further study.

4.2.1.2 Conventional Females and Males

Unlike for PBL, the results for the conventional pedagogy indicate that the interaction between gender and motivational factors do not play a significant role in learning mathematics. This means that females and males responded similarly in the conventional mathematics classroom. In that environment both female and male students have more passive roles. Thus, the gender differences may not have manifested because of the nature of how mathematics is taught there. Typically, students are more apt to listen to lectures and memorize content and so are not usually required to actively construct their own meanings in a social context as is required in the PBL environments.

4.2.1.3 Between Pedagogy: PBL vs Conventional

When compared to the PBL environment, the conventional mathematics learning environment manifested no positive learning motivational effects. The only significant motivational effect was higher test anxiety, which was true for both males and females. Within conventional classrooms, students actively demonstrate their knowledge mainly via traditional tests. These high-stake tests play a prominent role in the learning process, which may induce more anxiety as evidenced by our results.

4.2.1.4 Female vs. Female

Female students in the PBL environment responded differently compared to female students in conventional mathematics classrooms. In every area, PBL females seemed to have higher learning motivation than did their conventional counterparts. PBL females used more effective study strategies to organize and rehearse mathematics content, appreciated the value of mathematics more, and utilized peers as viable learning resources. The PBL environment seems to magnify conventional traits ascribed to females. As stated earlier, peer learning and organization are characteristics that correlate more with female behaviors. The PBL environment also allows them to see the practicality and applicability of the mathematics, so they appreciate the value of mathematics more. Again, the nature of the PBL environment (e.g., inquiry-based group work and active learning) may have fostered their more positive mathematics-learning motivations.

There was no statistically significant difference between PBL and conventional males in task value. This may be because these males, regardless of pedagogy, already valued mathematics. It was the PBL females who statistically significantly increased their appreciation of mathematics, perhaps because they were able, in the PBL environment, to better realize that math is not a male-oriented subject and that math has inherent value for females. Reasons as to why this may be warrants further study.

4.2.1.5 Male vs Male

Male students in PBL mathematics classrooms used study strategies and appreciated peer learning more than did their conventional counterparts. Inquiry-based group work may have encouraged male PBL students to engage cooperatively with their peers, which they would not have done otherwise. Additionally, male students in the conventional mathematics classrooms expressed more test anxiety, which can be attributed to the types of assessment that students experience in the conventional mathematics classroom. The paper-and-pencil tests, as well as the high stakes standardized assessments, are types of summative assessments, which focus on outcome or product, rather than formative assessments, which evaluate the learning process. Within PBL, male students may see the evaluative process as a tool for improvement instead of solely as a measure of mastery.

It should be highlighted that PBL female students had higher test anxiety than did both PBL and conventional males, though on a par with conventional females. The only statistically significant difference in test anxiety was between females (both PBL and conventional) and PBL males. This shows that within text anxiety there is an interaction effect in gender and pedagogy. In other words, gender had a stronger effect on test anxiety than did pedagogy; however, pedagogy did have an impact.

4.2.1.6 PBL Male vs Conventional Female

Conventional females showed higher test anxiety, while PBL males showed higher rehearsal, control of learning, and peer learning. In this analysis, gender differences as well as pedagogical differences come into play. Gender differences account for PBL males' higher use of rehearsal and belief in control of learning and for conventional females' high test anxiety. Pedagogical differences account for PBL males' higher appreciation of peer learning. Males and females within the PBL pedagogy showed the same difference in rehearsal and control of learning and test anxiety, which supports our analysis of gender differences. At the same time, the structure of the PBL approach impacted male students' higher appreciation of peer learning. It is important to note that these results are consistent with our analysis of the interactive effects of gender and pedagogy on learning motivation.

4.2.1.7 PBL Female vs Conventional Male

PBL females were higher in organization, rehearsal, and peer learning than were the conventional males, which also fits the pattern established through gender and pedagogy. Conventional males displayed no higher motivational factors.

In summation, we found that there are distinctive differences between how content learning and learning motivations are associated with gender and pedagogy in the mathematics classrooms. Study results indicate that pedagogy and gender had no impact on academic achievement. That is, within both PBL and conventional environments, females and males scored comparably on state standardized tests. However, interactive effects between gender and pedagogy on learning motivation do exist. Pedagogy played a stronger role in rehearsal, peer learning, and task value. Gender played a stronger role in test anxiety, organization, help seeking and control of learning. There were no statistically significant motivational differences in the conventional learning environment. The PBL approach was a more conducive environment, for both females and males, for learning motivations, including study strategies and self-regulated behaviors. The PBL students reported valuing and actively engaging in the mathematics more than did the conventional students. Another pedagogical influence was that the PBL environment seemed to allow more gender socialization patterns to emerge (e.g., females' higher test anxiety and males higher control of learning) than did the conventional approach.

Research has shown how students' motivation is an important factor in mathematics learning in the long run; thus, it is important to further research the impact of learning motivations on gender in the secondary mathematics context. This study adds some clarity to the sparse literature that exists in this domain. Questions still remain as to what aspects of secondary-mathematics pedagogies effectively interact with learner characteristics, such as gender, and how to increase learning motivations in secondary-mathematics students. The present findings as well as future studies will provide resources for secondary-mathematics teachers and the field at large.

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