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Effect of Classroom Gender Composition on Students' Development of Self-Regulated Learning Competencies*

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Success in any field depends on a complex interplay among environmental and personal factors. A key set of personal factors for success in academic settings are those associated with self-regulated learners (SRL). Self-regulated learners choose their own goals, select and organize their learning strategies, and self-monitor their effectiveness. Behaviors and attitudes consistent with self-regulated learning also contribute to self-confidence, which may be important for members of underrepresented groups such as women in engineering. This exploratory study, drawing on the concept of "critical mass", examines the relationship between the personal factors that identify a self-regulated learner and the environmental factors related to gender composition of engineering classrooms. Results indicate that a relatively student gender-balanced classroom and gender match between students and their instructors provide for the development of many adaptive SRL behaviors and attitudes.

Keywords: critical mass; engineering students; gender differences; role models; self-regulated learning

1. Introduction

Around the world, engineering remains a male-dominated discipline lagging behind other professional fields [1]. For example, percentages of women in the engineering workforce in the European Union range from 9% in the United Kingdom to 30% in Latvia with an average of 16.6% [2]. In the engineering workplace in the U.S., women are only 6% of management [3] and only about 14% of engineering faculty [4]. The percentage of females earning bachelor's degrees in engineering in the U.S. has changed little in the last twenty years from 15% in 1990 to 18% in 2010 [5]. Statistics examining undergraduate education, graduate education and the workforce consistently show disparities of significant magnitude between the numbers of males and females in engineering.

The reasons behind the low percentages of women in engineering are complex, multifaceted, and related to many different factors, including social, psychological and educational. Much of this research is nicely summarized in Hill et al. [6] for pre-college, university, and the workforce and Hersh [1] focusing on the global workplace. Researchers have posited that engineering itself is gendered [1, 7–10]. Recent studies show that women, once enrolled, persist and graduate in engineering at the same rates as men [11–13]. However, the experiences of women in undergraduate engineering education are different than those of men [14–16]. For example, females have been found to leave engineering earlier than males [17] with a majority of women dropping out of engineering programs in the first two years of the program [18].

Brainard and Carlin's [18] longitudinal study indicated that 25% of the female students who were enrolled in a science, mathematics, engineering or technology (STEM) major felt that a lack of self-confidence was a significant barrier to their success. This percentage rose to 44% in their senior year. That is, women's lack of self-confidence was both perceived to be a significant barrier to their success and this feeling increased rather than decreased over the course of women's experience in engineering programs. This lack of self-confidence is particularly noteworthy given the documented success of female students in their coursework throughout college [18, 19]. Understanding the factors that contribute to this lack of self-confidence in women students might therefore suggest strategies to improve the collegiate experience of female engineering students.

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This exploratory study seeks to determine if there is a relationship between the gender composition of the classroom, the gender match between the instructor and students and learning outcomes related to self-regulated learning. The results reported here are part of a larger study [20, 21] examining how environmental factors, such as pedagogical choices, contribute to the development of self-regulated learning (SRL) competencies in engineering undergraduates. We chose to study SRL because of its positive association with adaptive motivational, cognitive, and behavioral aspects of college student learning, behaviors and attitudes that typically result in increased self-confidence for learning, identified as an important factor related to student success. The previously published studies do not examine gender as a variable.

The independent variables examined in this paper are the environmental factors of the gender make-up of the classroom and instructor and student gender match. This expands upon previous work which considered the impact of pedagogy and gender of the instructor on students' characteristics of self-regulated learning [22]. These environmental factors have been identified in the literature as having the potential to affect student outcomes, especially in STEM disciplines [23]. The specific research questions asked here were as follows.

1. How do students respond differently on measures of SRL as a function of the gender composition in the classroom?
2. How do students respond differently on measures of SRL as a function of their gender match to their instructors?

In the remainder of this paper, we present a brief review of the literature on SRL, critical mass, and the effect of role models on learning outcomes in the college classroom. This is followed by our methodology, our findings on the relationships of critical mass and instructor and student gender on students' development of SRL competencies, and a discussion of the findings and their possible implications.

2. Review of the literature

2.1 Self-regulated learning

Self-regulated learning is a process in which learners are active participants in their own learning processes [24, 25]. Self-regulated learners select their own goals, select and organize their learning strategies, and self-monitor their effectiveness. The social cognitive view of self-regulated learning emphasizes the impact of the environment and behavioral influences, as well as personal processes which vary because of individual differences and situational factors.

Social cognitive theory assumes that self-efficacy is a crucial component of self-regulated learning. According to Zimmerman, "self-efficacy refers to perceptions about one's capabilities to organize and implement actions necessary to attain designated performance or skill for specific tasks." [26, p. 329] Research shows that students with high self-efficacy display more of the behavioral and environmental determinants of SRL, making self-efficacy critically important for academic success [26] including persisting longer when faced with opposition [27], which may be relevant for students in engineering.

2.2 Critical mass

Our first research question considers the influence of gender balance in the classroom. This seems particularly significant because of the known gender imbalance in most engineering classrooms. Given the low numbers of women in engineering education, there are typically not enough faculty or students to achieve what has been termed a "critical mass". "Critical mass" is the idea that a sufficient number of individuals inspire a collective action that is somehow different from that which is inspired by a single individual [28]. Most of this research has been done on women in leadership positions in industry. For example, in a study of "token" women in a corporation, Kanter [29] observed that gender stereotyping accompanies the presence of one or two women in a department and concluded that hiring women in clusters of at least three was needed. Etzkowitz and colleagues place this threshold at 15% [30] with popular conceptions putting it at 30% [31, 32]. Hersh says that at least 30% or even 40–60% of a group is needed for balance [1]. For faculty, researchers recommend a critical mass of at least three women in an academic department [33]. More research is needed to explore the concept of critical mass for women students in engineering education, particularly work that is of an intersectional nature that also considers the race/ethnicity of the women.

2.3 Role models in the college classroom

Our second research question considers the gender of the instructor and whether there is a role model effect for students that could be measured using SRL outcomes. The premise of the role model effect is that students respond differently to instructors of the same or different genders. This has been hypothesized to occur for a variety of reasons [23], which include: (1) biased interactions or expectations between teacher and student, (2) increased engagement between students and teachers of the same gender, (3) stereotype threat or the anxiety about confirming a negative stereotype and (4) different responses by gender to specific teaching styles. Will students report predictable patterns in attributes associated with SRL when taught by an instructor of the same gender?

While extensive research has examined the role model effect in pre-university settings, less research exists on the significance of the role model effect in higher education and these limited studies have yielded inconsistent findings. Boulware [23] summarizes these conflicting findings for women students and women instructors in the areas of course grades, enrollment in subsequent courses, and major choice. She suggests that the inconsistent findings exist in large part because different researchers have adopted different methodologies which include (1) examining relationships at different granularity levels (e.g. academic discipline, college level, department level or individual class level), (2) correlating outcomes to different environmental factors (e.g. the number of women instructors, the number of tenured women instructors, the number of courses taken with women instructors, etc.), and (3) examining different student outcomes (e.g. selection of major, persistence in major, completion of course, course grade, etc.). In addition to differences in methodology, some studies suggest that another confounding factor is that the significance of a role model effect may vary by academic discipline [34–36] with the effect perhaps being more important in disciplines with significant gender imbalances such as engineering. Boulware [23] concurs that a broader reading of the literature supports the notion that the strength of the role model effect varies with the gender imbalance in the classroom. Finally, Hoffman and Oreopoulos [37] suggest that another factor influencing the significance of any role model effect is the degree of interaction between the students and the faculty in the class and that the effect may be minimized in large introductory classes with little direct interaction between teacher and student.

This summary of the literature demonstrates the challenges in understanding the possible significance of both critical mass and the role model effect in practice and identifies the need for additional study of several related topics. While many authors posit the existence of the critical mass effect [38–41], it has not yet been verified to exist in the classroom in general or with undergraduate engineering women in particular [42]. It is therefore still an open question and our study seeks to add to the existing research base using a unique measure of academic performance (SRL attitudes/competencies)—this measure being both important and one that has not been studied before with respect to critical mass.

Studies that expand on the utility of critical mass to understand differential outcomes for male and female students would add considerably to efforts to work towards creating and supporting educational environments that benefit both genders. Furthermore, the predominance of research on the role model effect is in pre-university settings and the comparative lack of work in higher education suggests the need for more research at that level. While limited studies suggest that the role model effect may be particularly significant in the STEM disciplines, due to the gender imbalance in many STEM classrooms, there are few studies in this area. The aggregation of fields with a variety of gender compositions into the term STEM also complicates this work. Engineering, for example, is very different from biology in terms of gender balance. Finally, most studies examining the role model effect are motivated by persistence issues—the enrollment and retention of women and minorities in the STEM curricula. Fewer studies focus on student learning outcomes and, of those, the dependent variable studied is either the course grade or course completion. We have found no studies that examine the role model effect on actual pre/post measures of growth in student learning, either academic growth or psychological and behavioral growth as learners, suggesting a need for work in this area. This study seeks to address these issues by examining the existence of critical mass effects and the strength of role model effects in undergraduate engineering classes using measures of student self-regulated learning as the dependent variable.

3. Methodology

3.1 Participants

One hundred and seventy-six undergraduate engineering students and four engineering instructors from four universities in the U.S. participated in this study. Data was collected over a two-year period. The participants came from a small, private, specialty engineering school with about equal numbers of male and female students: two small, private liberal arts universities where male students were in greater numbers than female students, and with each course having a small student-to-instructor ratio; and one large, public university with a gender and student-to-instructor ratio typical of a large engineering program. Two of the universities were located in the northeastern U.S. while the other two were in the western U.S. In all, eleven course sections were included in the data set. The following courses were included in the study, one time each: circuits, heat transfer, metals and alloys, thermodynamics, and senior design. An engineering materials science course was taught twice, one time each at two universities. The following courses were included twice in the study by the same instructor: failure

Table 1. Number of male students, female students, and year in college for each course

Course Title	Male	Female	First-year	Sophomore	Junior	Senior
Heat Transfer	12	4	0	0	16	0
Thermodynamics	18	2	0	0	0	20
Failure Analysis (taught twice)	7	18	0	13	8	3
Metals and Alloys	3	6	0	3	1	5
Statics (taught twice)	25	16	1	36	3	1
Circuits	10	6	0	14	2	0
Materials Science (taught twice)	16	17	3	8	16	6
Senior Design	12	4	0	0	0	16
Total	103	73	4	74	47	51

analysis and statics. The instructors were all experienced tenured professors including one in chemical engineering, two in mechanical engineering, and one in electrical engineering. Three instructors were male and one was female. Table 1 shows the number of male and female students in each course and the students' year of study.

3.2 Procedure

A brief description of the study was given to the students by their instructor on the first day of class. With consent, quantitative data was collected electronically from the students prior to taking the course and after the course was completed.

3.3 Variables

Independent variables were the student gender balance in the course, operationalized as the proportion of females in each course and the gender match between students and instructor. Dependent variables consisted of the change from pre- to post-test in nine learning strategies and five motivational orientations as operationalized by the Motivated Strategies for Learning Questionnaire (MSLQ) [43].

3.4 Instrument

We chose the Motivated Strategies for Learning Questionnaire [43] to measure SRL outcomes because it is a well-researched, theoretically-based and widely used instrument with higher education populations. The survey has high predictive validity, internal consistency, and reliability [44]. Reliability estimates based on the data set from this study are consistent with those in the manual (ranging from 0.62 to 0.91).

Students responded to the MSLQ at the beginning and end of each term. The MSLQ is an 81 item self-report questionnaire designed to measure motivational orientations and the use of cognitive learning strategies in college students. The MSLQ requires students to respond to statements about themselves in relation to a specific course. The directions specifically ask the students about "motivation for and attitudes about this class" [43, p 41]; therefore students are thinking only about the class in which they are completing the questionnaire at the time of responding. The questionnaire is designed in a 7-point Likert format. A response of 1 on the Likert scale represents 'not at all true of me' and a 7 indicates 'very true of me.' The MSLQ has 15 subscales including: six subscales that address motivation (intrinsic goals, extrinsic goals, task value, control of learning beliefs, self-efficacy, and test anxiety) and nine subscales that address learning strategies (rehearsal, elaboration, organization, critical thinking, self-regulation, time and study environment, effort regulation, peer learning and help seeking). Table 2 provides an easy reference and brief description for each subscale within the MSLQ.

The MSLQ can be used in whole or in part. For this study, the test anxiety subscale was eliminated because tests were not given in all of the courses in the study. This reduced the MSLQ to 76 items. Additionally, the wording in several of the questions was slightly modified to more accurately reflect the learning environment of the courses. For example, specific references to "study" or "studying for the course" were replaced with "prepare" or "preparing for the course" and a reference to "lecture" was replaced with "class discussion."

3.5 Analyses

Paired samples *t*-tests were completed on student responses to the MSLQ taken at the beginning and end of the semester. A *t*-test is a statistical test used to determine if the means from two sets of data are significantly different from each other; *p*-values refer to the probability of obtaining a test statistic at least as extreme as the one that was actually observed, with the conventional threshold set at $p = 0.05$ needed to reject the null hypothesis. Three sets of paired sample *t*-tests were completed separating the data on the basis of: (a) a critical mass analysis based on the proportion of female students in the course categorized as either low (range is 11.4–13.9% female, $N_{\text{female}} = 10$, $N_{\text{male}} = 33$), moderate (range is 31.4–50% female, $N_{\text{female}} = 42$, $N_{\text{male}} = 61$), and high (range is 52.4–75% female, $N_{\text{female}} = 21$, $N_{\text{male}} = 9$), (b) instructor/student gender match

Table 2. Description of MSLQ subscales

Motivation Subscales	Brief Description	Learning Strategies Subscales	Brief Description
Intrinsic Goal Orientation	Participation in a task for the intrinsic desire to learn	Rehearsal	Using rote methods for learning (reciting, memory-based)
Extrinsic Goal Orientation	Participation in a task for reasons such as grades or rewards	Elaboration	Integrating and connecting information to be learned
Task Value	The value placed on the learning at hand	Organization	Different methods of organizing information for learning
Control of Learning Beliefs	Beliefs that outcomes are a result of one's own effort	Critical Thinking	Using prior knowledge for problem solving, decision making and evaluation
Self-Efficacy for Learning and Performance	Expectations that one will be successful and that one has the ability to be successful	Metacognitive Self-Regulation	An awareness of one's own knowledge and ability to control one's actions and emotions
Test Anxiety	How worried one is about demonstrating one's understanding	Time and Study Environment	Management of time and study environments
		Effort Regulation	Ability to control effort under less than ideal conditions for learning
		Peer Learning	Working with peers while learning
		Help Seeking	Managing the support of others in service of learning

Based on subscale descriptions from the Motivated Strategies for Learning Questionnaire [43, pp. 9–29].

(N = 95) and mismatch (N = 81), and (c) critical mass mediated by the instructor/student gender match or mismatch (i.e., low proportion and gender match [N = 33] and mismatch [N = 10]; moderate proportion and gender match [N = 57] and mismatch [N = 46]; and high proportion and gender match [N = 5] and mismatch [N = 25]). For the critical mass analysis, separate analyses were run for male and female students. Effects sizes are reported as Cohen's d, a measure of the magnitude of the treatment effect, with d of 0.2 to 0.3 interpreted as a small effect, d around 0.5 as a moderate effect and d greater than 0.8 as a large effect [45].

4. Results

4.1 Critical mass: Proportion of females in the course

Means (M) and standard deviations (SD) for all observed significant within-group differences are reported in Tables 3, 4 and 5 for low, moderate, and high proportion of female students in the course, respectively. When the proportion of females in the course was low (< 30%), females reported no significant differences in any area on the MSLQ from pre- to post-test. Males, on the other hand, reported an increase in metacognitive self-regulation $t(32) = 2.520$, $p = 0.017$, $d = 0.4388$ and a decrease in effort regulation, $t(32) = 2.555$, $p = 0.016$, $d = 0.4448$. When the proportion of females was moderate (30–50%), both females and males reported increases. Females reported increases in intrinsic goal orientation, $t(41) = 2.859$, $p = 0.007$, $d = 0.4412$, control of learning beliefs, $t(41) = 2.376$, $p = 0.022$, $d = 0.3666$, and critical thinking, $t(41) = 2.768$, $p = 0.008$, $d = 0.4271$. Males reported increases in rehearsal $t(60) = 2.116$, $p = 0.039$, $d = 0.2709$ and organization, $t(60) = 2.522$, $p = 0.014$, $d = 0.3229$. When the proportion of females was high (> 50%), females reported decreases in extrinsic goal orientation, $t(20) = 2.321$, $p = 0.031$, $d = 0.1786$, organization, $t(20) = 2.372$, $p = 0.028$, $d = 0.5177$, and regulation of time and study environment, $t(20) = 2.304$, $p = 0.032$, $d = 0.5028$. No significant differences pre- to post-test were found for males

Table 3. Means and standard deviations for significant within-group differences on MSLQ: Proportion of female students in course low (< 30%)

	Female Students		Male Students	
MSLQ Subscale	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)
Metacognitive Self-Regulation			4.46 (0.83)	4.69 (0.78)
Effort Regulation			5.71 (1.25)	5.34 (1.07)

Table 4. Means and standard deviations for significant within-group differences on MSLQ: Proportion of female students in course moderate (30–50%)

	Female Students		Male Students	
MSLQ Subscale	**Pre M(SD)**	**Post M(SD)**	**Pre M(SD)**	**Post M(SD)**
Intrinsic Goal Orientation	5.20 (1.08)	5.49 (1.13)		
Control of Learning Beliefs	5.30 (0.98)	5.61 (0.93)		
Critical Thinking	3.79 (1.11)	4.13 (1.31)		
Rehearsal			3.35 (1.23)	3.71 (1.24)
Organization			3.78 (1.18)	4.15 (1.12)

Table 5. Means and standard deviations for significant within-group differences on MSLQ: Proportion of female students in course high (> 50%)

	Female Students		Male Students	
MSLQ Subscale	**Pre M(SD)**	**Post M(SD)**	**Pre M(SD)**	**Post M(SD)**
Extrinsic Goal Orientation	3.26 (1.32)	2.81 (1.32)		
Organization	3.62 (1.17)	3.06 (1.26)		
Time/Study Environment	5.23 (0.55)	4.91 (0.68)		

when there was a high proportion of females. Interestingly, the majority of the effects in the critical mass conditions were approaching moderate effect sizes.

4.2 Instructor/Student gender match and mismatch

Within-group differences were found in the learning strategy subscale of time and study environment and the motivation subscale of task value when there was a gender mismatch. Students reported decreases in both of these areas although the effects are small: task value, $t(80) = -2.191$, $p = 0.031$, $d = 0.2453$ and regulation of time and study environment $t(80) = 2.565$, $p = 0.012$, $d = 0.2850$. No increases in any area measured by the MSLQ were found under conditions of instructor/student gender mismatch. Conversely, when there was an instructor/student gender match, no decreases in motivational or learning strategies were reported. Small increases were reported in the motivation area of intrinsic goal orientation, $t(94) = 2.145$, $p = 0.035$, $d = 0.2201$ as well as small increases in the use of rehearsal strategies $t(94) = 2.080$, $p = 0.040$, $d = 0.2134$; organization $t(94) = 2.986$, $p = 0.004$, $d = 0.3063$; critical thinking $t(94) = 2.235$, $p = 0.028$, $d = 0.2294$; metacognitive self-regulation $t(94) = 3.238$, $p = 0.002$, $d = 0.3322$; and peer learning $t(94) = 2.196$, $p = 0.031$, $d = 0.2253$. Means and standard deviations are reported in Table 6 for all MSLQ subscales where significant within-group differences were observed.

4.3 Instructor/student gender match and mismatch mediated by critical mass (proportion of females in the course)

Instructor/student gender match or mismatch mediated by the proportion of female students in the course results showed variation by the proportion of female students in the course. Means and standard deviations for MSLQ subscales with significant pre-post differences are shown in Table 7 when there was an instructor/student gender mismatch and Table 8 for an instructor/student gender match.

Table 6. Means and standard deviations for significant within-group differences on MSLQ: Instructor/Student gender match and mismatch

	Gender Mismatch		Gender Match	
MSLQ Subscale	**Pre M(SD)**	**Post M(SD)**	**Pre M(SD)**	**Post M(SD)**
Intrinsic Goal Orientation			5.20 (0.91)	5.35 (0.99)
Rehearsal			3.38 (1.27)	3.65 (1.23)
Organization			3.75 (1.23)	4.10 (1.33)
Critical Thinking			4.05 (1.32)	4.27 (1.19)
Metacognitive Self-Regulation			4.48 (0.86)	4.68 (0.76)
Peer Learning			3.85 (1.33)	4.10 (1.56)
Task Value	5.78 (0.95)	5.59 (1.16)		
Time/Study Environment	5.38 (0.77)	5.18 (0.89)		

Table 7. Means and standard deviations for significant within-group differences on MSLQ: High proportion of female students in course and gender mismatch

	Low		Moderate		High	
MSLQ Subscale	**Pre M(SD)**	**Post M(SD)**	**Pre M(SD)**	**Post M(SD)**	**Pre M(SD)**	**Post M(SD)**
Extrinsic Goal Orientation					3.35 (1.37)	2.95 (1.31)
Time/Study Environment					5.29 (0.54)	5.01 (0.72)

Table 8. Means and standard deviations for significant within-group differences on MSLQ: Proportion of female students in course and gender match

	Low		Moderate		High	
MSLQ Subscale	**Pre M(SD)**	**Post M(SD)**	**Pre M(SD)**	**Post M(SD)**	**Pre M(SD)**	**Post M(SD)**
Metacognitive Self-Regulation	4.46 (0.82)	4.69 (0.78)	4.49 (0.86)	4.70 (0.72)		
Effort Regulation	5.71 (1.25)	5.34 (1.07)				
Intrinsic Goal Orientation			5.31 (0.89)	5.52 (0.87)		
Rehearsal			3.43 (1.25)	3.93 (1.19)		
Organization			4.01 (1.21)	4.52 (1.18)		
Critical Thinking			4.23 (1.32)	4.56 (1.06)		
Peer Learning			4.26 (1.04)	4.61 (1.32)		
Help Seeking					4.05 (0.60)	5.30 (0.69)

4.3.1 Gender mismatch/low and moderate proportion of females

When the proportion of female students in the classroom was either low (< 30%) or moderate (30–50%) and there was an instructor/student mismatch, no differences were found for any subscale of the MSLQ from the beginning to the end of the term.

4.3.2 Gender mismatch/high proportion of females

When the proportion of females was high (> 50%) and there was an instructor/student gender mismatch, students reported moderate decreases in extrinsic goal orientation, $t(24) = 2.385$, $p = 0.025$, $d = 0.4770$ and regulation of time and study environment, $t(24) = 2.204$, $p = 0.037$, $d = 0.4407$. Means and standard deviations for significant within-group differences are reported in Table 7.

4.3.3 Gender match/low proportion of females

When there was a gender match between instructors and students, students reported an increase in metacognitive self-regulation, $t(32) = 2.520$, $p = 0.017$, $d = 0.4388$ and a decrease in effort regulation, $t(32) = 2.555$, $p = 0.016$, $d = 0.4448$, when the proportion of females was low (30%), both moderate effects.

4.3.4 Gender match/moderate proportion of females

When the proportion of females was moderate (30–50%) and there was a gender match between instructor and student, significant but primarily small increases were found pre- to post-test in intrinsic goal orientation, $t(56) = 2.137$, $p = 0.037$, $d = 0.2831$, rehearsal, $t(56) = 2.892$, $p = 0.005$, $d = 0.3830$, organization, $t(56) = 3.090$, $p = 0.003$, $d = 0.4093$, critical thinking, $t(56) = 2.448$, $p = 0.018$, $d = 0.3242$, metacognitive self-regulation, $t(56) = 2.515$, $p = 0.015$, $d = 0.3331$, and peer learning, $t(56) = 2.418$, $p = 0.019$, $d = 0.3203$.

4.3.5 Gender match/high proportion of females

When there was a gender match and the proportion of females was high (> 50%), students reported an increase only in help seeking, $t(4) = 5.5590$, $p = 0.005$, $d = 2.50$. Since the sample size here is so small (only five cases), it is difficult to draw conclusions and results are not likely to be sustainable with a bigger sample. Means and standard deviations for all significant within-group differences are reported in Table 8.

5. Discussion

5.1 Critical mass

The idea that perhaps it is not one influential role model that inspires behavior but actually the presence of a representative group of like individuals appears to have some support from the results of this study. In fact, the effect sizes for all findings were strongest when the data was analyzed by critical mass and by critical mass mediated by instructor/student gender match/mismatch. Considering only the percentage of females in the classroom, when there are few women (< 30%), women had no changes on any MSLQ subscales while men increased in one (metacognitive self-regulation) and decreased in another (effort regulation). As the percentage of women in the classroom exceeds the 30% threshold often used for establishing critical mass [31, 32], increases are found for all students on some MSLQ subscales, although the subscales were different for men and women. For females, increases were seen in intrinsic goal orientation, control of learning beliefs, and critical thinking, while males reported increases in rehearsal and organization. With more than 50% women in the classroom, a condition that did have a smaller sample size, men reported no changes while women reported decreases in extrinsic goal orientation, organization, and time/study environment. A decrease in extrinsic goal orientation may be desirable for SRL, especially if the reasons for such a goal are to avoid negative evaluations by others. Overall, these results suggest that the most positive impacts on SRL behaviors and strategies occurred for students in classrooms with a more balanced gender composition. Unfortunately, most engineering classrooms do not have more than 30% women, although there is variation by engineering sub-discipline [46].

5.2 Gender match/mismatch influences

The results show a pattern in which students reported statistically significant increases in regulating their motivation, cognitive strategies and learning context when in the presence of a same-gendered instructor. Students also reported statistically significant decreases in behavior and motivation regulation, although in fewer areas, when there was a gender mismatch. Students self-reported small to moderate gains in areas essential to becoming autonomous learners under matched-gender conditions. It is interesting to note that the largest effect size was observed for metacognitive self-regulation (d = 0.3322), which is perhaps the most directly related to SRL and critical to lifelong learning.

These results are consistent with what social learning research suggests about gender role development [47, 48] and with hypotheses about the effect of gender role models in higher education, in that a pattern of positive responses was observed when the instructor was of the same gender as the students. Social cognitive theory suggests that we model the behavior of those who are most like us or those whom we desire to be most like. Role models have the power to exert strong influence over the development and choices of those who are in a perceived subordinate position. In the classroom, the teacher can have considerable influence over the choices that students make in terms of their reasons for learning and which behaviors they engage to effect learning. The research supports this premise for students in elementary and secondary schools. It is less clear for students in higher education. Our results suggest that, at least in fields where there is a gender imbalance for both students and instructors such as engineering, the instructor's gender may contribute to different learning outcomes, lending support to the work of Robst and Russo [34], Bettinger and Long [35], and Carrell et al. [36] who suggest that the role model effect may be more pronounced under such conditions. However, in our study, there were two self-reported decreases, for task value and time/study environment, under gender mismatch conditions that were small in effect size. This is an important finding because it points to the possibility of mediating variables, apart from gender that may be at play in the higher education classroom.

Learning environments with gender matches and moderate percentages of women produced the greatest SRL-related learning gains. Again, this supports the ideas in the role model literature that a same-gendered role model can be beneficial. Also, reaching a critical mass of women in the classroom seems to result in gains for all students in SRL behaviors and strategies.

Considering the most common situations in engineering education for men and women, our results suggest that these conditions are not ideal for students' development as autonomous lifelong learners. Most male engineering students would experience instructor/student gender match and a low percentage of women in the classroom. Our results suggest that this condition would result in increases in metacognitive self-regulation but decreases in effort regulation. Most women engineering students would experience instructor/student gender mismatch and a low percentage of women in the classroom. Our results suggest that this condition results in no changes in SRL-related behaviors and strategies. The interplay of factors such as gender of the instructor, gender of the student, and gender composition of the classroom, among many other factors in the classroom, is complex. These results point to the need for more detailed analyses to understand the most important factors that should be addressed to enhance all students' learning in equitable classrooms.

6. Conclusions

These findings add to our understanding of the influences of critical mass and gender role model effects on self-regulated learning in higher education. Several interesting patterns emerged in this study on the relationship of the gender match of instructor and student with the student's development of self-regulated learning attitudes and behaviors. One key finding was that students responded most positively to instructors of the same gender, which is consistent with past research on role model effects. It is interesting that these effects are still discernible at these late developmental stages. Perhaps the gender of the mentor or model is highly salient in an environment which one has not fully embraced, such as a college major, or in a domain which is itself gendered, such as engineering. With respect to the issue of critical mass, the representation of similar others rather than just one influential role model showed overall stronger effects (as measured by effect size) than that of instructor/student gender match alone, suggesting that finding oneself in a situation with others who are similar may be an even more important facilitative factor influencing self-regulated learning outcomes. These results underscore the critical importance of finding creative strategies to overcome the male-dominance of engineering to help all students become more successful.

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