



Biological and Behavioral Patterns of Cognitive Processing and Motivational Self-Regulation across Scientific Disciplines

Ruth-Elizabeth Minga-Vallejo^{1*}, Herlinda Gervacio-Jiménez², Jorge Israel Astudillo-Zúñiga³, Yamira Iraisá Herrera-García⁴, José Darwin Farje-Escobedo⁵, Paulina Elizabeth Moreno-Yaguana⁶

¹ Universidad Técnica Particular de Loja, Ecuador. ORCID: <https://orcid.org/0000-0001-5856-5192>.
E-mail: reminga@utpl.edu.ec

² Universidad Autónoma de Guerrero, Mexico. ORCID: <https://orcid.org/0000-0003-3037-9528>.
E-mail: lindagervacio@uagro.mx

³ Universidad de Cuenca, Ecuador. ORCID: <https://orcid.org/0009-0000-3648-3428>.
E-mail: israel.astudilloz@ucuenca.edu.ec

⁴ Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas (UNTRM), Peru. ORCID: <https://orcid.org/0000-0003-2881-5992>. E-mail: Yamira.herrera@untrm.edu.pe

⁵ Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas (UNTRM), Peru. ORCID: <https://orcid.org/0000-0002-2164-6682>. E-mail: jose.farje@untrm.edu.pe

⁶ Universidad Técnica Particular de Loja, Ecuador. ORCID: <https://orcid.org/0000-0002-1427-1034>.
E-mail: pemoreno@utpl.edu.ec

Abstract

Even within the same cultures, research across disciplines shows ambiguity and inconsistency regarding gender differences in university learning. This study examined the main effect of gender and its possible interactions with disciplinary area on learning strategies and motivational self-regulation among technical and biological science learners at a university in Ecuador. A conceptual content analysis of a 32-item Likert-type questionnaire (0–6) was conducted on a sample of 454 students (265 men, 189 women; 231 technical area, 223 biological area) to group the items into categories: cognition and processing strategies; self-regulation and planning; motivation and self-efficacy; anxiety, procrastination and interference. Women combined yielded significantly higher achievement on all four dimensions compared with men (Cohen's $d = 0.33 - 0.55$), with the difference significant only for anxiety in the disciplinary area, where it was small (Cohen's $d = 0.36$). A statistically significant interaction between gender and area was also recorded for motivation and self-efficacy, $F(1, 450) = 5.45$, $p = .020$: among males, scores increased slightly in the technical area, while among females, scores increased slightly in the biological area. The results of the present study indicate that the gender difference in self-regulation is not consistent across STEM and biomedical disciplines, and that there is a need to create self-regulation-strengthening pedagogies specifically for the STEM disciplines rather than a too-general format.

Keywords

learning strategies; self-regulation; academic motivation; gender differences; higher education; technical sciences; biological sciences

Available Online: 10/09/2026

Introduction

Most young Latin Americans pursue their education at the university level, and this transition is a critical one. At this point, learning is no longer tightly controlled by the teacher and increasingly relies on students' ability to plan their learning, self-monitor and persist in their tasks, and self-manage emotions triggered by academic challenges. Studies of first-year students have documented a significant dropout rate in the early years of higher education and have linked increases in motivation and better academic results to stronger self-regulated learning (Simón-Grábalos et al., 2025). That is, much underachievement among first-year students is not simply due to a lack of disciplinary knowledge but also to a lack of skills in organizing their time, staying motivated to complete boring tasks, recovering from poor grades, etc., which are important to students' well-being. This recognition has led more researchers to focus on the role of learning strategies and motivational self-regulation in contemporary educational psychology. The term learning strategies are classically defined as "the set of procedures, techniques, and consciousness of students to select, organize, and elaborate information in reaching a learning target". From a self-regulation standpoint, learning is not an automatic process of acquiring information, but a constructive process in which learners develop mental capacity into academic skills (Zimmerman, 2002).

From this perspective, study habits (i.e., organizing study time, Arabic after-class review, summary writing, and transferring new knowledge to prior knowledge) are not separate tasks but rather the visible aspects of the patterns and processes in which students voluntarily engage to effectively pursue the goals they have set for themselves. He termed this process the "cycle of 3 steps": forethought, in which students develop plans and/or goals for their actions; performance – monitoring and controlling one's work while studying; and self-reflection – evaluating and adjusting beliefs about the functioning of the processes as needed for the next task (Zimmerman, 2002). Organization of learning resources and learning strategies doesn't, by itself, ensure their ongoing use. There is also a motivational element needed to continue working when the work is challenging. This has also been called the regulation of motivation, defined as the complex of activities that the student will use purposefully to initiate and sustain or even intensify a disposition to engage in or persist with a learning activity in the presence of events that also seem able to pose an impediment to it (Wolters, 2003). The regulation of motivation has a strategic place in the self-regulatory cycle of learning, because at times when students may become demotivated, distracted, delay starting their study, or are discouraged due to a poor grade, SRL efforts are prone to collapse. Self-efficacy, which refers to people's self-perception of their skills and abilities for carrying out certain actions, can play an important role in this process, since it can determine what kind of activities people choose to participate in, the effort put in, and the extent to which they persist through difficulty (Schunk, 1991).

A student with high self-efficacy may experience significant frustration at the beginning of a difficult course but can persist in their studies because they believe they are capable of passing it; a student with low self-efficacy may enter a disastrous mental state when first encountering difficulty, which further weakens their drive to learn. However, the link between strategies and motivation is far from automatic or unexplainable. Some theoretical perspectives define motivation as a precondition for cognitive strategies, suggesting that only students who find their motivation adequate will use them and be motivated to engage in deep study, while others hold that if students master correct and effective strategies, they will experience a sense of competence that will sustain their motivation over time. This theoretical ambiguity makes it well worth considering both constructs together and empirically testing their properties in particular populations, as current international research results are not fully congruent and may not be transferable to the context of Latin American universities. Gender is among the factors that have been explored in relation to SRL. In a literature search, Pajares (2002) reported that female students reported more self-regulation than male students regarding strategies to support students' learning, including goal setting, planning, record keeping, and structuring the study environment, and suggested that gender differences are related more to gender-stereotyped beliefs than to gender itself. In the case of higher education, a study of 1248 Finnish undergraduate students by Virtanen and Nevgi (2010) revealed that SRL strategies differed across disciplines and genders, thus questioning the validity of using gender or discipline individually as predictors in an examination of SRL strategies.

In a study of 450 Italian university students, Limone et al. (2020) concluded that men were more prone to

procrastination than women, due to less time-management skill and less use of metacognitive strategies. Müller, El-Ansari, and El Ansari (2022) compared 3,353 university students in Germany on perceived stress and anxiety at the affective level and found that women had higher anxiety scores and more positive screenings, while men had higher self-esteem scores. Taken together, these studies suggest a potential conflict between strategic and affective representations of the gender gap. Motivation and self-regulation do not form a homogeneous block in the technical sciences, as the evidence shows. Biwer et al. (2025) compared students in an undergraduate engineering program regarding how they study and noted a disconnect between what they know is helpful and what they actually do; this has been an ongoing challenge for students when self-regulated learning and technical contexts meet. Consider the additional level of complexity for women in these programs. Hardtke et al. (2023) interviewed women undergraduates studying engineering in Australia and reported that they felt out of place and lacked confidence in their intellectual ability due to a lack of gendered identity with engineering. Vera-Gajardo (2021) proposed a conceptual framework that explains the gender gap in engineering by linking the construct of belonging and the norm of masculinity. Alonso et al. (2021) traced how the decision to major in computer engineering is not the same for girls as for boys from secondary school through higher education. Consistent with this trend of self-selection of disciplines, Ribeirinha et al. (2024) found that female students had higher levels of career interests in science, while male students had higher levels of career interests in engineering and technology. Moraga-Pumarino et al. (2025) also found in a Chilean university that personal efficacy beliefs were higher for men than for women in a business field dominated by men.

The evidence is also consistent in the biomedical and health sciences, with results confirming that relationships among self-efficacy, motivation, and self-regulation are associated with academic performance. Turan et al. (2009) evaluated the metacognitive awareness and self-regulated learning skills of 862 medical students in schools with different curricula and reported differences by gender, phase of training, and curricular model. The role of problem-based learning in female medical students' planning and goal-setting skills was also investigated by Demirören, Turan, and Öztuna (2016) and the result was that the advancement obtained by female medical students showed a medium effect in problem-based learning setting, while self-efficacy beliefs showed a weak correlation with self-regulated learning skills. In a nationwide study of 1,930 Chinese medical students, Wu et al. (2020) found self-efficacy and learning engagement to be the mediators between motivation and academic performance; significantly, males had higher self-efficacy and lower academic performance than females. The results suggest that motivational benefits are not necessarily correlated with performance and that the gender gap may vary depending on the motivational factor assessed.

It is important to recognize that differences in self-regulation are not a static status. Rosário et al. (2015) conducted a study on motivational variables and the use of SRL strategies in an intervention with SRL strategies in four different cultures (Portugal, Spain, Chile, and Mozambique) and found that first-year students showed improvements in motivational variables and in the use of self-regulatory strategies in both cultures. A short time-management intervention has been shown to significantly reduce students' feelings of procrastination (Häfner et al., 2014) and to prevent the increase in perceived stress students can experience at the beginning of a semester (Häfner et al., 2014). In a recent systematic review, interventions directly implemented within academic content and run by the faculty were seen as more successful than those run in their own week extra-curricular programs, and both the cognitive and the metacognitive levels, as well as the motivational, behavioral, and affective ones, were indicated to be effective (Simón-Grábalos et al., 2025). An analytical perspective should not be limited to a single gender or a single discipline, but should combine both. When a comparison is made between two different disciplines, it is a comparison amongst two sorts of students – and a comparison between men and women is inevitably a comparison between two disciplinary cultures, if women are overrepresented in the biological sciences in comparison to the disciplinary sciences. The only way to disentangle these mixed effects and to identify whether the gender difference in self-regulation is general across subjects or restricted to specific subjects, and whether it is greater or lesser in university versus school settings, is through a factorial design.

In higher education, especially in places where gender-based disciplinary action is still significantly enforced, such as Ecuador, where empirical research on SRL remains limited, it is relevant to discuss this issue. The above is an example of the knowledge gap exposed, which the present study addresses. Second, the available evidence is predominantly from an international context—European, North American, or Asian—and therefore it is difficult to apply across Latin America, where higher education curricular structures are very different from those that emerged from the OECD countries. Additionally, the higher education admission system and study culture are quite distinct in Ecuador compared to countries in the OECD. Third, in many studies in the literature, motivation is treated as a single variable without specifying among its various aspects, such as achievement motivation, self-efficacy, and self-regulatory capacity, as described here as the ability to persist despite difficulties, to suppress distracting thoughts, and to recover emotionally from failures. Fourth, very few studies investigate differences in learning

strategies and motivational self-regulation by gender across disciplinary areas, although there are significant differences in study culture and cognitive demands across the technical and biological sciences.

Given this, the following research question was posed in light of the present study: What is the difference between male and female university students' subjective learning strategies and their learning self-regulation, and is this difference influenced by their study areas? What is the nature of this difference? The specific objectives were thus: (a) to test the difference between the means of male and female students across the four dimensions, (b) to test the difference between the means of students from the technical area and those from the biology area, and (c) to test the interaction between gender and area of study for each dimension.

Materials and Methods

The study gathered data at a single point in time to show/confirm a relationship between variables of interest, a quantitative and non-experimental, cross-sectional design. The scope was comparative in itself and, at a second level, factorial because the main effects of gender and area of study, as well as the interaction between them, were evaluated concerning the dependent variables. The sample included 454 students from a private university in the city of Loja, Ecuador, with programs classified by the university into the general technical area ($n = 231$, 50.9%) and the biological area ($n = 223$, 49.1%). Of the total sample, 265 participants (58.4%) identified as men and 189 (41.6%) as women.

Gender distribution played a significant role in the study; the sample was strongly male-oriented in the technical area (170 men to 61 women), whereas in the biological area it was largely the same, with a slight reversal (128 women to 95 men), confirming the disciplinary gender segregation characterized in the literature on STEM education and revisited as a limitation below. The age of the participants ranged from 17 to 27 years ($M = 18.65$, $SD = 1.51$), and the majority (57.9%) were between 17 and 18 years, covering the first semesters of university training. As for marital status, 97.8% reported being single, with proportions in common-law unions (1.5%) and married (0.4%). The sampling procedure was non-probabilistic and purposive, and questionnaires were administered in classrooms, with permission from the teachers concerned.

For data collection, researchers used a self-administered questionnaire, the Questionnaire on Strategies and Motivation for University Study (Cuestionario de Estrategias y Motivación para el Estudio Universitario [CEMEU]; García-Ripa et al., 2016), which had previously been used and validated in an Argentine university population. The questionnaire consists of 32 items on a Likert scale, adopted to capture study behaviors, metacognition, and emotional responses related to students' academic performance, ranging from 0 (never) to 6 (always). The questionnaire also included a sociodemographic section that provided information on sex, age, marital status, prior vocational guidance, and area of study. There was no evidence of a confirmed factor structure for the Ecuadorian population, and therefore the items were conceptualized into four dimensions using content analysis: Cognitive and Processing Strategies (CPS) (11 items), referring to elaboration, reading comprehension, and integration of concepts; Self-Regulation and Planning (SRP) (6 items), referring to organization of study time and self-testing; Motivation and Self-Efficacy (MSE) (6 items), referring to self-perception as a student and commitment to the chosen program; and Anxiety, Procrastination, and Interference (API) (7 items), referring to exam nervousness, difficulty concentrating, digital distraction, and discouragement after receiving a poor grade. Representative items included: "I try to reason and think about each topic so I can understand what I have read" and "I can manage my time well to learn and spend time on other activities."

The internal consistency of the global scale, measured by Cronbach's alpha for the 32 items, was .83, which is considered suitable for global research instruments in the social sciences. It was administered to all students in the classrooms during the first few weeks of the academic session, in coordination with the academic authorities of each participating faculty. Students were informed about the aim of the study, the voluntary nature of participation, the anonymity of their responses, and the exclusive use of the information for academic purposes. Data were then collected with the corresponding verbal and written informed consent. The administration took about 20 minutes; the whole procedure was supervised, and questions posed during the administration were answered, but no specific answers were elicited.

Respondents were screened prior to statistical analysis after data collection was completed. Data processing was carried out using Python 3 libraries (pandas, SciPy, and statsmodels). Descriptive statistics (means, standard deviations, and frequencies) were calculated for the sociodemographic variables as well as for each of the four dimensions. Second, internal consistency was computed for the global scale (using Cronbach's alpha) as well as for each of the subscales. Third, independent-samples *t* tests were used to compare the scores on the four dimensions by gender and area of study (using Welch's *t* tests to avoid assuming homogeneity of variance between groups with

different sample sizes), and Mann–Whitney U tests were also used (because scores were measured on a Likert scale and the data were ordinal). Cohen's d and the rank-biserial correlation were used to measure effect size, and 95% confidence intervals for d were calculated based on group sizes. Fourth, a two (gender) by two (area of study) cross-classification or analysis of variance was estimated for each dimension to examine possible cross-over effects, beyond those examined by single bivariate comparisons. Last, an item-level analysis based on Cohen's d identified the specific items with the greatest gender differences. Throughout, the significance level $\alpha = .05$ was chosen according to a conventional value.

The study was conducted in accordance with the ethical principles for research with human subjects outlined in the World Medical Association's Declaration of Helsinki, especially respect for a participant's autonomy and duty to uphold the well-being of a participant over any scientific interest, and to the Belmont Report's dictates of beneficence, respect for persons, and justice. Informed consent explicitly stated the study's goal and included a statement that participation was voluntary, with no academic repercussions, and that confidentiality would be maintained.

Each question was numbered and anonymized (so that no answer could be traced to an individual student). The resulting database was kept in a secure, protected area and used only for aggregate analysis. Several items might cause some discomfort, such as exam anxiety, difficulty focusing, or discouragement following a poor grade. The instructions called for participants to skip any item of their choice, and contact information for the student well-being service at the institution was provided in case they wanted to talk about these items. Administration was planned in coordination with the faculty authorities to avoid interfering with regular academic work. According to Ecuadorian regulations on research involving human subjects, the competent academic authorities of the institution reviewed and approved the research protocol.

Results and Discussion

The overall distribution of scores given on the four dimensions was conducted first prior to the inferential comparisons. The sample means were generally midrange, between 3.85 for CPS and 4.66 for SRP, suggesting some performance advantages but also moderately high use of study strategies and self-regulatory resources, leaving room for improvement, especially in the cognitive processing domain of SRP. The descriptive statistics and test-retest reliability coefficients are provided for each dimension in Table 1.

Table 1. Descriptive statistics and internal consistency of the assessed dimensions

Dimension	Items	M	SD	Range	α
Cognitive and Processing Strategies (CPS)	11	3.85	0.61	0–6	.56
Self-Regulation and Planning (SRP)	6	4.66	0.84	0–6	.66
Motivation and Self-Efficacy (MSE)	6	4.33	0.68	0–6	.38
Anxiety, Procrastination, and Interference (API)	7	4.15	0.64	0–6	.43
Global score	32	4.25	0.55	1.4–5.9	.83

Note. Response scale from 0 (*never*) to 6 (*always*). The global score was computed as the mean of the four dimensions. α = Cronbach's alpha.

Some comments are warranted regarding the reliability coefficients. The global scale score was satisfactory ($\alpha = .83$). For the MSE and API subscales, internal consistency was clearly below conventional values ($\alpha = .38$ and $\alpha = .43$, respectively), and for the CPS and SRP subscores, internal consistency was below conventional values ($\alpha = .56$ and $\alpha = .66$, respectively). This suggests that, from a conceptual standpoint, the item sets are partially heterogeneous in terms of the constructs they represent. Therefore, results for the MSE and API, particularly, should be used with caution and treated as an appropriate approximation rather than a consolidated result. Table 2 shows differences between men and women and between technical and biological in terms of scores. In all cases, women had significantly higher mean scores than men, with effect sizes in the small-to-moderate range as defined by Cohen et al. Gender comparisons were also significant in all cases using the Mann-Whitney U test ($p < .001$), eliminating the

need for the assumption of normality. The gender profile across the four dimensions is shown in Figure 1.

Table 2. Comparison of dimension scores by gender and by area of study (Welch's *t* test)

Dimension	Gender					Area of study				
	<i>M</i> Men	<i>M</i> Women	<i>t</i>	<i>p</i>	<i>d</i>	<i>M</i> Tech.	<i>M</i> Biol.	<i>t</i>	<i>p</i>	<i>d</i>
CPS	3.72	4.00	-4.94	< .001	-0.47	3.71	3.97	-4.62	< .001	-0.43
SRP	4.55	4.83	-3.48	< .001	-0.33	4.58	4.75	-2.14	.033	-0.20
MSE	4.19	4.54	-5.76	< .001	-0.55	4.28	4.39	-1.59	.113	-0.15
API	4.06	4.28	-3.66	< .001	-0.35	4.09	4.21	-2.13	.034	-0.20
Global	4.13	4.41	-5.48	< .001	-0.53	4.17	4.33	-3.17	.002	-0.30

Note. Men $n = 265$; women $n = 189$; technical area (Tech.) $n = 231$; biological area (Biol.) $n = 223$. Negative t and d values indicate higher scores among women (gender) or in the biological area (area of study). All gender comparisons were also significant with the Mann–Whitney U test ($p < .001$). CPS = Cognitive and Processing Strategies; SRP = Self-Regulation and Planning; MSE = Motivation and Self-Efficacy; API = Anxiety, Procrastination, and Interference.

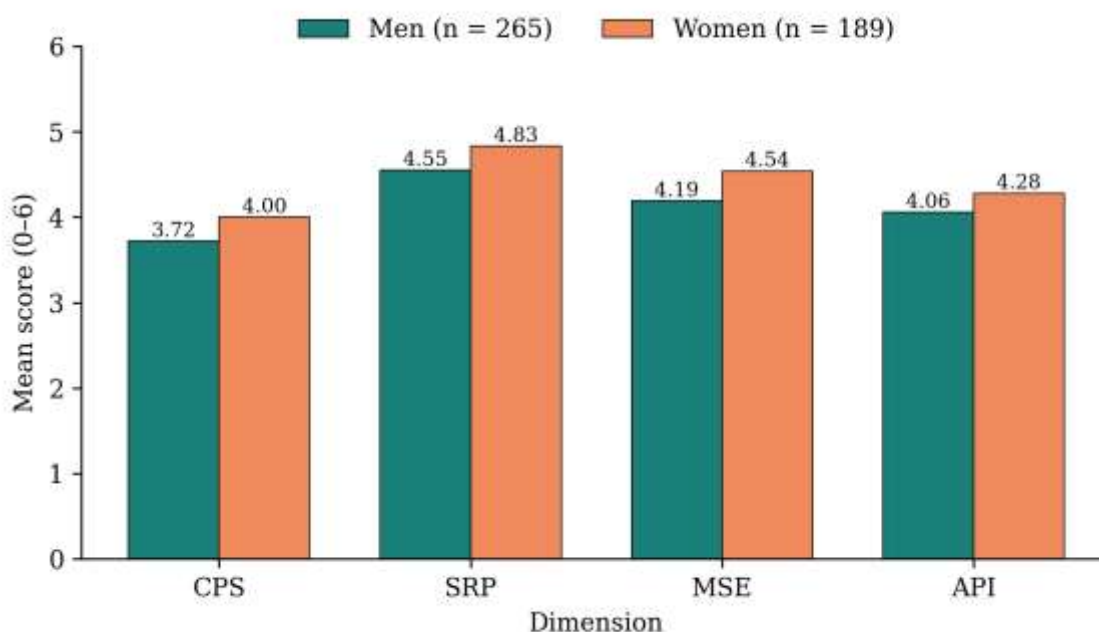


Figure 1. Mean scores on each dimension by gender (grouped bar chart). Values above the bars are group means on the 0–6 scale. CPS = Cognitive and Processing Strategies; SRP = Self-Regulation and Planning; MSE = Motivation and Self-Efficacy; API = Anxiety, Procrastination, and Interference.

The largest effect was observed for MSE ($d = 0.55$), followed by the global score ($d = 0.53$) and CPS ($d = 0.47$). The rank-biserial correlation for the global score ($r_{rb} = .34$) indicates that, if a woman and a man were chosen at random from this sample, there would be a slightly higher-than-chance probability (.67) that the woman would report the higher score on motivational self-regulation. These consistent female advantages align with the overall pattern previously summarized by Pajares (2002) regarding females' increased reporting of goal setting, planning, and structuring the environment, and with the results of Demirören et al. (2016), in which females' scores exceeded males on planning and males' exceeded females on goal setting. This is also in accordance with Limone et al. (2020), which found that time management and metacognitive strategies were weaker among male students, leading to a tendency toward procrastination. These findings, however, contradict Moraga-Pumarino et al.'s (2025) results showing higher personal efficacy beliefs for males and Wu et al.'s (2020) finding of higher intrinsic motivation among male medical students. The opposite results imply that the gender—motivational beliefs relationship is not

amenable to a simple generalization, and that contextual effects (assessment practices, classroom climate, and gender composition of individual programs) can overcome and modulate the gender effect even more than gender might directly influence motivational beliefs. Therefore, as Pajares (2002) contended, the differences between boys and girls in self-efficacy could be the result of gender-stereotyped beliefs and not an innate trait of women or men. The technical vs. the biological area revealed a pattern different from gender. However, there were statistically significant differences in CPS, SRP, and API (Table 2 and Figure 2), and these differences were generally smaller than those for gender, with no difference in MSE ($p = .113$). Students in the biological area performed higher than those in the technical area across all dimensions, with the greatest difference on CPS ($d = 0.43$). This finding is consistent with Virtanen & Nevgi (2010), who showed that students' disciplinary cultures influence the self-regulatory strategies they use, and with Biwer et al.'s (2025) finding that students do not always apply the strategies that they know work for them. It is striking, though, that the only dimension that did not show a significant area difference, MSE, is the dimension on which an interaction effect between gender was found, as reported next. This implies that the main effect of area is more complex when area is analyzed in the context of gender.

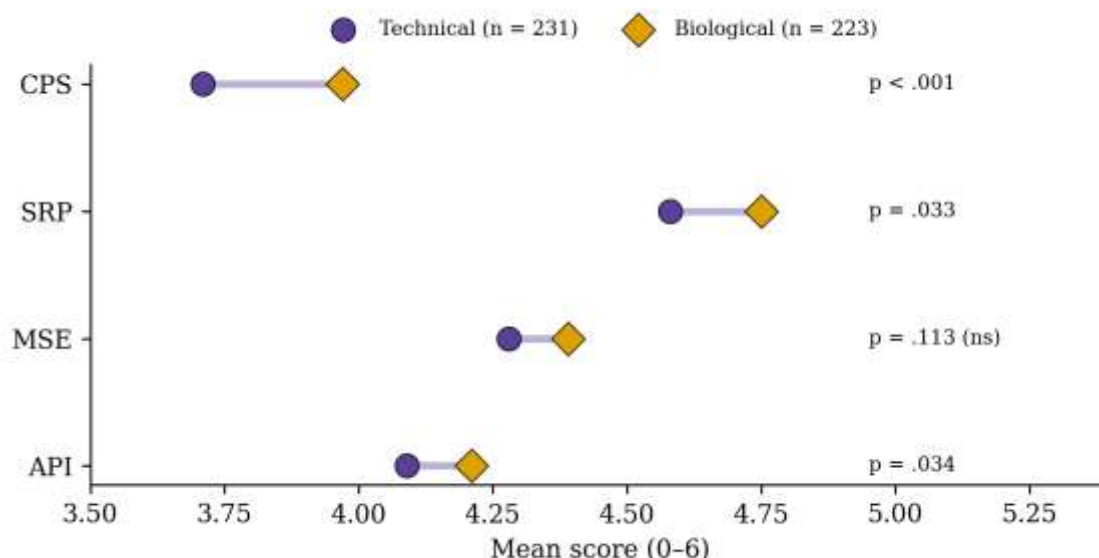


Figure 2. Mean scores on each dimension by area of study. Circles represent the technical area and diamonds the biological area; p values correspond to Welch's t tests. ns = not significant.

To explore this possibility, a 2×2 factorial analysis of variance (gender $\times$ area of study) was estimated for each dimension. Table 3 summarizes the results of these models.

Table 3. Results of the 2×2 factorial analysis of variance (gender $\times$ area of study) for each dimension

Dimension	F gender	p	F area	p	F G $\times$ A	p
CPS	13.46	< .001	10.79	.001	0.00	.976
SRP	8.76	.003	1.25	.265	0.27	.602
MSE	30.55	< .001	0.03	.861	5.45	.020
API	9.92	.002	1.11	.294	0.68	.410
Global	22.56	< .001	2.51	.114	0.07	.786

Note. Degrees of freedom were (1, 450) for all effects. G $\times$ A = gender $\times$ area of study interaction. The only significant interaction corresponds to Motivation and Self-Efficacy (MSE).

When gender was controlled, the main effect of gender was significant on four dimensions and the global score, while the main effect of area was significant only on CPS. Some of this attenuation is due to the unbalanced sex distribution across the two regions – part of the bivariate area effect in Table 2 may be due to sex distribution rather than the region, as women were overrepresented in the biological region. There was one significant two-way interaction for MSE, $F(1, 450) = 5.45$, $p = .020$. This relationship can be illustrated using a line plot with the crossover indicated (Figure 3). It is worth noting the presence of a strong area effect on the CPS after controlling for gender. Courses in the biological domain usually involve reading a lot, synthesizing and integrating concepts

across different levels of living organization, and relating new information to prior knowledge and understanding, which can promote elaborative and comprehension-monitoring strategies. The fact that curricular models influence metacognitive awareness and the development of SRL skills (Turan et al., 2009) and that SRL strategies differ systematically by discipline (Virtanen & Nevgi, 2010) is consistent with this interpretation. In contrast, in the absence of area main effects for both SRP and API when gender was controlled, this implies that planning and affective interference are less related to disciplinary demands and more to individual characteristics that differ across gender.

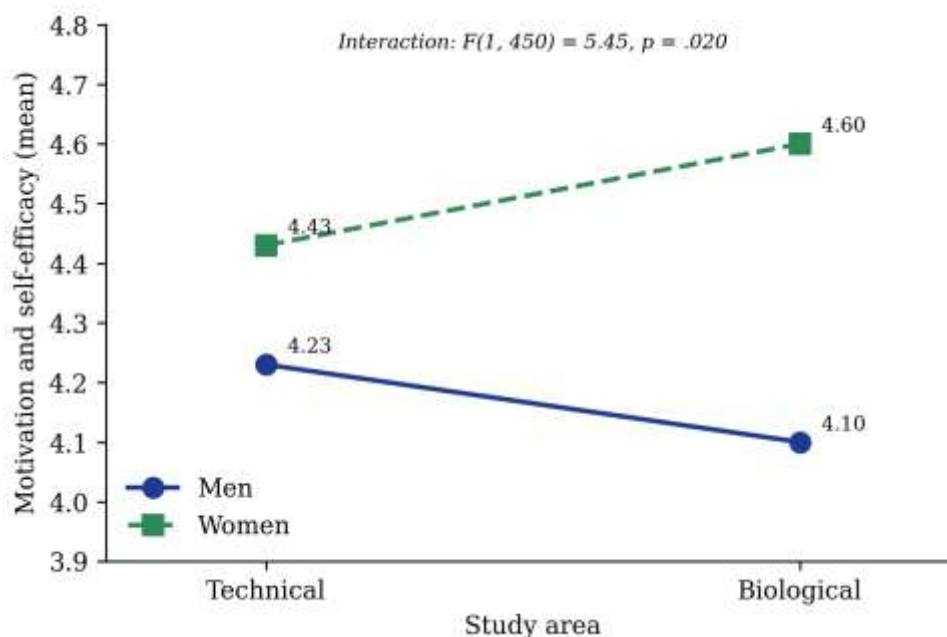


Figure 3. Gender × area of study interaction for Motivation and Self-Efficacy. Points represent cell means (men–technical M = 4.23; men–biological M = 4.10; women–technical M = 4.43; women–biological M = 4.60).

For both female and male students, motivation and self-efficacy were slightly higher in the technical area than the biological area, although the opposite was true for female students in the biological (higher) than the technical (lower) area, and, in turn, for male students in the biological (higher) than technical (lower) area. Qualitative: crossing trends in motivation and self-efficacy; the size of the female advantage is not uniform; it becomes larger in the biological area and smaller, but not nonexistent, in the technical area. Another possible explanation is that women who enter technical degree programs self-select or face different disciplinary norms or climates, so their self-efficacy experiences may differ from those of their peers in the biological area, which was the majority (128 of 223, 57.4%). This is congruent with the qualitative evidence provided by Hardtke et al. (2023), which revealed gendered perceptions of engineering identity that led participants in their study to feel out of place and unsure of their abilities and to view engineering as a distinctly masculine discipline and profession. It is also consistent with Vera-Gajardo's (2021) framework which explicitly highlighted the central role of belonging and masculinities in gender gap research for engineering.

The self-selection hypothesis is also supported by gender differences in career interests that are revealed by Ribeirinha et al. (2024) and by barriers to women's participation in computer engineering that are documented by Alonso et al. (2021). However, this is a speculative interpretation, since the cross-sectional study does not allow us to go beyond correlations and thus make causal inferences between the gender composition of each program and the level of motivation reported. The eight items that showed the greatest gender differences were all significant ($p \leq .002$) and are shown in Figure 4. Some of the distinctive elements of this battery are items which clearly refer to metacognition (e.g., test myself before the exam, connect concepts in a text, reason through what is read; "Connect concepts in a text, reason through what is read," "I am convinced about studying this program, even though it is not what the parents want") as well as items of global self-perception (e.g., consider myself a good student) and an item of vocational commitment in the face of family pressure (e.g., "I am convinced about studying this program, even though it's not what the parents want").

This finding of a female advantage in metacognitive behaviors, not surface study strategies, aligns with Turan et al. (2009), who found a gender difference in medical students' metacognitive awareness. Additionally, it aligns with

Biwer et al. (2025), who found that the disconnect between knowing and effectively using strategies is a main challenge in technical programs. The vocation-commitment item, which showed the largest differences, was not expected based on the literature consulted. This suggests that the self-control aspect of the gender difference applies to study behaviors not only in a literal sense but also to vocational self-determination in relation to external expectations, within the Ecuadorian context. This dimension does not appear in most self-regulation instruments built in Europe and North America and may reflect a culturally specific element of self-regulation.

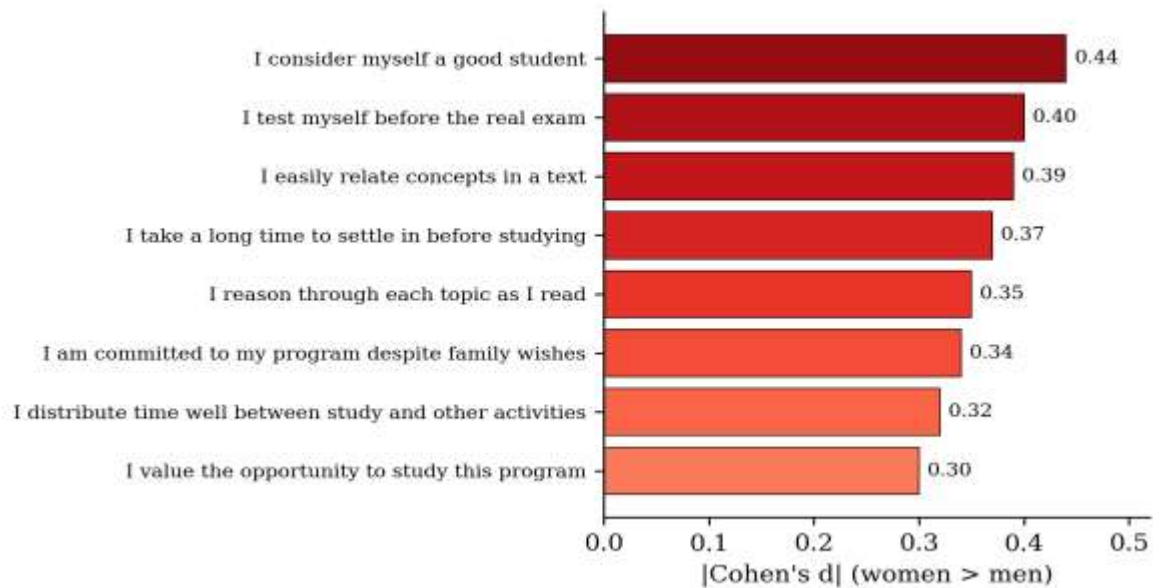


Figure 4. Items with the largest gender differences, ordered by effect size. Bars show absolute Cohen's d; all differences favor women and are significant at $p \leq .002$. Item wording is abbreviated.

All group differences are shown in terms of the size and accuracy of the differences in Figure 5. The confidence interval for gender did not contain the null value of zero for any dimension, while the confidence interval for the area effect on MSE did contain zero, reinforcing the general impression that gender was a stronger source of variance and that the area effect occurred only for cognitive processing.

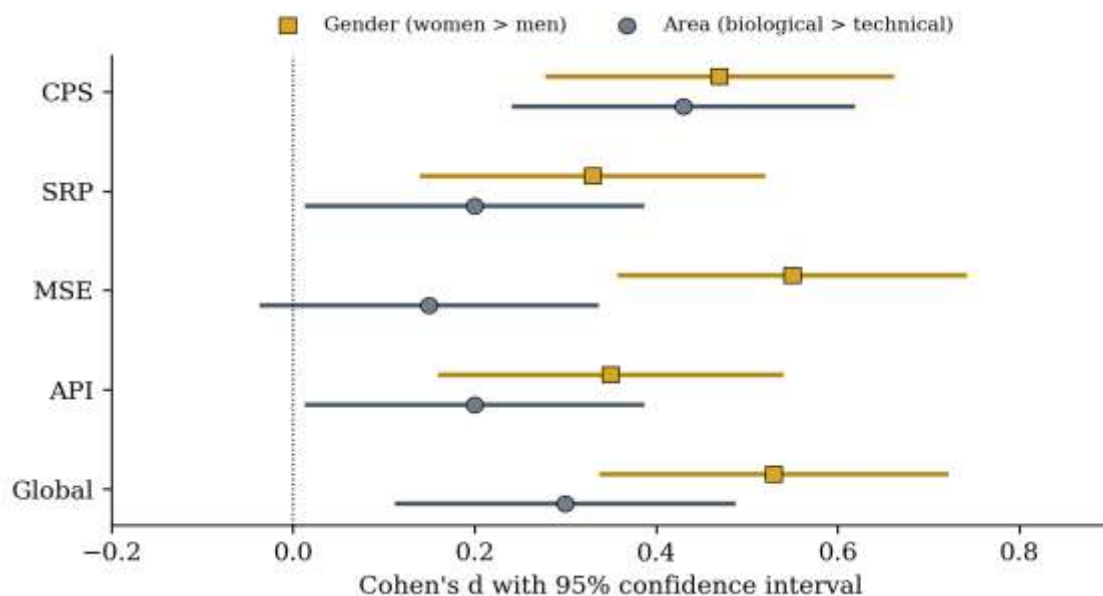


Figure 5. Effect sizes (Cohen's d) with 95% confidence intervals for gender and area-of-study comparisons. Positive values indicate higher scores among women or in the biological area. Intervals were derived from group sizes. CPS = Cognitive and Processing Strategies; SRP = Self-Regulation and Planning; MSE = Motivation and Self-Efficacy; API = Anxiety, Procrastination, and Interference.

The female advantage of the API dimension requires separate comment. This subscale involves factors related to exam anxiety, difficulty concentrating, distracting electronics, and procrastination; therefore, scores on this should be interpreted with the directionality of the specific item, so caution is advised due to low reliability. The observed effect ($d = 0.35$) mirrors to some degree the gender differences in perceived stress and anxiety that have been reported in a previous study by Müller et al. 2022, in particular women university students have lower perceived stress and anxiety, while a previous study reported by Limone et al. 2020, indicated lower procrastination among women. At any rate, the disparity is not large, but just moderate. In a more general sense, the gender gap observed is completely self-reported which means a portion could reflect differences in impression management rather than on gender differences in the behaviors observed. The female advantage reported here should thus not be interpreted as greater actual metacognitive competence, but rather as the use of metacognitive and self-regulatory behaviors that females more often report than males, assuming that greater reported use translates to greater actual competence, as in most designs that rely only on objective measures of competence. Another issue is the correlations between these self-reports and educational outcomes. Moraga-Pumarino et al. (2025) found no significant relationship between self-efficacy and academic achievement among Chilean business students, while Wu et al. (2020) found that higher self-efficacy was associated with greater academic performance, primarily through its effect on learning involvement. The fact that the present findings are in contrast gives reason to be careful about not drawing the blanket conclusion that higher self-reported self-regulation will result in better grades. The present investigation did not include performance data and therefore cannot determine whether the female advantage noted here reflects academic achievement; this issue could be explored further in studies that correlate questionnaire information with institutional academic records. Last but not least, the results have implications for academic support.

The present research extends the work on motivation, self-efficacy, and performance, as supported by Wu et al. (2020), by showing that the strength of motivation and self-efficacy is not homogeneous but varies qualitatively by discipline and gender. Academic support programs that aim to enhance students' self-regulation should therefore not be implemented in a generic fashion. It is important to take into account the gender and disciplinary foci of each program, with special attention to groups within a program that may have relatively lower self-efficacy measurements, such as women in technical areas in the sample. Across cultural dimensions, our research indicates that self-regulation programs can be successful (Rosário et al., 2015), can be implemented with only a few minutes of time-management training (Häfner et al., 2014), and that differentiation especially works when implemented at the intra-curricular and faculty levels (Simón-Grábalos et al., 2025).

4. Limitations and Scope for Future Research

The study has a few limitations and requires caution when interpreting the findings of this study. First, because this is a cross-sectional design, causal inferences about the relationships between gender, the area of study, and the self-regulation variables are not warranted; the patterns described are associative and may be affected by uncontrolled variables, including previous academic performance, socioeconomic status, type of secondary school attended, etc. Second, the self-report nature of the instrument only measures the student's self-assessment of his or her behavior and may therefore be subject to social desirability biases, and there may be systematic gender differences in these biases. Thirdly, two of four subscales (MSE and API) of the instrument did not reach conventional criteria, and the four-dimension structure was not confirmed factorially; results for these subscales, as well as the significant interaction for MSE, should be interpreted with added care until further validated by instruments with higher internal consistency. Finally, the imbalance between men and women in the technical and biological domains (a true institutional reality and itself a relevant finding) undermines the likelihood of detecting interaction effects in sparsely populated cells, such as for women in the technical domain ($n = 61$). Fifth, the study was conducted on the biological area, which provided a single category of life science programs that included both basic and biomedical, and this study therefore was unable to assess whether there were similarities in the relationship between motivation and self-regulation across biomedical and basic life sciences. Lastly, the sample was drawn from a single Ecuadorian institution; therefore, generalization to other university contexts in Latin America should be done with caution. However, future research should take several approaches to address these limitations.

Longitudinal research approaches could allow one to determine whether differences in self-regulation in university studies would remain stable, increase, or decrease across the academic span. Observed behavior or objective academic performance could also be included with self-report to help differentiate between self-perceived and effective metacognitive competence. Measuring invariance over the lower-reliability subscales (confirmatory factor analysis and tests across two genders and across five areas of study) is a definite preference. An intervention perspective is also promising: Self-regulated learning programs have proved to be fruitful across the board, and

time-management training is also beneficial (Rosário et al., 2015; Häfner et al., 2014, 2014); it could be interesting to see whether these interventions have cross-cultural effects, by gender and disciplinary area, preferably within the framework of regular course content (Simon-Grábalos et al., 2025). Further research in L1 contexts may also systematically measure vocational autonomy from family influence, as such variables might capture a culturally specific aspect of self-regulation. Finally, a similar factorial analysis could be performed with other universities in the region to determine whether the sex $\times$ area interaction effect observed here is a regularity across the region or specific to the university context investigated.

Conclusion

Based on the outcomes, this study yields three conclusions. Female students in the sample consistently reported higher use of cognitive and self-regulatory strategies and higher motivation and self-efficacy levels than did male students, with small-to-moderate effect sizes on each dimension for each task assessed. Second, as with most areas of study, technical or biological, these differences are not simply additive; there are qualitative differences in the relationship of the area of study to the difference of gender across dimensions. The effect of area on cognitive strategies, self-regulation, and anxiety is independent of gender, but the combined effects of area and gender exist in the combined domain of motivation and self-efficacy, where the gender difference is greatest in the biological area and least in the technical area. Third, the item-level analysis indicates that the female advantage is found not in the surface, but in a facet of vocational self-determination (SES, family pressure) and in metacognitive behaviors. The findings are relevant to the design of higher education institutions' tutoring or academic support programs with mixed classes in technical or biological programs. The results highlight the importance of providing targeted support to women in technical programs, where they are underrepresented and may feel less confident than other students in the biological field. They also provide the following guidelines for strengthening self-regulation programs: The program includes an explicit metacognitive component, in which metacognitive behaviors make up a large part of the gender difference discovered and are highly correlated with effective learning in both the biological and technical disciplines. A first step toward more intelligent and effective support for first-year university students is recognizing a gender difference in self-regulated learning, contextualized by discipline.

References

1. Alonso, M. T., Barba-Sánchez, V., López Bonal, M. T., & Macià, H. (2021). Two perspectives on the gender gap in computer engineering: From secondary school to higher education. *Sustainability*, 13(18), 10445. <https://doi.org/10.3390/su131810445>
2. Biwer, F., Taban, G., & de Bruin, A. (2025). How undergraduate engineering students regulate their learning: A qualitative comparison between different strategy users. *European Journal of Engineering Education*, 50(4), 744–763. <https://doi.org/10.1080/03043797.2025.2458117>
3. Demirören, M., Turan, S., & Öztuna, D. (2016). Medical students' self-efficacy in problem-based learning and its relationship with self-regulated learning. *Medical Education Online*, 21(1), 30049. <https://doi.org/10.3402/meo.v21.30049>
4. García-Ripa, M., Sánchez-García, M. y Rísquez, A. (2016). Estrategias de Aprendizaje y Autorregulación motivacional. Identificación de perfiles para la orientación de estudiantes universitarios de nuevo ingreso. *Revista Iberoamericana de Diagnóstico y Evaluación*, 41(1), 39-57. <https://aidep-aidap.org/revista/0041/RIDEP041-Art04.pdf>
5. Häfner, A., Oberst, V., & Stock, A. (2014). Avoiding procrastination through time management: An experimental intervention study. *Educational Studies*, 40(3), 352–360. <https://doi.org/10.1080/03055698.2014.899487>
6. Häfner, A., Stock, A., Pinneker, L., & Ströhle, S. (2014). Stress prevention through a time management training intervention: An experimental study. *Educational Psychology*, 34(3), 403–416. <https://doi.org/10.1080/01443410.2013.785065>
7. Hardtke, M., Khanjaninejad, L., Lang, C., & Nasiri, N. (2023). Gender complexity and experience of women undergraduate students within the engineering domain. *Sustainability*, 15(1), 467. <https://doi.org/10.3390/su15010467>
8. Limone, P., Sinatra, M., Ceglie, F., & Monacis, L. (2020). Examining procrastination among university students through the lens of the self-regulated learning model. *Behavioral Sciences*, 10(12), 184. <https://doi.org/10.3390/bs10120184>

9. Moraga-Pumarino, A., Salvo-Garrido, S., & Ortiz-Cea, V. (2025). Gender, self-efficacy, and academic performance: Evidence in business education program. *Behavioral Sciences*, 15(5), 563. <https://doi.org/10.3390/bs15050563>
10. Müller, C., El-Ansari, K., & El Ansari, W. (2022). Cross-sectional analysis of mental health among university students: Do sex and academic level matter? *International Journal of Environmental Research and Public Health*, 19(19), 12670. <https://doi.org/10.3390/ijerph191912670>
11. Pajares, F. (2002). Gender and perceived self-efficacy in self-regulated learning. *Theory Into Practice*, 41(2), 116–125. https://doi.org/10.1207/s15430421tip4102_8
12. Ribeirinha, T., Baptista, M., & Correia, M. (2024). Investigating the impact of STEM inquiry-based learning activities on secondary school student's STEM career interests: A gender-based analysis using the social cognitive career framework. *Education Sciences*, 14(10), 1037. <https://doi.org/10.3390/educsci14101037>
13. Rosário, P., Núñez, J. C., Trigo, L., Guimarães, C., Fernández, E., Cerezo, R., . . . Figueiredo, M. (2015). Transcultural analysis of the effectiveness of a program to promote self-regulated learning in Mozambique, Chile, Portugal, and Spain. *Higher Education Research & Development*, 34(1), 173–187. <https://doi.org/10.1080/07294360.2014.935932>
14. Schunk, D. H. (1991). Self-efficacy and academic motivation. *Educational Psychologist*, 26(3–4), 207–231. <https://doi.org/10.1080/00461520.1991.9653133>
15. Simón-Grábalos, D., Fonseca, D., Aláez, M., Romero-Yesa, S., & Fresneda-Portillo, C. (2025). Systematic review of the literature on interventions to improve self-regulation of learning in first-year university students. *Education Sciences*, 15(3), 372. <https://doi.org/10.3390/educsci15030372>
16. Turan, S., Demirel, Ö., & Sayek, İ. (2009). Metacognitive awareness and self-regulated learning skills of medical students in different medical curricula. *Medical Teacher*, 31(10), e477–e483. <https://doi.org/10.3109/01421590903193521>
17. Vera-Gajardo, A. (2021). Belonging and masculinities: Proposal of a conceptual framework to study the reasons behind the gender gap in engineering. *Sustainability*, 13(20), 11157. <https://doi.org/10.3390/su132011157>
18. Virtanen, P., & Nevgi, A. (2010). Disciplinary and gender differences among higher education students in self-regulated learning strategies. *Educational Psychology*, 30(3), 323–347. <https://doi.org/10.1080/01443411003606391>
19. Wolters, C. A. (2003). Regulation of motivation: Evaluating an underemphasized aspect of self-regulated learning. *Educational Psychologist*, 38(4), 189–205. https://doi.org/10.1207/S15326985EP3804_1
20. Wu, H., Li, S., Zheng, J., & Guo, J. (2020). Medical students' motivation and academic performance: The mediating roles of self-efficacy and learning engagement. *Medical Education Online*, 25(1), 1742964. <https://doi.org/10.1080/10872981.2020.1742964>
21. Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice*, 41(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2