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# Adaptive Individual Differences in Math Courses

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**Abstract:** A higher education that can be defined as sustainable ensures the acquisition of competencies that are necessary to address the current and future needs of the society in which it exists. Because math competencies are an essential component of college students' academic and professional success, poor performance outcomes are particularly problematic in the context of an education that aims to be sustainable. This research sought to identify dispositions that are predictive of math performance in the post-pandemic world to develop an early detection system for at-risk students of an understudied population (college students of Middle Eastern descent from Saudi Arabia). It specifically targeted female and male students in STEM or non-STEM majors who were enrolled in a math course of the general education curriculum. During the second semester of a return to entirely face-to-face instruction, their self-efficacy, math learning anxiety, math evaluation anxiety, and preference for morning or evening study activities were surveyed. In the post-pandemic world of this understudied population, the math performance of STEM male and female students was hurt by concerns about learning math. The math performance of non-STEM male students benefited from self-efficacy, whereas that of non-STEM female students was unaffected by any of the dispositions surveyed in the present investigation. These findings suggest that individual difference measures can inform early interventions intended to address performance deficiencies in selected groups of students with the overreaching goal of ensuring a sustainable education for all.

**Keywords:** math learning; STEM; sex; Middle East; Saudi Arabia



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## 1. Introduction

At its core, the term *sustainability* refers to the ability of a system, such as higher education, to exist over time by addressing the current and future needs of the society that it serves [1]. Within this framework, higher education institutions are entrusted with the role of fostering the development of competencies that will enable their students to cope with the demands of the society to which they belong [2]. It follows that to be sustainable, higher education is, by definition, one that fosters quality in computational literacy [3], for obvious reasons, spanning from grand to basic. Substantial problems in the world, such as climate change, pollution, breakdown of existing ecosystems, population crisis, etc., require individuals with basic computational literacy to understand problems and offer feasible solutions. More modestly, math is used in a variety of ordinary activities at home (e.g., management of personal finances) and at work, where quantitative skills are required by a large number of jobs.

In the general education curriculum of a university or college, math courses provide students with the fundamental computational knowledge and skills necessary to pursue careers in a variety of fields under the STEM denomination (science, technology, engineering, and math), as well as non-STEM fields (e.g., business, law, etc.). According to the extant literature, the use of the online medium for teaching and learning, demanded by

the recent COVID-19 pandemic, changed students' study habits (e.g., encouraged a more continuous effort; [4]), forced educators to review and update their study materials as well as instructional methods, and led to fruitful cooperation between administrators and faculty to find ways to optimally adapt to the online delivery medium [5–8]. As a result, comparisons of students' performance before the pandemic (face-to-face instruction) and during the pandemic (online instruction) have often yielded evidence of performance in the online classroom equal to or higher than that of the face-to-face classroom [4,8–10]. The present study is concerned with students returning to face-to-face math instruction in a post-pandemic world after having experienced almost two years of entirely online instruction. It seeks to identify individual differences in students' dispositions that at the outset of face-to-face math courses can influence their adaptation to the demands of such courses and, thus, shape academic success above and beyond initial math competency. It focuses on an understudied population of bilingual college students of Middle Eastern descent from Saudi Arabia who were enrolled in math courses of the general education curriculum taught in English. The underlying motive is to develop an effective prediction system for at-risk students in math courses that can be used by counselors and instructors to identify clusters of students who may benefit from specific targeted interventions at the outset of such courses. To this end, adaptive dispositions are herein defined as those that predict satisfactory math performance [11,12], whereas maladaptive dispositions are those that predict the opposite outcome. The choice of dispositions is guided by the findings of the extant literature, mostly from the Western pre-pandemic world, and, whenever available, by the evidence of the few studies that have targeted the selected student population. Whether the dispositions chosen for the present research foster a reliable roadmap for performance predictions in a sample of such students is the matter to be investigated.

## 2. The Selected Dispositions

One of the enemies of desirable performance in math is anxiety, a state of anticipatory apprehension over potentially deleterious outcomes [13]. Its inflated physiological arousal [14] and negative cognitions [15] lead to avoidance behavior and other unhealthy responses (e.g., cheating), which then translate into substandard performance [16–18]. Hopko et al. [19] and Schillinger et al. [20] have identified two separate sources of math anxiety whose relative intensity may uniquely define particular students and thus inform interventions focused on reduction: learning, which refers to situations in which mathematical content has to be acquired, and evaluation, which refers to situations in which performance is assessed. Consider, for instance, a student who, at the start of a math course, is overly concerned about testing (i.e., evaluation anxiety). Attention to the endpoint of activities involved in the acquisition of knowledge and skills is likely to introduce distraction into the learning process in the form of apprehensive thinking, thereby reducing the effort that the student exerts on such activities, as well as devaluing the utility of the knowledge and skills to be acquired. The student's responses may include seeking ways to reduce physiological arousal and avoiding disrupting thoughts during exams, which are in essence healthy responses. However, unhealthy responses may be contemplated too, such as cheating, shopping for purported "easy" instructors, and avoiding math courses until the very end. On the other hand, consider a student who, at the start of a math course, is overly concerned about being able to acquire the knowledge and skills that the course demands (i.e., learning anxiety). Attention to the process of learning gives the student more opportunities to express healthy responses, such as enhancing attention and effort to course activities and requesting tutoring. Namely, a student's responses to learning anxiety have a greater chance to lead to improved math performance than his/her responses to evaluation anxiety if they are properly identified and corrective actions are undertaken. As such, knowing a student's relative levels of learning and evaluation anxiety can inform interventions at the outset of a math course intended to promote healthy responses.

If left unchecked, math anxiety is known to be negatively related to attainment in math. However, evidence of a link between math anxiety and performance is not always robust

or clear-cut. For instance, correlations vary in size from null and small to moderate [21–24]. They tend to be greater in females than males [24,25], but not always [26,27]. For instance, Ma [28] and Zhang et al. [29] found no gender differences in the correlation between math anxiety and math performance. Instead, Devine et al. [30] reported math anxiety to be a significant predictor of performance in females but not males, whereas Miller and Bichsel [31] found that math anxiety was more predictive of basic math performance in males than in females. Concerning the magnitude of the anxiety experienced by students, the findings are also mixed, including greater levels of math anxiety in females than in males [32,33], in males than in females [34], or no gender differences [35]. Interestingly, Hembree [22] reported that although math anxiety was higher in female students, it did not predict their math performance. It did predict math performance in male students though.

The prevailing finding when the two key dimensions of math anxiety (learning and evaluation) are considered is a moderate negative relationship between math performance and either math learning anxiety or evaluation anxiety [36,37]. Yet, it is unclear whether these relationships might be replicated in student populations other than those assessed, such as Saudi students returning to face-to-face instruction, and whether gender or college major differences exist. An exception to the scarcity of findings from the Middle East is a pre-pandemic study conducted in Iran by Vahedi and Farrokhi [38] who found that math evaluation anxiety is greater in male students than female students, but reported no difference in learning math anxiety.

Poor self-efficacy is another potential enemy of desirable performance in math. Self-efficacy refers to a student's subjective judgment of his/her ability to overcome challenges and complete tasks [39]. A key aspect of this judgment is the belief that one can exercise control over potential challenges, such as those offered by a math class, thereby deflating apprehensive cognitions, reducing elevated physiological arousal, and curtailing undesirable behaviors (e.g., avoidance of math; [13]). Findings regarding the magnitude of self-efficacy beliefs in male and female students in different majors are mixed. For instance, in a Western sample, Sobieraj and Krämer [40] reported lower self-efficacy in female than male students but no differences between STEM and non-STEM students. In the Middle East (Saudi Arabia), Pilotti et al. [10] found that self-efficacy did not differ by gender or major.

Findings remain mixed if the relationship between self-efficacy and math attainment is considered. In Europe, Klug et al. [41], Roick and Ringeisen [42], as well as Stephanou and Tsoni [43] found self-efficacy to predict math performance. In the Middle East, Pilotti et al. [10] found that the relationship between self-efficacy and math performance was sensitive to demographic variables, such as gender or major. Namely, they reported a positive relationship between self-efficacy and math course grades in female STEM students, and self-efficacy and test math grades in male STEM students. In contrast, non-STEM students, irrespective of their gender, failed to display the expected relationship.

Inconsistent findings warrant further examination not only of the relationship between self-efficacy and math achievement but also of chronotype. Although preferences for morning and evening activities have been often reported to predict academic attainment broadly defined, whether such a relationship is limited to selected groups of students or disciplines is unclear. In Europe, Preckel et al. [44] and Gomes et al. [45] found eveningness to be associated with lower academic performance. In Africa, Mirghani [46] also found the same relationship. Women have been reported to display a stronger inclination towards morningness than men (Adan and Natale [47], Roenneberg et al. [48], and Mirghani et al. [49]). However, BaHammam et al. [50] and Pilotti et al. [10] found that Saudi college students had no distinctive preference for morningness or eveningness, a finding that is replicated in other parts of the world [51,52].

Concerning science-related fields, morning preferences have been reported to predict performance in STEM disciplines [53], only predict male students' performance in such disciplines [54], or be uncorrelated [55]. In Europe, Vollmer et al. [56] reported morning preferences to be linked to higher math performance after controlling for gender. In the Middle East, however, Pilotti et al. [10] found a positive relationship between preference

for morning activities and either math course grades or test grades in STEM male students. A null outcome was observed in STEM female students and non-STEM students.

### 3. The Present Study

The present study focuses on an understudied student population of male and female students of Middle Eastern descent from Saudi Arabia who have chosen a STEM major, such as engineering and computer science, or a non-STEM major, such as business and law. It is important to note that the definition of STEM education is often unclear [57,58]. The selected institution conceives of STEM education as an instructional approach that integrates contents and competencies specific to science, technology, engineering, and mathematics [57]. It complies with the view [2] that “STEM teaching and learning focuses on authentic content and problems, using hands-on, technological tools, equipment, and procedures in innovative ways to help solve human wants and needs.” (p. 60). Thus, at the selected institution, STEM teaching and learning emphasizes competencies that aim at combining theory and practice and solving problems [59]. Accordingly, STEM education is defined by three essential components: conceptual knowledge, operational or procedural knowledge, and problem-solving knowledge.

The choice of gender and major is based on prior research that has shown such demographic variables to differentiate students [9,10,60]. Gender is judged to be relevant as it refers to students who were born into a society defined by a strict patriarchal order, which is now redefining itself as one aiming at gender equity and meritocracy in education and employment [61–63]. For women, the promotion of gender equity through decrees and financial investments means a degree of freedom in decision making that many of them, their mothers, and grandmothers have long desired. For men, instead, the promotion of gender equity in education and employment entails the removal of privileges to which they had been entitled since birth. In such a society, the choice of a career, especially a STEM career, tends to clash with traditional gender stereotypes, making females’ enrollment and persistence in STEM fields challenging [60,64,65].

Our study exists in the context of a society promoting gender equity and STEM careers for women, which started in the pre-pandemic era and has continued unabated ever since. First, it aims to determine whether dispositions, such as self-efficacy, learning math anxiety, math evaluation anxiety, and preference for morning or evening activities (chronotype), differentiate students who are sorted by gender and major (STEM and non-STEM). Then, the study aims to assess the extent to which dispositions in each demographic group may predict math performance at the end of the semester.

The dispositions selected for the present investigation are assumed to be rather stable across time. As such, the findings of the extant literature, encompassing before, during, and at the tail-end of the pandemic, are relied upon to offer a roadmap for predicting the magnitude of the selected dispositions and their relationship with math performance. Yet, the study is guided by the assumption that an effective prediction system needs a recurrent assessment of its components to remain effective, especially in times of change. Furthermore, we recognize that the available findings are not always clear-cut and often pertain to student populations other than those of the Middle East. Thus, our predictions may, at times, entail logical extrapolations from the available findings.

Concerning math anxiety (a maladaptive dimension), we predict a moderate negative relationship between math performance and either math learning anxiety or evaluation anxiety [36,37]. However, if the magnitude of prior exposure to math (i.e., familiarity) that differentiates STEM and non-STEM programs matters [66], STEM students will exhibit less overall math anxiety. Furthermore, there may be differences in the type of anxiety that prevails in each group. For instance, the expected greater coverage of math in STEM programs may make learning anxiety more relevant to math performance in STEM students, whereas examination anxiety may be more relevant to math performance of non-STEM students. These patterns may be diluted in female students as the pressure to succeed

in Saudi society may be both greater and more novel for women, thereby creating more opportunities for both types of anxiety to be experienced.

Predictions concerning self-efficacy (an adaptive dimension) are guided by the findings of Pilotti et al. [10] regarding the magnitude of self-efficacy in Saudi students and its relationship with math attainment. Thus, although no gender or college major differences in the sheer magnitude of self-efficacy beliefs of Saudi students may emerge, we expect differences in the relationship between such beliefs and math performance. Specifically, we predict that if self-efficacy is conceptualized as a tool to counteract traditional gender stereotypes in fields that are still predominantly male-dominated, self-efficacy beliefs will be particularly beneficial to the math performance of STEM female students.

In addition to math anxiety and self-efficacy beliefs, chronotype may also matter as it is commonly used as an index of engagement in academic activities, thereby serving as an adaptive dimension. Due to the high temperatures often experienced during the daytime in Saudi Arabia, entertainment is often relegated to the evening and night, which is likely to conflict with early diurnal academic demands. Although we do not anticipate Saudi college students to display a stark preference for either morningness or eveningness [10,50] but fall into the intermediate category, we expect math performance to increase with a preference for morning activities if indeed chronotype indexes academic engagement. However, the positive relationship between morningness and math attainment may pertain preferentially to male students who are more likely than female students to routinely go out at night. Pilotti et al. [10] found that this relationship was exhibited by STEM male students, but not by non-STEM male students, probably due to the heavier demands that math courses place on STEM students.

## 4. Method

### 4.1. Participants

The participants were 666 students who were enrolled in one of the math courses of the general education curriculum of a Saudi university conforming to a U.S. curriculum and pedagogy. Participants were 475 females and 191 males. A broad variety of math courses were selected to include both STEM majors ( $n = 419$ ) and non-STEM majors ( $n = 247$ ), and all educational levels: Intermediate Algebra ( $n = 67$ ), Pre-Calculus ( $n = 65$ ), Finite Mathematics for non-STEM majors ( $n = 50$ ), Calculus for non-STEM majors ( $n = 94$ ), Statistical Methods and Probability ( $n = 121$ ), Calculus I ( $n = 31$ ), Calculus II ( $n = 64$ ), Calculus III ( $n = 104$ ), and Linear Algebra and Differential Equations ( $n = 70$ ). Classes were taught in the morning or early afternoon.

Students' age ranged from 18 to 36 ( $M = 20.50$ ), which reflected the existing enrollment trend at the selected university. Participants encompassed all educational levels: 45.95% freshmen, 37.39% sophomores, 12.91% juniors, and 3.75% seniors. Students were Arabic-English bilingual speakers. Adequate English competency (including speaking, reading, and writing) had been assessed prior to their enrolling in any of the general education courses included in our investigation.

### 4.2. Materials and Procedure

For all courses offered by the selected university, math instruction was delivered in English by faculty with degrees in the field of mathematics and at least 5 years of teaching experience in higher education. A student-centered pedagogy intended to foster active learning was required for instruction. Eight math instructors who were contacted at the start of the semester made their classes available to the researchers. During the second part of the semester, students were asked to complete three questionnaires posted online: the self-efficacy scale of Chen et al. [39], the Abbreviated Math Anxiety Scale (AMAS) of Hopko et al. [19], and the composite scale of morningness developed by Smith et al. [67]. Participants gave their consent before filling out the questionnaires. The percentage of students who participated was 80.05% (666 out of 832).

The self-efficacy scale of Chen et al. [39] assessed students' confidence in their abilities to complete tasks and overcome challenges. Students rated eight generic statements of self-confidence (e.g., "When facing difficult tasks, I am certain that I will accomplish them") on a continuum from strongly disagree (−2) to strongly agree (+2). A general self-efficacy scale as opposed to one focused on math was intended to gather information about students' abilities uncontaminated by social desirability confounders regarding the perception of math in STEM and non-STEM fields. Its internal consistency, as measured by Cronbach's alpha, was 0.93.

The AMAS contained 9 items describing situations in which students encounter mathematics [19]. Students rated how anxious they would feel in each situation on a continuum from strongly disagree (−2) to strongly agree (+2). They addressed two dimensions of math anxiety: learning math anxiety (LMA), as measured by items that described situations in which mathematical content had to be learned, and math evaluation anxiety (MEA), as measured by items that described situations in which performance in mathematics had to be evaluated. Cronbach's alpha of the LMA sub-scale was 0.75 and that of the MEA sub-scale was 0.72.

The composite scale of morningness [67] assessed individual differences in chronotype. Students reported the extent to which its 13 items applied to them, producing a range of scores from 13 to 55. A score equal to 22 or lower pointed to a preference for evening activities, a score between 23 and 43 was considered intermediate (i.e., no stark preference for being either a lark or an owl), and a score of 44 or higher defined a preference for morning activities. Cronbach's alpha was 0.82. To ensure a higher congruency with the descriptive statistics of the other measures, scores were translated into proportions. Thus, a preference for evening activities was indexed by a value of 0.40 or less, a preference for morning activities was indexed by a value of 0.80 or higher, and values between 0.41 and 0.79 represented the intermediate category.

The study was conducted under the purview of the Deanship of Research to conform to the guidelines for educational research of the Office for Human Research Protections of the U.S. Department of Health and Human Services as well as those of the American Psychological Association's ethical standards. As such, informed consent was obtained before participation. To protect participants' identities, no identifying information appeared on data files after all information was collected and shared with individual students. At the end of the semester (during debriefing), to foster self-awareness of individual dispositions and thus ensure a benefit to participants, students were given the opportunity to examine and reflect on their scores. Information regarding students' reactions and comments (all anonymized except for gender and major) was used to inform the interpretation of the results of quantitative analyses.

## 5. Results

The results described below are organized by the question they intend to answer. Results of inferential statistics are deemed significant at the 0.05 level. Group differences are examined via analysis of variance (ANOVA). In each of the identified groups, the contribution of dispositions to course performance is examined through linear regression. The variable "educational level" is not included in the analyses discussed below, since it failed to contribute to the patterns produced by gender and major.

### 5.1. Do Major and Gender Differentiate Students' Dispositions and Math Performance?

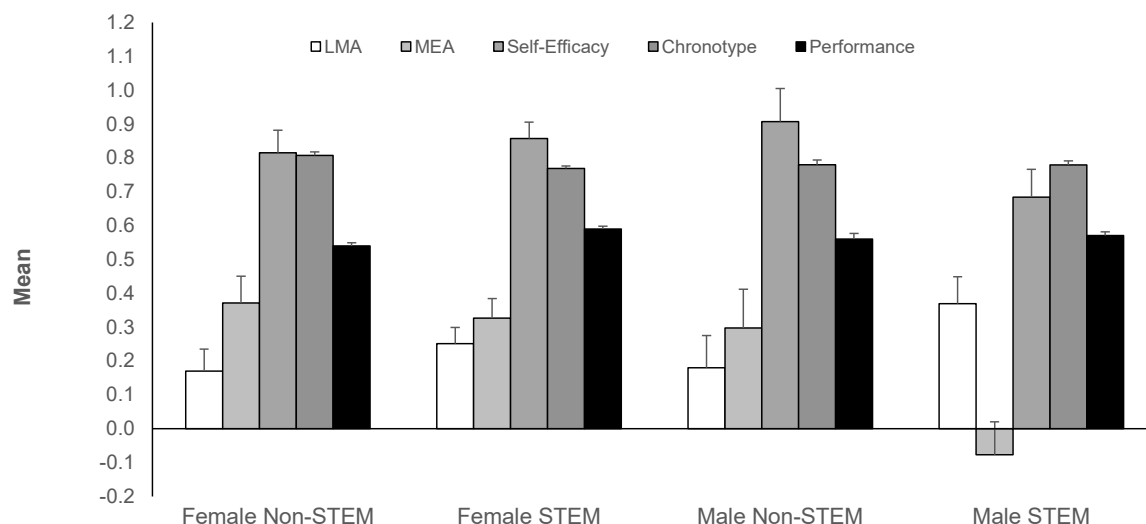
At the end of the semester, letter grades were made available by the instructors. Each letter grade was given a numerical value by taking the middle of the range the grade covered on a continuum from 0 to 1 (A+ = 0.980; A = 0.925; B+ = 0.875; B = 0.825; C+ = 0.775; C = 0.725; D+ = 0.675; D = 0.625; F = 0.590). A two-way between-subjects ANOVA was carried out with self-efficacy, LMA, MEA, chronotype, and performance as the dependent variables, and major (STEM or non-STEM) and gender (female and male) as the independent variables.

The analyses yielded a gender difference in math evaluation anxiety ( $F(1, 661) = 7.02$ ,  $MSE = 1.043$ ,  $p = 0.008$ ,  $\eta p^2 = 0.011$ ), illustrating greater evaluation concerns for female students (+0.35) than male students (+0.11). STEM students also experienced less evaluation anxiety (+0.13) than non-STEM students (+0.34;  $F(1, 661) = 5.45$ ,  $MSE = 1.043$ ,  $p = 0.020$ ,  $\eta p^2 = 0.008$ ), and were more morning oriented (0.58 and 0.55, respectively;  $F(1, 661) = 10.01$ ,  $MSE = 0.015$ ,  $p = 0.002$ ,  $\eta p^2 = 0.015$ ). Neither other effects nor interactions were found to reach significance [ $F_s \leq 3.37$ , *ns*]. Table 1 illustrates the descriptive statistics of four groups of students defined by gender and major.

**Table 1.** Descriptive statistics of participants classified by gender and major.

Variables	Female Non-STEM	Female STEM	Male Non-STEM	Male STEM
LMA (−2→2)	+0.17 (0.065)	+0.25 (0.048)	+0.18 (0.095)	+0.37 (0.080)
MEA (−2→2)	+0.037 (0.079)	+0.33 (0.058)	+0.30 (0.115)	−0.08 (0.097)
Self-efficacy (−2→2)	0.82 (0.067)	0.86 (0.049)	0.91 (0.098)	0.68 (0.082)
Chronotype	0.54 (0.010)	0.59 (0.007)	0.56 (0.014)	0.57 (0.012)
Performance	0.81 (0.010)	0.77 (0.007)	0.78 (0.015)	0.78 (0.012)

Although the interaction of gender and major failed to reach significance for math evaluation anxiety ( $F = 3.37$ ,  $p = 0.067$ ), the significant gender difference that emerged from the analysis was largely driven by STEM male students who showed no evidence of evaluation anxiety (−0.08) compared to the other groups who did (non-STEM females: +0.37; STEM females: +0.33; non-STEM males: +0.30). Not surprisingly, these groups showed no difference between concerns about learning and concerns about evaluation ( $t_s \leq 1.72$ , *ns*). STEM male students were the only ones who showed concerns about learning, but not about evaluation ( $t(111) = 3.80$ ,  $p < 0.001$ ). It is important to keep in mind that differences in dispositions did not correspond to differences in math performance ( $F_s \leq 2.89$ , *ns*). Figure 1 offers a visual analog for the values exhibited by each group of students in Table 1.



**Figure 1.** Descriptive statistics of selected dimensions and performance by gender and major.

### 5.2. Do Dispositions in Each Student Group Predict Math Performance?

A linear regression analysis with dispositions as the predictors and performance as the outcome variable was conducted in each group to identify dispositions that could predict performance (see Table 2). For female and male students in STEM majors, concerns about learning negatively impacted their course performance. In non-STEM majors, self-efficacy benefited the course performance of male students, whereas no dispositions predicted performance in female students.

**Table 2.** Dimensions as predictors of students' class performance.

Outcome Variables	B	SE	Beta	t	Sign.
<i>Non-STEM Female</i>					
Constant	0.849	0.041			
LMA	−0.017	0.011	−0.122	−1.545	<i>ns</i>
MEA	0.006	0.008	0.057	0.726	<i>ns</i>
Self-Efficacy	0.005	0.010	0.036	0.468	<i>ns</i>
Chronotype	−0.082	0.072	−0.088	−1.138	<i>ns</i>
<i>STEM Female</i>					
Constant	0.715	0.038			
LMA *	−0.029	0.009	−0.179	−3.153	0.002
MEA	−0.001	0.008	−0.005	−0.082	<i>ns</i>
Self-Efficacy	0.006	0.009	0.040	0.700	<i>ns</i>
Chronotype	0.095	0.063	0.086	1.514	<i>ns</i>
<i>Non-STEM Male</i>					
Constant	0.791	0.076			
LMA	−0.025	0.019	−0.150	−1.312	<i>ns</i>
MEA	0.022	0.016	0.153	1.349	<i>ns</i>
Self-Efficacy *	0.055	0.021	0.287	2.550	0.013
Chronotype	−0.113	0.134	−0.096	−0.846	<i>ns</i>
<i>STEM Male</i>					
Constant	0.733	0.054			
LMA *	−0.035	0.013	−0.259	−2.753	0.007
MEA	0.012	0.013	0.085	0.917	<i>ns</i>
Self-Efficacy	0.010	0.013	0.067	0.720	<i>ns</i>
Chronotype	0.093	0.089	0.098	1.046	<i>ns</i>

Note: Non-STEM females:  $R = 0.176$ ; STEM Females:  $R = 0.205$ ; Non-STEM males:  $R = 0.386$ ; STEM males:  $R = 0.317$ .  
\* signifies dimensions that made a significant contribution to the outcome variable (i.e., course performance).

## 6. Discussion

In the present study, the dispositions of four groups of Middle Eastern college students from Saudi Arabia defined by their gender and major were examined. Its findings can be organized into four main points. First, as a whole, math examination anxiety was greater in female students than male students and in non-STEM students than STEM students. Interestingly, male students in STEM majors were the only ones to experience no evaluation anxiety, but some learning anxiety. The other groups experienced both learning anxiety and evaluation anxiety without noticeable differences between the two. Thus, except for males in STEM majors, these findings replicate those of Baya'a [32], and Betz [33], who reported greater levels of math anxiety in female students, and of Leppma and Darrah [68], who found higher scores in non-STEM majors.

Interestingly, in our study, the unique emotional pattern of males in STEM majors did not correspond to differences in math performance among student groups. In the introduction, we predicted that learning anxiety may have adaptive features that can lead students to enhance their exerted effort and potentially improve performance. No evidence supportive of this prediction was uncovered in STEM students, that is, in learners whose math competencies are key to their major. These findings are consistent with those of Jamieson et al. [37] who also reported that learning anxiety makes a negative contribution to math performance. However, Jamieson et al. [37] also found an equivalent negative contribution of evaluation anxiety to math performance, whereas we did not. Our students' informal comments, collected during debriefings, indicated that a rationalization might have been at work. Namely, the presence of learning anxiety without evaluation anxiety in STEM male students might result from their rational decoupling concerns about learning and testing, grounded on the realization that testing depends on learning. Instead, the other student groups appeared to mash together the two types of anxiety.

Another way to conceptualize these uneven patterns of concerns is to assume that, during learning, students suffered from demand appraisal, which arises from one's esti-



mation of the effort demanded by a given situation that fosters a sense of vulnerability and uncertainty [69] and impairs performance [37]. However, there was no evidence that, during testing, STEM male students benefitted from resource appraisal, which refers to a sense of ability, knowledge, and familiarity to cope with testing [70]. Resource appraisal is linked to enhanced math performance. Although STEM male students did not show evidence of evaluation anxiety, their performance was statistically equivalent to that of the other groups.

Second, although group differences in evaluation anxiety were detected, they were not predictive of math performance. Instead, two variables that did not differentiate groups of students, learning math anxiety and self-efficacy, were found to be selectively linked to math performance, but in opposite directions. Specifically, learning anxiety was detrimental to math performance in both male and female STEM students. Self-efficacy was beneficial to math performance only in non-STEM male students. These findings suggest that the mere examination of the magnitude of a disposition across different groups of students may be misleading. Namely, there may be no evidence of differences in the magnitude of the disposition, but the disposition makes a preferential contribution to the performance of some students, but not to that of others.

Third, although there were no group differences in self-efficacy, only the math performance of non-STEM males benefited from it. All other groups showed a non-significant trend in the same direction. These findings are similar to those of Pilotti et al. [10], who reported that non-STEM students, irrespective of their gender, failed to display the expected relationship. However, in their study, there was a positive relationship between self-efficacy and math performance, as measured by course grades, in STEM female students. In STEM male students, self-efficacy only predicted final test math grades. The study of Pilotti et al. [10] was conducted during the first post-pandemic semester. Thus, the findings of the current study may illustrate longitudinal changes in the adjustment to fully face-to-face courses of students in STEM and non-STEM majors. In fact, students did not exhibit different levels of self-confidence, but they differed in the way their self-confidence was related to daily activities. Debriefings suggested that non-STEM students found the return to face-to-face courses particularly demanding (e.g., time-consuming commuting, breaks between classes to fill in new ways, more distractions, etc.). Non-STEM men were more likely to spontaneously relate their self-confidence to current academic activities, whereas non-STEM women related their self-confidence mostly to future activities (e.g., finding a job), thereby making it less likely to predict performance in their math class. STEM students, irrespective of their gender, treated the return to face-to-face courses as a welcome event that would benefit many aspects of their lives. Yet, they also pegged their self-confidence on future activities.

Fourth, as expected [10,50], Saudi college students did not display a stark preference for either morningness or eveningness but mostly fell into the intermediate category. Yet, the extent of students' preference for morning activities, albeit modest, was unrelated to their math performance, whereas Pilotti et al. [10] found math performance to increase with a preference for morning activities in STEM male students, but not in non-STEM male students, probably due to the heavier demands that math courses place on STEM students. The study of Pilotti et al. [10] was conducted on students facing the first post-pandemic semester of face-to-face instruction, whereas the current study involved students dealing with the second post-pandemic semester. We reasoned that in Saudi Arabia, entertainment is often relegated to the night, due to the high temperatures experienced during the daytime, and that men would be more likely to go out at night. It was then proposed that nightly entertainment is likely to conflict with early diurnal academic demands, especially with the heavy cognitive demands of STEM programs, thereby making males in STEM programs more susceptible to the benefits of morningness. However, during the second post-pandemic semester, the excitement of being able to go out freely might have subsided, thereby making chronotype less likely to continue to be related to the academic performance of STEM male students.

## 7. Conclusions

In sum, the findings of our study and those of the available literature suggest that a prediction system for at-risk students needs to be periodically validated, especially in times of change, through research that reassesses the relationship between adaptive and maladaptive dispositions and performance in students grouped into relevant demographic clusters (e.g., gender and college major). Then, based on the pattern of relationships between dispositions and performance, interventions can be developed to minimize the impact of maladaptive dispositions, and/or maximize the impact of adaptive dispositions that are tailored to students' particular characteristics and needs [18]. For instance, consider that contrary to lay beliefs, stress is not necessarily harmful to performance [71]. The nature of the appraisal of stress may determine its impact on performance by integrating physiological changes with the assessment of (a) the demands of the situation in which stress is perceived and (b) one's coping resources. Therefore, in the STEM students of our study, modifying the appraisal of the demands of learning and available coping resources could promote more adaptive responses during learning [37], and thus potentially improve math performance. Consider two students who are learning a complex math topic while experiencing equal levels of sympathetic arousal (i.e., "stress"). One believes that he/she has the resources (e.g., background knowledge, study time, tutoring, etc.) to meet the demands of learning that topic, whereas the other appraises the demands of learning as exceeding his/her available resources. The former will appraise learning as a challenge, whereas the latter will appraise it as a threat. Challenges tend to be associated with improved performance, whereas threat responses tend to be associated with poor performance [37]. Interestingly, changing a student's experience of feeling threatened to one of being challenged may require as little as the instructor informing students that the increased arousal felt during learning is not harmful, but rather has evolved to help human beings respond to demanding situations (e.g., faster heart rates improve the delivery of oxygen to the brain) and, as such, increased arousal can aid performance [72,73]. Similarly, the link between self-efficacy and performance can be strengthened by instructions that help students reappraise their self-confidence in a variety of practical contexts, including specific academic activities. Whether this type of reappraisal merely reinforces the link between self-efficacy and math performance in non-STEM male students or creates a beneficial link in the other student groups is a matter to be investigated.

It is important to note that our study reflects the broader context of the post-pandemic world, which is defined by the re-adjustment to face-to-face instruction of students, instructors, and administrators. Yet, the post-pandemic world does not entirely obliterate the changes brought about by the pandemic. Namely, the adaptation to the online medium for teaching and learning caused some changes in educational practices that are here to stay. The informal inquiries that preceded our study (all anonymized) gave us a window into the silver lining of the pandemic. For instance, educators admitted that the sudden transfer to the online medium forced them to review and update their course materials, fostered repeated self-examinations of instructional methods and their impact on students' engagement and performance, and facilitated productive collaborations with other educators as well as administrators and IT staff. The return to face-to-face instruction has renewed questions about course materials and teaching styles, thereby giving educators opportunities to solidify that sense of community and continuous engagement that grew during the pandemic. Concerning students, the pandemic led to an adjustment of their study habits by fostering a more distributed type of learning characterized by a continuous expenditure of effort [4,9]. Our informal inquiries are not entirely clear as to the persistence of these changes though. Students often admitted that distributed learning is ideal as it produces gains in performance and promotes self-confidence in mastering materials and tasks. They also often admitted that they have been both the beneficiaries and the observers of such outcomes. Yet, they acknowledged that the recognition of benefits has encountered a world full of old and new distractions that may limit the transfer of this useful habit to the post-pandemic world.

A key limitation of the present study is the identification of dispositions other than those selected for the present investigation that can shape math performance in non-STEM female students. Of course, such dispositions may also relate to performance in the other student groups. Furthermore, in the current study, we have focused on adaptive and maladaptive dispositions that we believe may contribute to math performance, under the assumption that they either facilitate or hurt students' adaptations to the demands of math courses, above and beyond existing math competency. Ramirez et al. [74] have argued that both dispositions that introduce distraction during learning and testing and pre-existing math competency contribute to students' performance in math courses, thereby acknowledging two views of math anxiety. In the anxiety-as-a-distraction view, anxiety is seen as causing a transient reduction in the cognitive resources available to students in working memory, a system whose functioning is needed for successful performance in math. Distraction may reflect students' focus on task-irrelevant cognitions (e.g., worries) whose processing takes away resources from task-relevant cognitions. In the reduced-competency view, math anxiety is conceptualized as the consequence of students' reduced math abilities, which leads students to avoid taking math classes, further missing opportunities to hone their math skills. Thus, a factor that remained unexplored in our study is pre-existing math competency due to data not being available. An additional limitation of our study is the use of convenience sampling for recruitment. In this context, the uneven sample of male and female students can be attributed to the consistently lower engagement in activities not directly linked to course grades of male students also found in earlier studies of the same student population [10]. In a society in transition from a patriarchal order to one aiming at gender equity, women are determined to explore the opportunities they have been granted recently, thereby being much more engaged than men [10]. As such, their participation in activities that are not directly linked to course evaluations tends to be much higher than that of men. Another limitation of our study is its reliance on self-reports. Even if confidentiality is offered, the use of self-reports makes the findings of our study dependent on the extent to which students were willing to share their views of themselves or, more simply, were aware of their internal motives. Lastly, it is important to remember that the students sampled in the present study are bilingual speakers who were learning math in their second language (English). Although English competency was assessed before they entered the general education program, the added burden of a second language may make the dispositions identified in the present investigation unique to students who are also bilingual. It is important to note though that evidence regarding the impact of second language processing in the extant literature is not clear-cut. For instance, the language in math texts is often reported as more complex than ordinary prose. It contains many unfamiliar symbols and graphs as well as novel words whose meanings may differ from those of everyday language [75]. Studies stressing this viewpoint have reported a link between higher math performance and learners' reliance on their first language [76]. In contrast, other studies have shown that students prefer to rely on English (i.e., their second language) in math courses and that their performance is adversely affected by time restrictions, thereby questioning the extent to which extraneous factors may shape outcomes above and beyond a student's prior use of a language [77,78].

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