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What Are Male and Female Students' Views of Science in a Society in Transition? A Self-Study of an Institution of Higher Education

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Abstract: Consensus exists among countries of the world that science literacy is necessary for sustainability. Instruction may emphasize comprehension of scientific contents as well as the use of scientific information to examine and understand life on earth, but students' interest in science is the base on which such instruction rests. In the present field research, we examined female and male college students' views of science education within their chosen major (*STEM* versus *non-STEM*). We specifically selected students whose socio-cultural context is that of a society in transition from a patriarchal model to one that fosters gender equity. A successive-independent-samples design was used to administer a simplified version of the RISC surveys to two clusters of students differing in educational experience: entry-level students (first and second year) and exit-level students (third and fourth year). Female and male students majoring in *STEM* or *non-STEM* disciplines at each level were targeted. Although there were no gender differences in major selection at the entry level, at the exit level, male students were more numerous in *STEM* than *non-STEM* majors. Only a few gender differences were recorded in students' views of science education within their *STEM* and *non-STEM* majors. At the exit level, opinions about majors were positive across the board. In the microcosm of an academic institution inside a society once defined by patriarchy, gender is now less of a distinctive professional marker for students receiving a college education. Because attitudes are often linked to behavior, these findings also demonstrate the usefulness of periodic institutional assessments of not only students' performances but also attitudes and preferences to determine the need for gender equity interventions.

Keywords: STEM; gender; views of science; academic level; social change

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1. Introduction

For quite a while, Saudi Arabia (SA) has been featured in the mainstream press and popular media as a rigidly gender-segregated social system characterized by separate spaces for men and women. Gender relations have been portrayed as defined by norms and regulations of self-determination and opportunities that favor men over women. In the last decade, a flurry of top-down decrees, declarations, and monetary investments have attempted to rectify the starkly uneven fields that women and men had to navigate since early life [1,2]. Thus, SA can now be described as a society in transition from a patriarchal system to one in which gender equity is considered a necessity [3–5].

The 2030 Vision [6,7], a programmatic list of goals that SA hopes to achieve, offers the written rationale for societal changes which rest on the realization that the economic engine of SA is to be restructured to ensure sustainability. Sustainability refers to development that meets "the needs of the present without compromising the ability of future generations to meet their own needs" [8] (p. 16). Restructuring entails diversifying the economy away from natural resources as well as transforming it into a knowledge-based, meritocratic apparatus. In a knowledge-based economy, education is largely repurposed to generate innovation [9]. As such, an educated and skilled population is needed to create, share, and use knowledge [9], thereby rendering science, technology, engineering, and mathematics (STEM) education a socio-economic priority. In recognition of this priority, in 2008, the Ministry of Education introduced new mathematics and science curricula with an emphasis on student-centered instruction, problem-solving and critical thinking [10]. The new curricula formally downgraded rote learning and teacher-centered instruction as pedagogical tools [11].

The enhancement of science curricula in SA reflects a global trend in the education sector that acknowledges the importance of a scientifically literate populace for sustaining life in the ever-evolving ecosystems of our planet. Not surprisingly, definitions of science literacy emphasize different aspects of active learning. They may underscore students' comprehension of concepts and principles, under the assumption that learning, especially in science, does not involve merely absorbing a static mass of knowledge. They may also highlight students' abilities to use scientific information to examine and solve practical problems [12,13]. All, however, recognize that science literacy relies on learners who understand how science works and have had practice with the evaluation of scientific information [14]. In addition to the recognized importance of instruction, science literacy is known to depend on learners' attitudes, which shape their interest, attention, and response to matters of science [12,15,16]. Most studies on views of science, however, have focused on K-12 rather than college students [15,17]. Very few studies have concerned college students in the Middle East who are considered the primary engine of innovation and social change in the region [18]. The evidence is not only scarce and mixed but also limited to specific disciplines. For instance, in SA, Zafar et al. [19] who examined health science students' attitudes toward scientific research, reported rather unfavorable attitudes toward it, which improved as students progressed through their college majors. Instead, Al-Shalawy and Haleem [20] found health science students to have a positive attitude toward scientific research. A survey of health science students from universities located in three Middle Eastern countries (SA, Bahrain, and Kuwait), conducted by Amin et al. [21], confirmed the finding of Al-Shalawy and Haleem. Among teacher education students in Turkey, Turkmen [22] also found positive attitudes toward science. However, in Jordan, Gheith and Aljaberi [23], who investigated the image of scientists held by teacher education students, found that students possessed stereotypical images of scientists as likely to be old males working in labs. Such images do not bode well for gender equity in science.

Whether there are gender differences in attitudes towards science in a society in transition towards a different economy and socio-cultural order, such as SA, is unclear. Structural changes intended to delete the patriarchal imprint on the education system and the workforce have been both swift and substantial though. Because all SA citizens are now expected to contribute to the economic engine of the country, educational and professional opportunities for women have increased substantially. For instance, academic programs in higher education and career opportunities in the job market are now open to both men and women [24,25]. Overall, female university students are overrepresented relative to men [26]. Of course, time is needed for change to spread across the entire ecosystem in which women and men, mostly of young age, live. Women are still underrepresented in many occupations and face challenges in accommodating the demands of personal and family life to their professional aspirations [27,28].

Of particular interest here is a curious fact about women in higher education. Currently, in most countries around the world, women are underrepresented in science, technology, engineering, and mathematics domains [29,30]. Instead, a mixed picture emerges from SA. Namely, the country exhibits a higher percentage of female STEM graduates than males in natural sciences, mathematics, and statistics but the opposite ratio in engineering [31]. Yet, in 2021, it achieved a Gender Parity Index of 0.980 in overall educational attainment [32]. In 2020, the score was 1.08 in tertiary education enrollment [33], indicating largely equivalent access to education for women and men.

The main driving force behind the popularity and thus the relevance of STEM education is largely its potential for the economic benefits that may arise from a country's ability to secure a competitive edge in research and technology [34]. Gender equity is the cornerstone of the 2030 Vision. It represents the recognition that a sustainable economy is not only one to which all members of a society have the opportunity to contribute, but also one that relies on the acquisition, use, transmission, and creation of knowledge, thereby making human talent the most important asset [35]. In SA, gender equity is particularly important in science education. The plan for a knowledge-based society cannot become a concrete reality without the contribution of women who represent a large portion of SA's society (42.2% according to the World Bank's statistics of 2021 [36]).

According to Shakeshaft [37], definitions of gender equity emphasize either equality of opportunities and treatments or equality of outcomes. The latter definition recognizes students' diversity of needs and backgrounds as a key aspect of treatment. Namely, it implies that female and male students may require exposure to treatments tailored to their unique features to achieve equal outcomes. Both definitions though underline that any educational system has "the moral and legal obligation to provide equality of opportunity" as a necessary step for gender equity [38] (p. 403).

2. Literature Review

What are the current conditions of female and male students in STEM programs around the world? A wealth of studies has originated from the Western world. Studies often differ in their focus on particular features of the population selected for study, such as educational level (e.g., primary school, junior and high school, college, and graduate school), type of workforce (e.g., careers), geographic location, ethnicity, etc. They also differ in their focus on performance outcomes (e.g., grades, achievement test scores, persistence, graduation rates, etc.), cognitive variables (e.g., academic preparation), or a combination of affective and cognitive variables (e.g., self-perceptions, attitudes, and identities). Studies may be descriptive or attempt to predict the factors that lead to a particular pattern of outcomes. Although assorted in nature, the findings of metanalyses, which are intended to show reliable patterns across individual empirical studies, have been particularly instrumental in underscoring the complexity of the matter.

The evidence gathered from meta-analyses has illustrated findings that often favor males over females in different areas, such as interest in traditional STEM fields (e.g., engineering) [39], spatial visualization abilities [40], assertiveness and self-esteem [41], preparation [42] and other individual background characteristics (e.g., family influences, expectations, values, preferences, psychological factors) [43], as well as macro-factors (e.g., structural barriers in K-12 education, cultural stereotypes, societal perceptions of STEM fields) [43–45]. In many studies, variables displaying differences serve as explanatory devices to account for performance, enrollment, and persistence differences in STEM fields, either as a whole or segregated by discipline. Null differences have also been reported. For instance, Else-Quest et al. [46] found no overall differences in math achievement over two decades across 69 nations throughout the world. Despite overall similarities in achievement, males were found to be more confident, more motivated to do well, and less anxious about their math abilities than females. Furthermore, overall null differences in math achievements masked substantial variability across countries, which reflected the status and welfare of women.

A key aspect of research on STEM students is the examination of their attitudes. Broadly speaking, attitudes are "a mental or neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related" [47] (p. 810). Concerning science, Kind, Jones, and Barmby [48] suggest that attitudes toward science refer to an individual's feelings about science, founded on his/her knowledge and beliefs about what science is in its different facets. Research on students' attitudes toward science has focused on either their view of the social relevance of science or, more narrowly, their views of science related to their course of study and future professional aspirations. Notwithstanding the focus of particular studies, the overarching scope of attitudinal research has been to assess students' science attitudes, measure any change in attitudes resulting from particular interventions or treatment methods, and/or identify the relationship between attitudes toward science and science-related behaviors. The underlying assumption of this type of research is that once attitudes are formed, they are long-lasting and difficult to change [49,50]. Indeed, attitudes have been defined as enduring evaluations stored in memory [51]. As such, attitudes toward science are believed to impact students' participation in science and performance in science disciplines [52,53].

Globally, although students' attitudes toward science often show that the prevailing disposition toward science and technology is typically positive [54], regional differences have been uncovered [55,56]. Attitudes toward science at school have been reported to vary along with demographic indices, such as age, gender, and socioeconomic background [57]. Specifically, gender differences have been highlighted by the findings of the ROSE (the Relevance of Science Education) research of Sjøberg and Schreiner [54]. In their research, male students are found to be interested in matters of a more technical and mechanical nature, whereas female students tend to be interested in matters of a more human nature (e.g., health and medicine) [54].

In SA, a few studies have covered different student groups defined by educational level. Their outcomes differ as a function of the time the investigations were conducted. As noted earlier, substantial investments in the development of science education by the Ministry of Education have been recent. Investments have been propelled by criticism of inadequate laboratories, trained laboratory personnel, equipment, and pedagogy [58–61]. Thus, changes have focused on fostering the implementation of an updated science curriculum, administered through suitable equipment and facilities, at all educational levels. The new science curriculum emphasizes a student-centered environment driven by inquiry-based instruction and attention to international standards [58].

Not surprisingly, recent studies on attitudes toward science tend to portray an encouraging picture of such attitudes in students at the elementary and secondary levels. For instance, Saif and Asiri [62] who examined attitudes toward learning science in elementary school children, found no gender differences. However, students residing in urban centers had more positive attitudes than those from rural areas. Furthermore, attitudes became more positive as age increased. Alanazi [59] who surveyed the attitudes of high school students toward knowledge and practical work in secondary school biology, chemistry, and physics reported that students appreciated practical work in science lessons. They saw practical experience with science as enhancing their problem-solving skills, and their ability to think logically. Yet, students' attitudes toward scientific disciplines can change over time. Thus, it is important to understand such attitudes in college students as dispositions toward science will be more likely to impact professional choices and employment decisions. Furthermore, as reported in the introductory section, the evidence concerning college students is not only scarce and mixed but also limited to particular disciplines [19–23].

3. The Present Study

The present research is grounded in the theory of planned behavior [63], according to which attitudes toward a particular behavior (e.g., pursuing a *STEM* degree) are one of the factors that define the relationship between attitudes and behavior. As such, the research relies on the assumption that understanding college students' attitudes about science and their views of themselves as consumers of scientific knowledge and practices is key to (a) understanding their educational and career choices, as well as (b) developing interventions intended to foster gender equity in higher education and, indirectly, in the job market. College students are the primary target of the 2030 Vision of SA, which relies on the principle of meritocracy to achieve a sustainable future through innovation. They are expected to fill the positions that are now held by a large number of expatriates [28,64] and be the core constituency of the engine that can make the economy of SA sustainable.

As such, their attitudes towards science and personal views are relevant. To the extent that attitudes can affect behavior [16,65–67], they can shape the learning of scientific research and its artifacts.

The conditions that are thought to foster equivalent outcomes in science education between female and male learners in SA and around the world depend on hotly debated assumptions about the sources of gender differences [68]. Assumptions about sources bring forth questions that have practical implications. For instance, if abilities are equivalent and sufficient rigor is applied to science education, can female and male students be expected to achieve the same educational outcomes? Alternatively, if there are individual differences in engagement in science education (e.g., attitudinal disparities), such as among learners of the same sex and between the two sexes [68], what are the curricular and pedagogical changes necessary to ensure that male and female students achieve the same educational outcomes? Consider curricular and instructional interventions that build on the assumption that females and males are equal in their approach to science education, and that inequality in education is caused by external factors. Such interventions are expected to be effective once these external obstacles are removed. To avoid discriminatory practices, for instance, informational training may be used to acquaint students and their parents with the equal ability (i.e., potential) of males and females to study science and become scientists. Instead, science education operating under the assumption that female and male learners differ in their approach to science education may require an exploration of the different interests and attitudes that learners possess. Evidence of individual differences may then be used to develop teaching materials and practices that accommodate a broad variety of interests and attitudes. To determine the suitability of each assumption, and consequently make sensible curriculum and instructional choices, or even develop interventions intended to rectify unfairness, a straightforward data-driven approach is needed. Such an approach can offer reliable and valid information about the consumers of scientific information (i.e., students) [69] that a higher education institution intends to educate.

As noted earlier, in SA, women are well represented in many STEM fields, except in engineering [31–33]. The latter may be the byproduct of the delayed opening of engineering programs to female applicants, persisting gender stereotypes that define suitable careers, or the allure of financial independence that a business degree appears to offer to females [69–71]. Although macro-level statistics of SA may suggest that STEM enrollment and graduation for women are non-issues, micro-level data from particular institutions may indicate otherwise. In the approach that we advocate and demonstrate here, knowledge of students' attitudes at a particular institution is as critical as knowledge of their level of engagement and performance [72], considering that attitudes often shape behavior. Interestingly, the youth of SA, especially women, who are expected to play a crucial role in accepting or rejecting changes to their society [73], have been reported to desire a society based on gender equity [74]. In our research, we advocate a micro, data-driven, periodic assessment of college students' attitudes toward science and their self-reported abilities within their chosen field of study. Such an assessment can offer useful information about the unique issues and needs of the population a given higher-education institution serves.

The present research relies on a successive-independent-samples design to survey female and male students in *STEM* and *non-STEM* fields at the start and the end of their academic journey. It specifically offers a test of the gender stratification hypothesis [75], according to which gender differences in *STEM* fields reflect gender inequities in educational and economic opportunities available in a given society. The gender stratification hypothesis sees gender equity in education as important for female students' achievements, self-confidence, and values attributed to *STEM* knowledge, skills, and careers. The hypothesis rests on the assumption that if female students recognize their education as a valued commodity in their communities, they are likely to feel invested in their education, leading to greater effort, persistence, and success [46]. It follows that if females and males are afforded the same opportunities through the re-engineering of a society that was once defined by a patriarchal order, gender differences will be likely to be minimized.

In the present research, we specifically focus on college students' attitudes toward science and their academic major, as well as subjective reports of their academic skills, learning styles, and learning gains. College students were specifically selected from a Saudi higher education institution that has adopted, since its inception in 2006, curricula of US import and student-centered pedagogy, both of which promote gender equity standards as defined by equality of opportunities for female and male students. In such a context, the gender equity guidelines of the 2030 Vision are embodied in students' quotidian educational experiences. Thus, its students represent the ideal testing ground of the gender stratification hypothesis [75], according to which gender differences in *STEM* fields reflect gender inequities in educational and economic opportunities available in a given context. We hypothesize that female and male college students in such a context may not demonstrate in their attitudes the residues of the gender segregation practices of the past. Alternatively, the past may be difficult to delete. As such, although the 2030 Vision has been integrated into the curriculum and pedagogy of *STEM* fields, traditional views of gender-suitable occupations and roles are likely to seep into the ways students perceive science, differentiating students in *STEM* (engineering and computer science) and *non-STEM* majors (e.g., business or law). Of course, differences may exist as a function of the length of academic experience. Thus, we predict attitudinal differences between entry-level (first and second year) learners and exit-level (third and fourth year) learners if the curriculum and instruction received have been interiorized. Namely, we anticipate a more positive view of science and the fading of gender differences as students' academic experience increases.

4. Method

4.1. Material

The *Research on the Integrated Science Curriculum* (RISC) surveys [76] were simplified to focus on students' opinions of their selected major (see Appendix A). The surveys were selected for having been effectively used to assess students' opinions and self-reported knowledge of science matters [77,78]. All students were asked questions organized into three thematic sections: Section 1 (Cronbach's Alpha = 0.79) served to collect students' opinions of science and their role as consumers of scientific information and practices. Opinions were reported on a 5-point scale from strongly agree (+2) to strongly disagree (−2). Section 2 (Cronbach's Alpha = 0.93) served to collect information about students' learning styles. Items defined students' learning styles along the dimensions of reflective vs. active, and abstract vs. concrete [79], which were presented as opposing ends of a 6-point scale. Section 3 (Cronbach's Alpha = 0.83) required students to assess their general academic skills on a 5-point scale from 0 (I am in the lowest 10%) to 4 (I am in the highest 10%). Two additional sections were given only to exit-level students to evaluate their views of their major after sufficient experience with its demands and contents was acquired. In Section 4 (Cronbach's Alpha = 0.94), students were asked to evaluate the learning gains obtained from their major on a 5-point scale from "no gain or very small gain" (0) to "very large gains" (+4). Items referred to two categories of gains: general benefits and scientific research-specific benefits. In Section 5 (Cronbach's Alpha = 0.75), students were asked to express their overall opinions of their major, which were to be reported on a 5-point scale from strongly agree (+2) to strongly disagree (−2).

Short-form surveys (including Sections 1–3) or long-form surveys (including Sections 1–5) were preceded by demographic questions about students' gender, educational level, major, the main reason for major selection, and goals beyond the undergraduate degree. Goals encompassed several choices, such as graduate school (either in a science-related field or in another field), a degree or certificate serving as a qualification for teaching, no plans for additional education beyond the undergraduate level, or undecided/not reported.

The content validity of the revised surveys and the scales used to measure students' responses were assessed by pilot-study participants (n = 10: 5 *STEM* and 5 *non-STEM* students). Participants were selected based on their availability from the pool of students who were considered for the research. Being a pilot-study participant would thus exclude the student from further inclusion in the research. Content validity was established by asking pilot-study participants to judge the relevance of the items of the 5 sets on one of three options: not necessary, useful but not essential, or essential. A content validity ratio (CVR) [80,81] was computed for each set: (number of judges selecting essential − number of judges)/number of judges). The CRV values of the items of the 5 sets were all above 0.62, which is the minimum CRV for 10 judges set by Lawshe [80]. Then, pilot-study students were asked to answer the surveys. Except for Section 2, they expressed concerns about the intermediate points of the original 6-point scale and did not use such points in their responses. As a result, 5-point scales were utilized for Sections 1 and 3–5.

4.2. The Sample

Participants (age range: 18–25) were full-time students of a higher education institution located in the Eastern Province of SA. The selected university offers academic programs with curricula of US import, which have been accredited by international organizations. *STEM* majors encompass the fields of engineering and computer science, whereas *non-STEM* majors include business and law fields. Each program is preceded by a general education curriculum, which was developed by the Texas International Education Consortium (TIEC) to ensure the acquisition and practice of basic skills. Instruction, which is imparted in English, is driven by a pedagogy that can be described as student-centered. The institution caters to students from families with middle-class backgrounds.

There were 173 first- and second-year (entry-level) students and 136 third- and fourth-year students (exit-level). Entry-level students qualified for participation by virtue of their being enrolled in an introductory mathematics course, whereas exit-level students qualified for participation by virtue of their being enrolled in an assessment course which is required for graduation. Students were sent an invitation to participate via email. Following informed consent, the surveys took approximately 15–20 min to complete. The participation for entry-level students was 66.70% and for exit-level students was 71.96%.

5. Results

5.1. Key Characteristics of the Sample

Table 1 displays the number of students classified by gender (male or female), major (*STEM* or *non-STEM*), and educational level (entry or exit). The outcomes of non-parametric inferential statistics carried out on demographic data are assumed to be significant at the 0.05 level. *Non-STEM* students served as the control group as their academic majors limited their exposure to science to mainly general education courses.

Table 1. The percentage of participants classified by gender (male or female), major (*STEM* or *non-STEM*), and educational level (entry or exit).

Entry-Level	***STEM***	***Non-STEM***
Female (n = 119)	61.34%	38.66%
Male (n = 54)	68.52%	31.48%
Exit-Level		
Female (n = 72)	45.83%	54.17%
Male (n = 64)	76.56%	23.44%

A chi-square test for independence indicated that the selection of *STEM* or *non-STEM* majors did not significantly vary by gender for entry-level students, χ^2 (1, n = 173) < 1, *ns*. Most students simply selected *STEM* majors. For exit-level students, males tended to be overrepresented in *STEM* majors, whereas females displayed the opposite pattern (albeit less starkly), χ^2 (1, n = 136) = 13.36, $p < 0.001$. This pattern was also reported by administrators and faculty who often noted a trend for female students to switch to business majors as experience with *STEM* courses increased and the demands of the selected majors became more tangible. To wit, in the first and second years of college, women and men tended to be equally represented in *STEM* majors (as per the percentage of students within each gender that selected particular majors). In the third and fourth years, gender differences emerged. Furthermore, the decline in participants from the entry-level to the exit-level period was found to be consistent with the overall withdrawal rates of the selected university. Administrators and faculty often commented that as students progressed through their degree plans and challenges emerged, withdrawal decisions tended to increase in frequency. It is important to note though that at the entry-level females tended to be overrepresented as respondents. This number does not reflect enrollment differences, but merely the tendency of female students to compensate for past gender inequities by being more engaged in both curricular and extra-curricular activities than male students [69,70].

Table 2 presents the percentage of students in each demographic category who were interested in pursuing graduate education. A chi-square test for independence failed to support significant gender differences in entry-level students who selected either *STEM* majors, χ^2 (1, n = 110) < 1, *ns*, or *non-STEM* majors, χ^2 (1, n = 63) < 1, *ns*. At the exit level, *STEM* female students expressed a desire to pursue graduate education that was greater than that of male students, χ^2 (1, n = 82) < 5.91, p = 0.015 (57.58% vs. 30.61%). Gender differences were not significant among *non-STEM* students, χ^2 (1, n = 54) = 1.36, *ns*, although a trend in the same direction was detected (64.10% vs. 46.67%).

Table 2. The percentage of participants who declared an interest in pursuing graduate education as a function of gender (male or female), major (*STEM* or *non-STEM*), and educational level (entry or exit).

Entry-Level	***STEM***	***Non-STEM***
Female	60.27%	45.65%
Male	59.46%	52.94%
Exit-Level		
Female	57.58%	64.10%
Male	30.61%	46.67%

Irrespective of major, gender, or educational level, the most reported reason for selecting a major was enjoying its content (80.26%). As a distant second, there was its practicality (e.g., job opportunities; 13.27%). A few students attributed major selection to the advice and influence of others (e.g., parents, relatives, and friends; 1.94%), or to the need to contribute to one's society (4.53%).

The following results are organized according to the thematic section to which they pertain. As per the demographic data, the outcomes of inferential statistics are assumed to be significant at the 0.05 level.

5.2. Students' Opinions on Science (Section 1)

Students' opinions of themselves in their role as consumers of scientific information and practices were reported on a 5-point scale from strongly agree (+2) to strongly disagree (−2). Opinions were examined by categorizing items into a positive view or a negative view of science. In Table 3, which displays descriptive statistics, scores above 0 indicate an overall favorable attitude, whereas scores below 0 indicate an unfavorable attitude. A $2 \times 2 \times 2$ between-subjects factorial ANOVA with gender (male or female), major (*STEM* or *non-STEM*), and educational level (entry or exit) as the factors was conducted on the difference between positive and negative views. The only significant effects were produced by educational level, $F(1, 301) = 12.06$, $MSE = 0.567$, $p = 0.001$, $\eta p^2 = 0.039$, and major, $F(1, 301) = 17.97$, $MSE = 0.567$, $p < 0.001$, $\eta p^2 = 0.056$. Namely, exit-level students held more positive views of science than entry-level students (+0.86 vs. +0.53). Similarly, *STEM* majors held more positive views of science than *non-STEM* majors (+0.90 vs. +0.49; other Fs ≤ 1, *ns*).

Table 3. Responses to "Opinions about Yourself and Science": mean difference between positive and negative attitudes and standard error of the mean (SEM) as a function of gender, major, and educational level.

	$STEM\ \overline{X}$	SEM	$Non-STEM\ \overline{X}$	SEM
Entry-Level				
Female Students	+0.83	(0.083)	+0.28	(0.118)
Male Students	+0.75	(0.131)	+0.24	(0.153)
Exit-Level				
Female Students	+1.13	(0.122)	+0.70	(0.133)
Male Students	+0.87	(0.103)	+0.73	(0.214)

5.3. Students' Learning Styles (Section 2)

Student responses were measured on a 6-point scale. The dimensions of reflective vs. active, and abstract vs. concrete [79] were represented by opposing ends of the 6-point scale. The two middle points of each scale were attributed a 0. The points on each scale away from the middle received a positive value if they illustrated a preference for reflection or abstraction either moderate or intense (+1 or +2). They received a negative value if they illustrated a preference for action or concreteness either moderate or intense (−1 and −2). Each dimension of students' learning styles (i.e., reflective vs. active, and abstract vs. concrete) [79] was submitted to a $2 \times 2 \times 2$ between-subjects factorial ANOVA with gender, major, and educational level as the factors. Tables 4 and 5 illustrate students' ratings by major and educational level. In Table 4, scores above 0 indicate a preference for reflection over action, whereas scores below 0 indicate the opposite preference. In Table 5, scores above 0 indicate a preference for abstraction over concreteness, whereas scores below 0 indicate the opposite preference.

Table 4. Responses to "Statements about Yourself": mean attitudes valuing reflection over action and standard error of the mean as a function of gender, major, and educational level.

	$STEM\ \overline{X}$	SEM	$Non-STEM\ \overline{X}$	SEM
Entry-Level				
Female Students	−0.24	(0.081)	−0.40	(0.108)
Male Students	−0.13	(0.178)	−0.66	(0.168)
Exit-Level				
Female Students	−0.61	(0.129)	−0.42	(0.129)
Male Students	−0.24	(0.113)	−0.08	(0.136)

When the dimension reflective vs. active was examined, educational level was found to interact with gender, $F(1, 301) = 4.51$, $MSE = 0.613$, $p = 0.034$, $\eta p^2 = 0.015$. Although there was a widespread tendency to be more action-oriented than reflective (as indexed by negative scores), males and females did not differ in their preference for action over reflection at the entry-level stage, $t(171) < 1$, *ns* (−0.40 vs. −0.32). At the exit-level stage, females tended to prefer action over reflection much more than males, $t(134) = 2.34$, $p = 0.021$ (−0.52 vs. −0.16). Educational level also interacted with major, $F(1, 301) = 6.74$, $MSE = 0.613$, $p = 0.010$, $\eta p^2 = 0.022$. At the entry-level, *non-STEM* students tended to prefer action over reflection much more than *STEM* students, $t(171) = 2.13$, $p = 0.035$ (−0.53 vs. −0.19). At the exit level, there was no difference in the preference for action between *STEM* and *non-STEM* students,

$t(134) < 1$, *ns* (-0.43 vs. -0.25; other *F*s ≤ 2.00, *ns*). When responses to the dimension concrete vs. abstract were examined, no significant effects or interactions were observed, *F*s ≤ 2.04, *ns*. The negative scores indicated a widespread inclination toward concreteness.

Table 5. Responses to "Statements about Yourself": mean attitudes valuing abstraction over concreteness and standard error of the mean as a function of gender, major, and educational level.

	STEM $\overline{X}$	***SEM***	***Non − STEM*** $\overline{X}$	***SEM***
Entry-Level				
Female Students	−0.03	(0.088)	−0.28	(0.134)
Male Students	−0.29	(0.119)	−0.35	(0.244)
Exit-Level				
Female Students	−0.25	(0.175)	−0.41	(0.124)
Male Students	−0.20	(0.148)	−0.37	(0.293)

5.4. Self-Assessment of One's Skills (Section 3)

Students' assessment of their skills on a 5-point scale from 0 (I am in the lowest 10%) to 4 (I am in the highest 10%) was submitted to a $2 \times 2 \times 2$ between-subjects factorial ANOVA with gender, major, and educational level as the factors. Table 6 illustrates the descriptive statistics of this analysis. Exit-level students reported higher evaluations of their skills than entry-level students (2.94 vs. 2.72), $F(1, 301) = 5.39$, $MSE = 0.543$, $p = 0.021$, $\eta p^2 = 0.018$. There was also a significant interaction of gender and major, $F(1, 301) = 4.20$, $MSE = 0.543$, $p = 0.041$, $\eta p^2 = 0.014$. *Non-STEM* male students and female students did not differ in their self-evaluations of possessed skills, $t(115) < 1$, *ns* (2.79 vs. 2.73). *STEM* females, however, gave themselves higher evaluations than *STEM* males, $t(190) = 2.30$, $p = 0.022$ (3.06 vs. 2.75; other *F*s ≤ 2.38, *ns*).

Table 6. Mean evaluation and standard error of the mean for "My Skills Relative to Other Students in my Field of Study" as a function of gender, major, and educational level. Skill level was measured on a 5-point scale from 0 (I Am in the Lowest 10%) to 4 (I Am in the Highest 10%).

	STEM $\overline{X}$	***SEM***	**Non − STEM** $\overline{X}$	***SEM***
Entry-Level				
Female Students	2.93	(0.096)	2.54	(0.137)
Male Students	2.59	(0.118)	2.82	(0.173)
Exit-Level				
Female Students	3.19	(0.080)	2.90	(0.096)
Male Students	2.91	(0.097)	2.76	(0.180)

5.5. Benefits of Selected Major (Only Exit-Level Students—Section 4)

Responses collected on a 5-point scale from "no gain or very small gain" (0) to "very large gains" (+4) were organized into two categories analyzed separately: general benefits and scientific research-specific benefits. For each category, responses were submitted to a 2×2 between-subjects factorial ANOVA with gender (male or female) and major (*STEM* or *non-STEM*) as the factors. Table 7 illustrates the descriptive statistics of these analyses. Neither general benefits nor science-specific benefits yielded significant effects or interactions, *F*s ≤ 1.68, *ns*. Thus, towards the end of one's undergraduate educational endeavors, female and male students mostly reported benefits across both types of majors.

Table 7. Mean evaluation and standard error of the mean for "Benefits of My Major" (upper panel: general benefits. Bottom panel: scientific research-specific benefits). Responses were collected on a 5-point scale from "no gain or very small gain" (0) to "very large gains" (+4).

Exit Level	*STEM* $\overline{X}$	*SEM*	*Non − STEM* $\overline{X}$	*SEM*
General Benefits				
Female Students	2.78	0.128	2.92	0.132
Male Students	2.67	0.108	2.74	0.266
Scientific Research Benefits				
Female Students	2.65	0.140	2.43	0.127
Male Students	2.51	0.109	2.34	0.254

5.6. Overall Evaluation of Major (Only Exit-Level Students—Section 5)

Students' overall opinions of their major were reported on a 5-point scale from strongly agree (+2) to strongly disagree (−2). Responses were submitted to a 2 × 2 between-subjects factorial ANOVA with gender and major as the factors. Table 8 illustrates the descriptive statistics of these analyses. Neither effects nor interactions were found to be significant, $Fs \leq 3.34$, *ns*. Again, as for students' opinions of the benefits of the selected major, evaluations were positive across the board.

Table 8. Mean of "Overall Evaluation of Major" and standard error of the mean. Responses were collected on a 5-point scale from strongly agree (+2) to strongly disagree (−2).

Exit Level	*STEM* $\overline{X}$	*SEM*	*Non − STEM* $\overline{X}$	*SEM*
Female Students	+1.15	0.131	+0.81	0.098
Male Students	+0.95	0.112	+1.09	0.141

6. Discussion

The assumption underlying our research was that attitudes are important in shaping students' interests, attention, and responses to science (e.g., selection of a *STEM* major and completion of the coursework associated with it). Furthermore, we argued that science literacy not only is reliant on such attitudes but also is the pedestal upon which the sustainability of the society envisioned by the 2030 Vision plan for SA rests. Within this broader context, the findings of the present research support the gender stratification hypothesis [75], according to which gender differences in *STEM* fields reflect gender inequities in educational and economic opportunities available in a given society. It follows that gender differences are likely to be minimized if (a) the re-engineering of the society to which females and males belong affords them the same opportunities and (b) quotidian educational experiences embody gender-equity standards. It is important to note that two ingredients may make the context examined in the present research a likely fertile ground for change to begin punctuating ingrained patriarchal traditions and habits in the minds of college students: (1) the awareness of the recipients of gender-equity standards (i.e., college students) of their relevance in the larger societal context. Indeed, in debriefings, participants often mentioned that one of the goals of the much-publicized 2030 Vision is for both female and male college students to be the primary contributors to the re-engineering of Saudi society. (2) The visibility of opportunities that are equal to women and men in the participants' quotidian context, such as that offered by the college life of an educational institution that fosters gender-equity standards in its curriculum and pedagogy.

In such a context, our results can be summarized in three points: First, although men and women did not appear to differ in the frequency of *STEM* versus *non-STEM* major selection at the start of their academic journey, women tended to be less represented in

STEM majors towards the end of their academic journey. Yet, towards the end of such a journey, female students also expressed a desire to pursue graduate education more often than male students. These findings indicate that female students' intentions to succeed in professional fields are rather strong. Perhaps, the fading of decades of gender bias has propelled the belief that they possess skills and qualifications to succeed professionally, thereby seeing graduate education as a viable option. Yet, obstacles exist in the pursuit of knowledge and practice in scientific fields (e.g., math inadequacy beliefs), which combined with the allure of financial independence that a business career offers, can make moving to *non-STEM* business majors a sensible alternative [4]. This interpretation is consistent with the "leaky pipeline" view of women in science. Although the metaphor refers to the loss of women from *STEM* fields at every educational stage [82,83], we use it here to highlight the pattern we uncovered at the undergraduate level within the institution selected for our research. This pattern may not be immediately visible in macro-level statistics covering the entire country as women in higher education tend to outnumber men. Yet, they are visible in statistics involving engineering, the discipline that was chosen as the major by most of the participants of our study (77.08%).

Second, gender differences were limited to students' opinions of their skills and learning styles. In *STEM* majors, female students judged themselves as possessing greater skills than male students. Across majors, at the end of their academic journey, but not at the start, females also judged themselves as more action-oriented than male students. These findings are consistent with the interpretation of the data regarding graduate school education discussed above. Namely, after decades of gender bias, women's desires to demonstrate their abilities and qualifications [84] are strong, especially in fields that were previously out of reach. Such demonstrations are often believed to require tangible action, thereby enhancing the value that women attribute to action over reflection as a useful mode of information processing. The minimal gender differences along with the overall positive attitudes toward science uncovered in our study are consistent with the findings of Al-Shalawy and Haleem [20] and Amin et al. [21] who surveyed college students in health sciences. Together, such findings may be symptomatic of the sociocultural changes in the SA society introduced by the 2030 Vision. To wit, young adults who are completing their undergraduate education appear to be responsive to the institutional forces that are attempting to restructure the economic engine of the country and with it some of its sociocultural practices. The extent to which responsiveness is widespread may be gleaned from findings underscoring women's optimism about societal change inspired by gender equity [72], but also highlighting pockets of concern [85].

Third, a few differences based on the major selected were found. At the exit level, students in *STEM* majors had a more positive view of science than students in *non-STEM* majors. The enhanced familiarity with scientific practices and artifacts attributable to *STEM* curricula and instruction may be responsible for this outcome, as familiarity is known to enhance liking [86]. Interestingly, at the beginning of their journey, *STEM* students expressed a much less action-oriented learning style than *non-STEM* students. Yet, in the end, learning style differences disappeared. The latter finding suggests that students' educational experiences, irrespective of the unique properties of each major, shape information processing uniformly. Alternatively, it indicates that existing differences are obscured by students' desires to demonstrate abilities and qualifications at the end of their educational journey.

Implications and Limitations

Our study is a snapshot of the views that students hold regarding the science education they are receiving and of themselves as learners of scientific knowledge and practices. Concerning the issue of gender equity, our study is also a snapshot of students' views at a particular institution at a given time. Thus, it is important to recognize that macro enrollment and graduation statistics of SA illustrate promising prospects for women. Such statistics, however, may fail to capture the particular challenges female students face at the institutions in which they have chosen to enroll. The results obtained here can be used by the selected higher education institution as a springboard for particular interventions to address the issues fostering the uncovered patterns. For instance, it may be of interest to identify the particular obstacles that lead female students to move to *non-STEM* majors, thereby ensuring that students who have chosen a *STEM* major can complete it [87,88]. Of course, additional information may be gathered from performance data and qualitative data from focus-group interviews if interventions are to be effective. The current data and interpretations may not fit another institution catering to older students or students from families with a socio-economic background lower or higher than that of the middle class. They also may differ from institutions that do not rely on a curriculum imported from the US. Yet, the assessment methodology advocated by our study, rather than its results, is intended to generalize to other institutions and hopefully become a regular aspect of their functioning [89].

It may also be of interest in future research to consider other aspects of student populations, including a fine-grained examination of different majors within the *STEM* and *non-STEM* categories. Consider, for instance, academic programs that embody the cross-discipline of sustainability science [90] compared with more traditional *STEM* programs, such as engineering. Sustainability science represents the integration of social and natural sciences to find solutions to the complex problems that the earth is facing, such as changes to the earth's ecosystems brought about by climate change (e.g., water scarcity, land degradation, biodiversity losses, etc.). Thus, one may ask whether the views of science held by students enrolled in environmental programs that focus on sustainability science differ from those of students in other *STEM* fields. Future research will examine this gap in the literature, although preliminary evidence from the Western world [16] suggests that differences are to be expected.

7. Conclusions

In summary, within the ecosystem of a higher education institution that relies on curricula of US import and student-centered education, females were less represented than males at the exit-level stage of engineering and computer science programs. At the entry-level stage of such *STEM* programs, females and males were similarly represented. This pattern emerged even though gender differences in students' opinions about their skills favored females in such *STEM* programs. The latter might underscore female students' overall higher self-efficacy beliefs (i.e., confidence in one's abilities), which is contrary to evidence from the Western world, where self-efficacy beliefs tend to favor males who are enrolled in engineering and computer science programs [91].

In our study, at the exit-level stage of *non-STEM* programs, females were overrepresented relative to males. Thus, in our study, the "leaky pipeline" metaphor applied to the academic journey of female students enrolled in *STEM* programs, who move to *non-STEM* programs as their education progresses. Contrary to studies in the Western world, however, there was no evidence of a "leaky pipeline" at the entry-level stage [92–94].

In the introductory section, we remarked that attitudes are related to behavior. Yet, we uncovered evidence pointing to a possible discrepancy between the two variables. Female students' diminished representation in *STEM* fields at the exit-level stage coexisted with confidence in one's skills and, more broadly, positive attitudes toward science and the selected major. Because of the descriptive nature of our study, we can only speculate on the sources of this discrepancy by relying on the extant literature. To this end, the theory of planned behavior [63] provides a helpful framework. According to this theory, injunctive normative beliefs, along with attitudes, are important factors in shaping a person's behavior. They refer to the expectation or subjective probability that individuals or groups that serve as referents (e.g., friends, family, instructor, teaching assistant, etc.) offer approval or disapproval for the behavior under consideration (e.g., pursuing a *STEM* degree). Kalender et al. [95] and Kim et al. [80] have noted that female students do not identify much with *STEM* fields and related professions due to their interpretation of the feedback they receive from others. Namely, female students believe others do not see them as belonging to *STEM* fields. Thus, academic challenges, which are typical of college life, or misinterpretations of well-intentioned feedback may easily lead to a change in the major chosen earlier. Kalender et al. [95], for instance, cite well-meaning comments from instructors and teaching assistants, such as "it is an easy question to answer!" in response to a student's query. Due to lingering stereotypes about women in *STEM* fields, male and female students may internalize such comments very differently. Specifically, female students may interpret them as devaluing their inquiries, thereby reducing future engagement and persistence in the selected *STEM* field. If such experiences are the main reason for the gender representation gap we observed in our study, educators' approaches to *STEM* female students may need to be revised to foster identification. The creation of opportunities to publicly recognize the work of female students, such as science fairs, may also counteract stereotypes that develop unintentionally in the classroom. The extant literature also suggests a variety of improvements in learning materials and teaching strategies for lecture and laboratory activities, as well as faculty development programs [95–97]. Such improvements are likely to face implicit and explicit forms of resistance to change [98]. All proposed remedies though rely on the approach that we advocate here. Namely, examining the conditions under which female and male students function at a particular institution (including their knowledge base and attitudes) is the first step in fostering the ideal conditions for academic success.

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Appendix A

The following are the sections of the questionnaire administered to students: Section 1 was devoted to students' opinions about science. See Table 3 for results (all participants).

Positive attitudes towards science
Even if I forget the facts, I'll still be able to use the thinking skills I learn in science.
The process of writing in science helps me to understand scientific ideas.
I get personal satisfaction when I solve a scientific problem by figuring it out myself.
I can do well in science courses.
Explaining science ideas to others has helped me understand the ideas better.
Negative attitudes towards science
I wish science instructors would just tell us what we need to know so we can learn it.
Creativity does not play a role in science.
Science is not connected to non-science fields (e.g., history, literature, law, economics, or art).
Science is essentially an accumulation of facts, rules, and formulas.
In science classes, there is too much emphasis on figuring things out for yourself.
If an experiment shows that something doesn't work, the experiment was a failure.

Section 2 was devoted to students' learning styles. See Table 4 for results (all participants).

Attitudes Valuing Reflection Versus Action	
I would describe myself as reflective.	I would describe myself as action-oriented.
I value patience.	I value getting things done.
I would describe myself as an observer.	I would describe myself as a doer.
I would describe myself as evaluative and logical.	I would describe myself as receptive and accepting.
I like to watch what is going on.	I like to see the results of my actions.
I am reserved.	I am prepared.
Attitudes Valuing Concrete Versus Abstract Information Processing	
I prefer subjects with precise answers.	I prefer subjects with multiple interpretations.
I like to be exact and precise.	I like things to be varied and colorful.
I take a precise and calculated approach to solving problems.	I take a creative and imaginative approach to solving problems.
I strive for accuracy.	I strive for versatility.
I prefer solving problems that can be clearly described and have a clear solution	I prefer solving problems that have no clear description and no clear solution

Section 3 was devoted to self-assessment of one's skills. See Table 5 for results (all participants).

Creativity
Leadership
Participation in class discussions
Skill in setting realistic yet challenging goals for myself
Understanding others
Writing skill
Skill in accurately estimating the time it takes to complete assignments
Working with a student group or team
Mathematical skill

Section 4 was devoted to the benefits of the selected major. See Table 6 for results (only exit-level students).

General Benefits
Clarification of a career path
Ability to integrate theory and practice
Learning ethical conduct in your field
Ability to read and understand primary literature
Skill in how to give an effective oral presentation
Self-confidence Learning to work independently
Becoming part of a learning community
Scientific Research-Specific Benefits
Skill in the interpretation of results
Tolerance for obstacles faced in the research process
Readiness for more demanding research
Understanding how knowledge is constructed

Understanding the research process in your field
Understanding of how scientists work on real problems
Understanding that scientific assertions require supporting evidence
Ability to analyze data and other information
Understanding science
Learning laboratory techniques
Skill in science writing
Understanding of how scientists think
Confidence in my potential to be a teacher of science

Section 5 was devoted to students' overall evaluation of Major. See Table 7 for results (only exit-level students).

This major was a good way of learning about the subject matter.
This major was a good way of learning about the process of scientific research.
This major had a positive effect on my interest in science.
I was able to ask questions in classes and get helpful responses.
If I were to start again, I would select the same major.

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