The Experiences of Undergraduate Saudi Students in the STEM Trajectory: A Closer Look at Major Choice and Persistence Intentions

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THE EXPERIENCES OF UNDERGRADUATE SAUDI STUDENTS IN THE STEM TRAJECTORY: A CLOSER LOOK AT MAJOR CHOICE AND PERSISTENCE INTENTIONS

Manal Ajran Almalki, Ph.D.

Western Michigan University, 2022

STEM fields (Science, Technology, Engineering, and Mathematics) are a key source of economic progress in many countries. As the Kingdom of Saudi Arabia works toward an innovative and knowledgeable economy, more qualified national professionals in STEM are needed. Nevertheless, the problem of STEM attrition is still insufficiently explored in Saudi Arabia, which may indicate a gap between skills of the Saudi workforce and the country’s need for economic development. Therefore, this study attempts to provide more information about the STEM trajectory in Saudi Arabia, underline possible attrition points that require more attention, deliver a better understanding of the factors that impact student persistence in the sciences, and finally, explore the nature of gender differences in STEM. The first part of this study highlights the importance of the first year of university with students’ directions toward STEM and assesses the contributing environmental factors that impact students’ decisions to continue on or drop out of the STEM trajectory. The second part of this study targets students in STEM majors and focuses on the affective factors contributing to students’ experiences in STEM and how these experiences impact students’ intentions to persist in these fields. Two different questionnaires were culturally adapted and validated to be used in this study. The study participants are current students at a university in Saudi Arabia.

The results show that the first year of university is an attrition point for potential capable STEM students. A low level of behavioral and environmental engagement was found among first-year students, and only 31% of them declared STEM for their majors. The second year of
university was also found to be critical for students’ persistence in STEM. While students across the university showed moderate levels of affective engagement, the second-year students had the lowest affective scores. Second-year students are found to be at a higher risk for leaving, as 26% expressed intentions to change their major out of STEM. The findings align with what is reported in the literature—the majority of students who leave STEM fields do not persist because of their experiences in the early years. The study recommends placing more attention on the influential aspects of students’ experiences and providing students with more social and academic support, especially during the early years of the STEM trajectory.
THE EXPERIENCES OF UNDERGRADUATE SAUDI STUDENTS IN THE STEM TRAJECTORY: A CLOSER LOOK AT MAJOR CHOICE AND PERSISTENCE INTENTIONS

by
Manal Ajran Almalki

A dissertation submitted to the Graduate College in partial fulfillment of the requirements for the degree of Doctor of Philosophy
Mallinson Institute for Science Education
Western Michigan University
June 2022

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ACKNOWLEDGEMENTS

The highest praise and gratitude are dedicated to Allah for giving me the opportunity and guidance to accomplish this dissertation.

I would like to express my deepest appreciation to Dr. Brandy A. Pleasants, the committee chair. Your help, advice, and encouragement carried me throughout the stages of my dissertation. I would also like to extend my gratitude to my committee members Dr. Betty AJ Adams and Dr. Jasvir K. Pannu for their insights and feedback.

A special thanks to my husband, Yaser, my children, and my family. It would not have been possible to achieve my goals without you. Thank you for your constant support and understanding during my PhD journey.

Lastly, I would like to extend my sincere thanks to the faculty and colleagues at Western Michigan University, the Ministry of Education in Saudi Arabia, and the Saudi Arabian Cultural Mission to the United States.

Manal Ajran Almalki
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CHAPTER I

INTRODUCTION

Statement of the Problem

In 2016, the government of the Kingdom of Saudi Arabia announced long-term goals for the country, known as the Saudi Vision 2030. It aims to transform the country’s economy from an oil-based to a knowledge-based economy (Kingdom of Saudi Arabia, 2020; Nurunnabi, 2017). Investing in STEM disciplines through creating more qualified professionals is a substantial orientation taken by the government to enhance the knowledge economy and reach the desired outcomes of the Vision 2030. However, the review of existing literature shows that there is a need to ensure Saudi students are on the way to STEM-relevant directions. According to the Education Statistics Center in the Ministry of Education (2021), a majority of undergraduate students in Saudi Arabia receive non-STEM degrees, specifically in law, commerce, and business. In particular for women, STEM fields are not among the top chosen fields. Taking into consideration that Saudi students typically show readiness and initial intentions to join STEM fields during secondary education, when they are intentionally following the scientific track, their direction may change during or after the early years of university (Khoshaim, 2017; Khoshaim et al., 2018). The literature also indicates that Saudi women, in particular, have difficulties traveling along science career paths. Women are unlikely to take part in STEM careers (El-Swais, 2016) or participate in STEM research, which has the lowest rate of women working in STEM among Arab countries, at 1.4% (UNESCO, 2015).

Based on the literature review, the area of undergraduate attrition and the lack of women in STEM disciplines has not been extensively studied in Saudi Arabia. There is not much
research done on the experiences of the first year of university and STEM selection, nor on the experiences of undergraduate STEM majors or on overall science career intentions. Therefore, this study aims to explore the situations that Saudi students have in the undergraduate level of the STEM trajectory. It will also highlight the gender difference in selecting STEM majors as well as in the overall intentions to persist in STEM careers for the university years and beyond.

**Statement of the Purpose**

This study investigates two critical stages inside the STEM trajectory in Saudi Arabia. The first part of this study examines the starting point where potential STEM students make academic decisions to continue selecting STEM majors or switch to non-STEM majors/drop out of college. The second part of this study examines the following stage, particularly students in STEM majors, and the students’ persistence intentions in these fields. Figure 1 shows the STEM career path and the proposed critical transition points for students in Saudi Arabia.

![Figure 1. The STEM trajectory in Saudi Arabia and possible attrition points](image)

students leave STEM

students in STEM
Theoretical Framework

Two theoretical frameworks are integrated to support this study. The theories are used complementarily to gain a better understanding about the STEM trajectory in Saudi Arabia.

The first theoretical framework comes from the environmental perspective on undergraduate retention, as emphasized by Tinto’s (1975) student integration model and Astin’s (1984) student involvement theory. The environmental perspective handles the first part of this study, which focuses on first-year student retention in STEM paths in Saudi Arabia. The environmental perspective highlights the importance of the context around the student: college environment, faculty, peers, and area of study, that all play a critical role in students’ decision to persist or drop out of college. Taking the environmental perspective into account, first-year students come to college-level science courses with prior interests, skills, or initial intentions to join STEM. Their first-year experience shapes their intentions (weakens or strengthens initial intentions) as described by Tinto’s model of student integration (1975). If the initial intentions are strengthened enough, there is a higher possibility of a student pursuing a degree in STEM. If the initial intentions are weakened, a student’s career goals may change and shift away from STEM fields.

The second theoretical framework is derived from motivational theories. The motivational perspective handles the second part of this study, which is students’ persistence intentions in STEM paths in Saudi Arabia. Motivational theories, such as the social-cognitive career theory (Lent et al., 1994) and the expectancy-value theory (Wigfield & Eccles, 2000), highlight the importance of the affective factors, such as science identity, sense of belonging, academic self-efficacy, confidence, and expectations to determine individual’s motivation, career behavior/choice, and career persistence in STEM.
Research Questions

This study addresses seven research questions to provide more information about the experiences of undergraduate Saudi students in the STEM trajectory. The first four research questions address the first part of this study, and the rest of the questions address the second part.

Study Part I

1) What are the behavioral, environmental engagement experiences of students within the science-track at the beginning of their first year at a university in Saudi Arabia?
   a. Do the behavioral, environmental engagement experiences of Saudi students change by the end of their first year?
   b. Are there differences between men’s and women’s behavioral, environmental engagement experiences by the end of their first year at a university in Saudi Arabia?

2) Are there differences in the total behavioral, environmental engagement experiences between students who determine or do not determine majors in their first year, within the science track, at a university in Saudi Arabia?

3) What are the academic major choices declared by Saudi students who have made their decision in their first year, within the science track, at a university in Saudi Arabia?

4) What reasons are given by Saudi students who have decided to major in STEM or other fields?

Study Part II

5) What are the affective engagement experiences of second year and beyond students majoring in STEM at a university in Saudi Arabia?
a. Are there differences in the affective engagement experiences between students across university years?

b. Are there differences between men’s and women’s affective engagement experiences?

6) What reasons are given by Saudi students who intend to leave the STEM trajectory at any time during university?

7) What do students think about gender differences in STEM in Saudi Arabia?

**Significance of the Study**

In Saudi Arabia, policymakers want to produce more qualified national professionals in STEM to develop a knowledge-based economy and achieve the country’s Vision of 2030. This study attempts to provide more information about the STEM trajectory in Saudi Arabia, underline possible attrition points that require more attention, deliver a better understanding of the factors that impact student retention in the sciences, and capture possible gender differences in STEM.

The first part of this study highlights the importance of the first year of university on students’ directions toward STEM. It targets students who experience introductory science courses during the first year of university and assesses the contributing environmental factors that may impact students’ decisions to continue on or drop out of the STEM trajectory.

The second part of this study targets students who decided to continue on the STEM trajectory and are currently in STEM majors. It focuses on the affective factors contributing to students’ experiences in STEM and how these experiences impact students’ overall intentions to persist in their fields at the undergraduate level and beyond.
Definition of Terms

STEM fields

STEM fields refer to the academic disciplines of Science, Technology, Engineering, and Mathematics. Throughout this document, the terms of sciences and science-related fields are also used interchangeably with STEM, matching the inconstancy of these terms in the literature.

STEM trajectory

STEM trajectory is sometimes described as the STEM pipeline metaphor, STEM track, or STEM path. It is the assumption of stages that express the path to a career in STEM. Research in STEM education usually uses these terms as a guide to investigate STEM attrition across career paths and establish appropriate policy interventions to support students at a certain stage. In this document, STEM trajectory describes the actual steps that students in Saudi Arabia need to follow toward a career in STEM.

First year of university

It is the first year of higher education for students after K-12 education. The nature of the first year of university is different from country to country as well as among institutions. In this document, the focus is on first-year students who had prior preparation of science courses during secondary education as well as recently joining the STEM track in higher education. In Saudi Arabia, it has been called the preparatory year or foundation year within the scientific track, where students experience intensive introductory science courses that are intended to prepare them for higher education.
CHAPTER II

LITERATURE REVIEW

STEM Attrition

Introduction and Background: The United States

STEM fields have been identified as critical areas of knowledge to the economic progress in developed countries. In the U.S., policymakers, institutions, and researchers focus on reducing STEM attrition in undergraduate education as well as recruiting more students into STEM majors as a way to create more STEM professionals for the nation (National Academy of Science, 2005; National Science Board, 2012, National Academies of Sciences, Engineering, and Medicine, 2016). Despite the attention, attrition from STEM has remained an ongoing challenge (Bettinger, 2010; Chen 2013; Seymour et al, 2019). According to the National Center for Education Statistics (NCES) report by Chen (2013), 48% of undergraduate students who joined STEM between 2003 and 2009, had left the field by 2009. Some leavers (28%) switched their major to non-STEM fields, while other leavers (20%) quit college completely without a degree in any major. Similar findings of attrition rates reported in the literature, for instance Bettinger (2010), examined students’ pre-college choices of major and their college decisions. Only 43% of students who intended to major in STEM decided actually to go into STEM fields. However, students who intended to major in non-STEM fields stayed in non-STEM fields, with only 5% shifting into STEM fields.

It has been two decades since research in science education has shown that the reasons behind students’ leaving STEM fields are not related to their academic ability and intellect (Seymour & Hewitt 1997). In Talking About Leaving, Seymour and Hewitt (1997) pointed to the alarming loss of students in STEM and concluded that the greatest factors contributing to STEM
attrition come from concerns about STEM culture and issues with the educational experiences in STEM disciplines, including teaching and curriculum controlled by faculty and institutions. Since then, Seymour and Hewitt’s (1997) work has been a foundation for researchers to reform STEM education and many resources have been given to solve the problems students have in STEM fields. In 2019, Seymour et al. published a replication study, Taking About Leaving Revisited, to report changes in STEM attrition and compare the rates of loss with previous findings. Despite evidence of progress and considerable improvements, the replication study found that the losses in STEM are still occurring “only 52% of students who enter a major in a STEM field complete a STEM degree” (Seymour et al. 2019, p.437). The replication study also shows that the current factors contributing to leaving STEM decisions are similar to the factors identified in the previous study, which mostly related to the negative learning experiences in STEM classrooms.

As the literature on STEM attrition still shows a frequent loss of many potential STEM graduates, many researchers believe that retention issues are related to students’ transition from high school to higher education and to the challenges that students experience to adjust. The majority of students who leave STEM fields do not persist after their first two years in higher education (Tinto, 1987; Seymour & Hewitt, 1997; Eagan et al., 2014; Seymour et al, 2019). The problem also notably includes high performing students. Chen (2013) in his NCES report found that high-performing students were more likely to leave STEM fields and switch majors than low-performing students. Similarly, Bettinger (2010) found that half of top performing students who indicated interest in STEM majors did not choose STEM fields later; rather, they switched to non-STEM majors, particularly into business. Also, Seymour et al. 2019 found high-achieving students are still leaving STEM fields, especially women.
During the first years of higher education, potential STEM students enroll in introductory level science courses. The research on STEM attrition shows that having negative experiences in those introductory science courses leads students to decide to leave STEM majors (Seymour & Hewitt, 1997; Seymour et al, 2019). Introductory science courses are designed to serve as gateways to continue studies in STEM. Because of their often negative effects on students, researchers sometimes refer to them as gatekeeper courses. Also, introductory science courses sometimes are described as “weed-out” courses which refers to the early challenges for potential STEM students to determine their ability in pursuing STEM (Mervis, 2011; Weston et al., 2019).

As the literature shows, one of the negative effects of gatekeeper courses is the instructional methods associated with it. Seymour and Hewitt (1997) emphasized the impact of gatekeeper science courses in pushing capable students out of STEM. Seymour and Hewitt (1997) identified that about 90% of interviewed students who switched out of science, were concerned about the pedagogy and of lecture being the primary instruction mode used in their introductory science courses. In the replication study, Seymour et al. (2019) also found that 96% of switchers mentioned poor quality teaching and pedagogy as enhancing their decisions to leave STEM. Akiha et al. (2018), in an observation-based study of STEM classrooms across multiple educational levels, found that the significant shift from more active learning courses in middle and high school to lecture-based courses at the first year of college could be contributing to student attrition at STEM. Other researchers examined first-year students’ expectations regarding classroom instruction, and they found that first-year students expected the class time to be spent doing scientific activities and working in groups which is different from the most common instructional practices used, listening to lecture. Inaccurate student expectations can result in
negative experiences in the introductory science courses and then impact subsequent retention in STEM (Brown et al., 2017; Meaders et al., 2019).

**What Impacts Retention in Sciences?**

There are many theoretical perspectives existing in the literature regarding student retention in higher education and attrition from college. Researchers who focus particularly on undergraduate retention and attrition within STEM disciplines widely use theories with environmental perspectives, such as Tinto’s (1975, 1987, 2005) student integration model and Astin’s (1975, 1984) student involvement theory. Both theories emphasize the importance of the context around the student, college environment, faculty, peers, area of study that all play a critical role in students’ decision to persist or drop out of college.

Tinto’s model of student integration claims that a student’s decision to persist or drop out of college is strongly predicted by their integration of two systems: academic integration and social integration (Tinto, 1975, 1987, 2005). Academic integration includes students’ achievements and overall intellectual development. Social integration includes students’ integration into the society of their institutions, faculty, and peers. According to the model, a student comes to college with some goals based on their interests, skills, abilities, and family background. In his model, Tinto argued that students’ experiences (the integration of both systems: academic and social) at the first year of college will continuously modify (weaken or strengthen those goals) initial goals. Tinto then clarified that those modified goals impact students’ decision to stay or leave the college.

According to Astin (1975, 1984), student involvement refers to “the quantity and quality of the physical and psychological energy that students invest in the college experience” (p. 307).
Astin’s theory emphasized both students’ mental and physical engagement in the academic experience. Astin argued that student involvement is the other face of student retention. The greater involvement in academic institutions means greater persistence at the institution. Also, Astin (1993) in his study of college dropouts, clarified that lack of involvement was the most common reason students stated for their dropping out of college. Astin (1993) emphasized the importance of student-student interaction, including participating actively in student activities, working in groups, and tutoring other students, as well as student-faculty interaction that includes working with faculty on research projects, assisting faculty in teaching a class, and talking with faculty outside of class. Those involvement measures have positive effects on students’ behavior, academic development, major field choices, and retention.

The work of Pascarella (1980) and Kuh (2001, 2009) were also among the most cited papers on the literature of retention in science. Pascarella (1980) emphasized the importance of students’ college experience and the interaction with the social and academic aspects of their institution, especially the informal interactions between students and faculty. Pascarella (1980) identified many forms of student-faculty interactions, and also clarified that the most beneficial one comes from extending the study content into informal contexts. This form of interaction had a significant association with first-year students’ motivation, success, and persistence in college. Kuh (2001, 2009) in his extensive work emphasized the importance of student involvement in college. Kuh (2001, 2009) confirmed that the more engaged and involved a student, the more likely the student will succeed, persist, and graduate. Kuh et al., (2008) used the term student engagement and considered it a key contribution to address retention issues in higher education. Kuh (2009) has defined student engagement as “the time and effort students devote to activities that are empirically linked to desired outcomes of college and what institutions do to induce
students to participate in these activities.” According to Kuh, promoting student engagement in college is associated with many aspects, including level of academic challenge, active and collaborative learning, student-faculty interaction, enriching educational experiences, and supportive campus environments.

The literature of retention in science shows extensive studies conducted on students’ experience in STEM majors and their connection with the university environments. Many researchers focused particularly on faculty-student connection within a classroom setting for its importance in student retention in STEM. Seymour and Hewitt (1997) in their early work emphasized the chilly and unwelcoming climate of the STEM disciplines as well as the role of STEM professors in student departure. Hong and Shull (2010), in a qualitative study, identified the lack of positive relationships that engineering students experience with their faculty members and the intentions of students’ early leaving. Kuley et al. (2016) investigated what the college could do/change to make first year more successful for engineering students. They found that students need to feel their first-year professors want them to succeed, and students benefit from professors who are engaged, enjoy teaching, and explain concepts clearly. Park et al. (2019) explored some faculty discrimination practices that negatively impact student retention in STEM. Micari and Pazos (2012) found that the more positive relationship a student has with their professor the higher the student’s final grade as well as the higher their confidence in their ability to succeed in organic chemistry courses, which are considered highly challenging, a gateway to science-related fields, and tend to have high attrition rates.

Additional to the importance of faculty-student interactions within a classroom setting, faculty-student interactions outside the classroom are also found to positively impact student retention in STEM. Interactions outside of formal teaching settings may include talking with
faculty during office hours, joining mentoring academic programs, working with a faculty member on scientific research, or working in a laboratory. Those types of interactions can promote students to continue pursuing STEM majors (Hunter et al., 2007; Russell et al., 2007; Graham et al., 2013). For example, Seymour et al. (2004) interviewed 76 students to define the benefits of participating in undergraduate research experiences as well as looked at their explanations of possible gains. Seymour et al. (2004) found that 91% of the students reported personal and professional gains such as greater confidence in science research, thinking and working like a scientist, planning for graduate science school, and shifting attitudes to learning and working as a researcher.

Even though faculty members have an important role in student decisions to leave STEM, faculty often do not recognize their role. According to Seymour and Hewitt (1997), STEM professors often see their role as one to produce high quality students and eliminate other students who are not academically strong enough. Therefore, STEM professors often consider students’ early leaving as appropriate for unfit students. Seymour and Hewitt argued that there is no analytical evidence indicating only low performing students dropped out. Instead, high performing students were found to leave STEM as often as low performing students (Seymour & Hewitt, 1997; Bettinger, 2010; Chen, 2013, Seymour et al, 2019). In a single institution, Gandhi-Lee et al. (2017) found that most of 27 interviewed STEM faculty were not worried about the need for future STEM graduates as well as unaware of their high impact on student retention and their responsibility to influence STEM recruitment and retention.

Besides the critical role of positive interactions between students and faculty, teaching practices and curriculum design also play a role in student retention in STEM. The way students learn about science, especially in the introductory level of science courses, presented a key
contributing factor causing students to leave, according to Seymour and Hewitt (1997). The lack of engagement in the classroom, insufficient organization by faculty, and dullness of presentations were all mentioned by students as evidence of poor teaching. The poor quality of teaching in science courses even led highly qualified students to decide to switch out of the sciences (Seymour & Hewitt, 1997). Therefore, many researchers focus on the primary role of STEM professors and their instructional approaches as well as on student engagement, classroom activities, and active learning.

For instance, Watkins and Mazur (2013) investigated the relationship between changing the traditional method of teaching science (lecture) to Peer Instruction (PI) in an introductory physics course and the impact on student retention in STEM disciplines. PI is a teaching technique that aims to increase student engagement in a classroom as well as encourages students to discuss with peers and instructors about the difficult parts of the study content. According to the authors, PI contains a ConcepTest which is a multiple-choice question asking about challenging concepts from introductory physics courses. The instruction starts by shifting the focus from instructor to students where the instructor poses a ConcepTest and asks students to think about the question. Students answer the question by using clickers, flashcards, or writing it on paper. The instructor moves forward in teaching depending on students’ responses. If 30%-70% of students answer the ConcepTest correctly, the instructor asks students to discuss their answers with peers or in a small group. Students are encouraged to share thoughts with someone that has a different answer. If less than 30% answer correctly, the instructor may take some time to explain the concepts by using lecture. If more than 70% answer correctly, the instructor gives a brief comment and moves on to the next or related concepts. For the data collection, the study included first-year students of an introductory physics course at Harvard University between
1990 and 1996. In each year, the course was scheduled for 1.5 hours twice a week. The course was taught using only traditional lecture-based approach in 1990 and had 105 students. The course used the PI approach in 1991 and after, and the total number of students were 1,072. At the beginning of each introductory physics course, students were asked to share their plans of their future major. There were 101 students that showed interest to major in STEM in the traditional lecture-based course, and a total of 997 students indicated intention to major in STEM in the courses using PI. The authors linked these data to students’ majors recorded at graduation. The authors then analyzed the relationship between the instructional methods and the students who initially planned to major in STEM and then later switched to non-STEM majors. For data analysis, the authors used a chi-square test to compare the percentages of students who did switch out of STEM in the traditional lecture-based course with other courses using PI. Watkins and Mazur found that the percentage of students who switched out of STEM majors after the traditional teaching was 0.11%. The percentage of students who switch out of STEM after Peer Instruction was 0.05%. The authors also compared the percentage of leavers from year to year. They found that the highest percentage of students leaving were in 1990, when the course was taught traditionally. For other years when peer instruction was used, the percentage of students leaving in each year is more than 50% smaller compared to the year of 1990.

One of the strengths of this study is that the authors focused on the introductory physics course and used the engaging teaching strategies (peer instruction) to assess student retention in STEM disciplines. The literature often shows that students find physics difficult, especially during the first year when undergraduate students experience the complexity of the material. That may lead students to not choose physics-related fields or switch out of STEM majors totally. Watkins and Mazur (2013) provide evidence that a single science course within the
introductory level, especially a difficult course like physics, can have a significant long-term influence on student retention in STEM majors.

In addition to the importance of student-faculty interaction and the obvious role of faculty in content delivery and enhancing student retention in STEM, the literature also emphasizes the importance of student-student interaction as another approach to address STEM attrition in undergraduate education. Student-student interaction, as mentioned by Astin (1975, 1984) and Kuh (2009), is the communication between students both in and out of the classroom. Student-student interaction in the classroom is usually promoted by the instructor. Students in the classroom have the opportunity to discuss their understanding, ask each other questions, listen to each other's comments, and build their direction of learning. It can be in a small classroom size, for example, when cooperative learning and group working takes place in a science laboratory. It also can be in a large classroom such as in a lecture hall when an instructor uses the ConcepTests approach, as discussed by Watkins and Mazur (2013), and encourages students to participate in think-pair-share activities. Student-student interaction also happens outside of the classroom such as a student tutoring another student, studying in groups for exams, and working with peers in extracurricular campus activities like in academic teams or culture clubs (Astin, 1975, 1984; Kuh, 2009).

Research on retention in science often shows the significant impact of peer interactions. For example, Barker, McDowell, and Kalahar (2009) conducted a study to determine the most important environmental factor during the introductory course of computer science that can increase students' engagement and retention in computer science majors. The authors studied eight factors including student-student interaction, student-faculty interaction, collaborative learning opportunities, prior experience with programming, teaching assistants, classroom
pedagogy, meaningful assignments, and gender/race/ethnicity. The authors utilized a linear regression to check the relationships between those factors and students' intention to major in computer science. The findings show that student-student interaction was the best predictor of students’ intention to persist in the major beyond the introductory level of computer science. The finding of this study supports the importance of peer interactions and recommends institutions to focus on that factor to retain students in computer science.

Moreover, in a large empirical study, Astin and Astin (1992) investigated the factors that influence students to major in STEM. The authors found that between their first year and senior year, the percentage of students in STEM declined from 28% to 17%. According to Astin and Astin (1992), one of the significant factors affecting student retention in STEM is the interaction with peers. The authors emphasized that a student’s interest in STEM majors can be clearly affected by their peers’ choice. If more of a student's peers are majoring in one of the STEM fields, the higher probability that student will also choose and persist in the same area of STEM. Astin and Astin (1992) recommended that institutions continue to retain and attract students to major in STEM until reaching a certain critical mass where the change can carry on and succeed.

Numerous institutional interventions have been made to increase student-student interactions for its important effect on STEM recruitment and retention. For instance, Drane, Micari, and Light (2014) evaluate the effectiveness of the Gateway Science Workshop (GSW) program after 10 years of implementation in Northwestern University, a highly ranked university in the U.S. The GSW program is referred to as a peer-led, small-group, problem-oriented learning program in five gateway science courses: biology, chemistry, physics, mathematics, and engineering. In the first week of fall quarter in each year, students are invited to join the program. Students, who were willing to participate, met in groups outside of the classroom for
two hours a week. They worked together on a challenging worksheet that included problems related to the course material written by faculty. In each group, there were five to seven students with one peer facilitator, who was doing well in the course as well as received the essential training on the group working skills and on the worksheet content. The authors emphasized the benefits of the program on students' problem-solving skills collaboratively with peers, as opposed to the common learning methods like listening to lecture or reading information. The authors also pointed out the importance of learning from the peer leader, where students' learning can be more effectively scaffolded. Leader peers were considered to have a slightly higher level of knowledge above others students which is different than learning from instructors where their knowledge is far beyond most students' current level of understanding. In this research, the authors referred to retention as the percentage of students who started in the fall and completed all three quarters (fall, winter, and spring) of the course sequence. Completing the introductory science course sequence is a requirement for students to pursue STEM majors. The authors found that students who participated in the Gateway Science Workshop had significantly higher GPAs than non-participants. The authors also found that the workshop participants persisted in the linked science course sequences at higher rates than students who did not participate. The authors in this study successfully provided evidence indicating that peer interactions are positively related to persistence in science disciplines.

In a small study on the effectiveness of peer interaction and retention in STEM, Cutright and Evans (2016) discussed the benefit of the one-credit class offered by the University of Akron during the 2014-2015 academic year for first-year students who received a National Science Foundation (NSF) scholarship to pursue STEM majors. The one-credit class involved peer mentoring to enhance interactions between more experienced STEM students (peer mentors -
seniors) and less experienced students (freshmen). The one-credit class focused on learning about soft skills such as time management and note taking skills as well as included peer-mentoring activities such as working on STEM projects, writing a technical paper, completing reflective journals, and doing a poster presentation about a chosen topic. The results of the survey and interviews showed that all participants (eight students) indicted positive experiences interacting with the peer mentors. The participants learned essential study habits and important skills for projects in other STEM classes. Also, peer mentoring helped freshmen students to adjust more easily to the academic environment. For the impact on retention, all participants maintained academic eligibility for the NSF scholarship program, and only two students switched out of STEM and went to a non-STEM major.

Based on the literature review, institutions play a key role in improving undergraduate STEM education. There has been considerable research on institutional efforts to increase students’ persistence in STEM fields. Instructional practices take different forms including orientation programs, undergraduate research opportunities, early intervention programs, and summer bridge programs. Other institutional efforts include academic and career advising, enhancing interaction between students and students to faculty, and encouraging faculty to use interactive teaching strategies. However, many of the discussed interventions were found in the literature to be particularly focused on students with stronger levels of academic preparation. For instance, more selective institutions provide first-year students necessary interventions to pursue STEM majors. Those students are considered to be ready to start and finish a STEM bachelor’s degree. Also, students, who receive a scholarship to pursue STEM majors such as the National Science Foundation (NSF) scholarship, have more opportunities to join interventions to maintain their eligibility for the scholarship. Those students are also considered to be previously prepared
as they were qualified enough and met the requirements for the scholarship. Therefore, more research is needed to discuss interventions experienced by a variety of students regardless of their previous academic differences as well as clarify the effectiveness of such interventions to retain general students in STEM fields.

**Saudi Arabia and STEM Disciplines**

In 2016, the government of the Kingdom of Saudi Arabia announced the long-term goals and expectations for the country, known as the Saudi Vision 2030. The Saudi Vision 2030 aims to transform the country’s economy from an oil-based to a knowledge-based economy (Kingdom of Saudi Arabia, 2020; Nurunnabi, 2017). The goal is reducing the dependency on oil and diversifying the economy through the growth of many public sectors such as health, finance, investment, education, technology, industry, transportation, recreation, and tourism. As documented in the report of Saudi Arabia’s vision for 2030, the vision is formulated around three major themes: a vibrant society, a thriving economy, and an ambitious nation (Kingdom of Saudi Arabia, 2020). A vibrant society is related to strengthening Islamic and national identity as well as to offer a fulfilling and healthy life. A thriving economy refers to diversifying the economy and increasing employment. An ambitious nation includes enhancing government effectiveness and enabling social responsibility. Each theme contains different directions and numerous goals. Therefore, there are 96 strategic objectives marked to be achieved by 2030 to ensure a successful socioeconomic transformation. Such far-reaching goals include reducing the unemployment rate among Saudi citizens from (11.6%) to (7%), empowering women and increasing their participation in the labor market from (22%) to (30%), increasing the average life expectancy from (74) to (80) years, qualifying three Saudi cities to be among the top 100 world cities, promoting at least five Saudi universities to be among the 200 best universities in the world,
focusing on industrial development and local production as well as increasing the non-oil exports from (16%) to (50%), and finally increasing the economy of the country to move its rank from 19 to be 15 among the world’s largest economies.

To achieve the Saudi Vision 2030, the government of the Kingdom of Saudi Arabia has established several operational programs to ensure the implementation process of the strategic objectives. For instance, *The National Transformation Program (NTP)* aims to promote action plans and develop essential initiatives designed to produce the desired outcomes of the vision 2030 (National Transformation Program, 2020). One of the program’s directions is investing in STEM disciplines and developing these fields to enhance a knowledge-based economy.

Involving King Abdulaziz City for Science and Technology (KACST) is one way to achieve such efforts. KACST is a scientific governmental organization that aims to promote science, technology, research, and innovation (King Abdulaziz City for Science and Technology, 2020). It is responsible for providing essential communication between Saudi institutions about scientific works, supporting the application of scientific research to enhance the economy, and encouraging Saudi youth to develop advanced technologies and participate in research and innovation within the country as well as internationally. KACST develops many approaches to ensure the progress of STEM disciplines in the country. For example, KACST launched Maeen which is a national research network that is connected to more than 65 research networks around the world. Maeen aims to provide high-speed connectivity to serve scholars in Saudi Arabia about scientific research, innovations, applications, and industrial productions (Maeen, 2020).

*The National Transformation Program (NTP)* also focuses on STEM disciplines through K-12 and higher education. *The National Transformation Program (NTP)* identifies 36 initiatives planned to be implemented through the Ministry of Education (National Transformation
Program, 2020; Mitchell & Alfuraih, 2018). Those initiatives were designed to meet goals within the Saudi Vision 2030, such as improving the quality of education, increasing the efficiency of scientific research, motivating innovation, and assisting students in the direction of desirable professional choice (Ministry of Education, 2020). One of the initiatives, for instance, is establishing a center for Science, Technology, Engineering, and Mathematics Education Development. The main goals of that center are aligned with the Saudi Vision 2030, which aims to prepare students with essential skills and knowledge to drive innovation as well as to stimulate students’ interest to choose STEM-related careers.

**STEM in Saudi Education and Retention**

In Saudi Arabia, students’ interest in STEM careers typically appears in the last two years of secondary education (grades 11 and 12). All students at the first year of secondary education (grades 10) take general courses including: Arabic, English, Islamic studies, social studies, literature, history, mathematics (levels:1 and 2), chemistry (level:1), physics (level:1), biology (level:1), and computer science (levels:1 and 2; Ministry of Education, 2020). At the beginning of the second year of secondary education, students have the opportunity to choose between two paths: humanities track or scientific track. Students, who choose to be in the humanities track, complete their secondary education in studying advanced courses in Arabic, English, Islamic studies, social studies, and management studies. Students, who choose to be in the scientific track, study advanced levels of mathematics and science courses, such as chemistry (levels: 2, 3, and 4). Each track prepares students for higher education. Students in the humanities track are able to join several fields such as administrative and social sciences but are not able to be in fields like STEM and medicine in the future. Students in the scientific track can join any fields in
higher education including STEM, medicine, health, administration, and social sciences (Ministry of Education, 2020).

After completing secondary education and moving to higher education, all students have to enroll in a mandatory program known as a preparatory year or a foundation year (Ministry of Education, 2020). The preparatory year is one full academic year that aims to prepare first-year students to pursue higher education in Saudi universities. It provides students with basic courses that bridge the gap between secondary education and higher education. The preparatory year in Saudi universities consists of two to three paths depending on the university’s goals. The typical paths are the scientific track and administrative track. A student, who was in the humanities track during the secondary education, can only enroll in the administrative track in the university. A student, who was in the scientific track during secondary education, can enroll in either paths of the preparatory year — scientific track or administrative track (King Abdulaziz University, 2012).

First-year students, who are in the scientific track, attend general preparation courses including mathematics, English proficiency, communication, and statistics. Additionally, as a preparation for STEM fields, students need to also complete introductory science courses in chemistry, physics, and biology. Moreover, the preparatory year enhances the development of important skills such as communication and collaboration. Also, it involves students in academic challenges and scientific practices (Ministry of Education, 2020; King Abdulaziz University, 2012; Khalil, 2010).

Despite the numerous roles of the preparatory year to smooth the transition from secondary to higher education, many students in the scientific track struggle with this transition which causes them to leave school after the first year of university or in other cases change their
intended majors away from the sciences (Khoshaim, 2017; Khoshaim et al., 2018). Also, Onsman (2011) mentioned the significant number of female students (63%) represented by the college population in Saudi Arabia; however, the majority of them were found in humanities and social sciences. Considering the importance of STEM fields in creating the future knowledge-based economy, as intended by the Saudi Government and Vision 2030, policymakers, researchers, and educators should pay sufficient attention to STEM subjects within the first year of university. The preparatory year is the first year of university for Saudi students, and it works as a connection between secondary education and higher education. Therefore, first-year students are subject to have different experiences between the introductory science courses taken in the first year of university and the basic science courses taken in secondary education. As the international research on retention in science shows, having negative experiences in the introductory science courses may lead students to decide to leave STEM majors as early as after their first year of university (Seymour & Hewitt, 1997). Also, the significant shift from more active learning courses in secondary education to lecture-based courses at the first year of university is considered a key contributing factor in student attrition in STEM (Akiha et al., 2018).

In terms of research about the first year of university in Saudi Arabia, the main focus is usually found to be on students’ academic performance in mathematics (such as Yushau & Omar, 2007) or on academic performance in English (such as Alshammari, Parkes, & Adlington, 2017; Alghamdi & Deraney, 2018). Little research has been conducted on students’ experiences in the first year of university (such as Alghamdi, 2015). Alghamdi (2015) aimed to measure students’ satisfaction of preparatory year at Al-Baha University. According to the author, student satisfaction is considered an indicator for the effectiveness of the preparatory year program as
achieving the desired outputs, such as student retention in higher education and improving the academic and communication skills. The author asked 350 students to complete a questionnaire that aimed to measure their satisfaction about faculty members and teaching methods, course content, exams and evaluation, management of student affairs, academic advising, learning resources, and facilities and support services. Alghamdi found that students in both scientific and literary tracks had a low to moderate satisfaction level. Alghamdi mentioned the possibility of students having many problems in the preparatory year program reflected by their low level of satisfaction. The study provided several recommendations to satisfy students, such as paying attention to student satisfaction level, improving student services, encouraging students to join seminars and scientific conferences, and adopting adequate standards to increase the academic quality. This study supports the importance of first-year experiences for students; however, it does not directedly aim to assess students’ retention in STEM fields after their first-year of university. Also, this study was implemented in a single institution in Saudi Arabia. More research is needed to study how students experience the first year of university in different institutions as well as measuring the changes in students’ intentions to either enter or avoid STEM majors.

Conclusion

To maintain the position of being a leader in research and advanced economy, the policymakers in the United States call to increase the number of students pursuing degrees in STEM. The literature in STEM attrition frequently highlights the importance of the first-year of university to the subsequent student retention in STEM. Most early studies, as well as current works, focus on the context around first-year students, considering that college environment,
faculty, and peers, that all play a role in students’ decision to persist or drop out of STEM majors.

Taking the environmental perspective into account, first-year students come to college-level science courses with prior interests, skills, or maybe initial intentions to join STEM. Their first-year experience shapes their intentions (weakens or strengthens initial intentions), as described by Tinto’s model of student integration (1975).

To strengthen students’ intentions toward STEM, in other words, to retain students in STEM, Astin (1975, 1984) and Kuh (2001, 2009) emphasized the importance of student involvement and engagement within the university environment. The literature presents the value of institutional interventions and instructional practices. Interventions on an institutional level may include programs designed to provide support for students to adjust to the new form of science courses as well as to make a successful transition to the university environment. As the literature shows, sufficient programs could aim to engage students in undergraduate research or enhance students’ interactions with faculty and other students. In terms of the importance of the instructional practices, previous studies also show that lecture-based courses fail to engage the majority of students in STEM majors. The literature frequently presents the importance of incorporating interactive and engaging teaching methods as they can make a remarkable difference in retaining students in STEM fields.

On the other side, the government of the Kingdom of Saudi Arabia aspires to create a more knowledge-based economy, known as Saudi Arabia’ Vision 2030. Policymakers recognize the importance of STEM fields to develop the economy and achieve the country’s vision. Thus, they command to create more qualified national professionals in STEM disciplines. However, there is a need to ensure that Saudi students are working toward STEM-relevant directions.
Students typically show readiness and initial intentions to join STEM during the last two years of secondary education. However, their direction may change during or after the first years of university. The importance of the first year of university in Saudi Arabia lies in its role in smoothing the transition from secondary education to higher education as well as providing students with introductory science courses as requirements to pursue STEM majors. Evidence from the literature shows that educational research in Saudi Arabia has not well examined the experience students have in the first-year of university as well as not yet assessing contributing environmental factors that impact students’ decisions to persist or drop out of STEM majors.
Women in STEM

Historical Background: Western Culture

Opportunities for women in science education have swung up and down during the past two centuries. As Schiebinger (1987), Scantlebury and Baker (2007), and Wils (2010) discuss, the debate on this topic started early in the nineteenth century, when science was thought to be a menace to women’s health. Western society was affected widely by the view that women should learn science in the context of drawing, painting, and cooking, not in the context of professional science. Science was exclusive to men because it was thought that science had masculine characteristics. Therefore, women were not able to do science at a level that men did because of physical, psychological, and intellectual barriers that were thought to hinder females from doing well in science. However, the authors also note that while men still held the most active roles in the field of science, by the late nineteenth century, women had started finding opportunities to be involved in actual science. For example, some women tended to self-education and worked with family members who were scientists. These women worked on recording observations, printing, and performing calculations. In some case, they had a supporting role in other’s work instead of doing their own scientific research. Marie Curie (1867-1934) was a well-known female scientist who worked with her husband, Pierre Curie (1859-1906), in pioneering research on radioactivity (Ogilvie, 1986). In terms of schooling, science education was considered a luxury. Accessing science courses was limited to middle- and upper-class women and could only be accessed by women who lived in urban areas (Schiebinger, 1987; Scantlebury & Baker, 2007; Wils, 2010).

Baker (1998) and Baker (2001) explain that despite the positive direction for women’s inclusion in science at the end of the nineteenth century, the activity of women in science education began to wane during the early twentieth century. As a result of World War I and the
weaknesses of the economy, men were encouraged to study mechanical and scientific subjects, to get higher levels of education, and to work on industrial and scientific production. Woman were directed to learn domestic skills as well as to work at teaching, nursing, and clerical jobs. During that time, and because such education could be costly, women began leaving science. In the United States, for example, there was an 80% decline in science enrollment among women between 1900 and 1928 (Rury, 1991; Baker, 2001). The lowering of women’s participation in the sciences at that time raised little or no concern among the majority of the society (Schiebinger, 1987). The situation stayed the same until about 1960 when women scientists started calling for a change. For example, Rossi (1965) asked "Why so few women in science?" Rossi outlined various social changes needed to encourage women in science. Everyone, boys and girls, must be educated equally; boys should know their roles to the future family, and women should value future professional roles. Also, Rossi suggested offering social help for women to maintain the three roles of a professional scientist, a wife, and a mother. In 1980, as a further step to make science accessible for women, a law in the U.S. declared that men and women have equal opportunity in education, training, and employment in science (Handelsman et al., 2005). Additional efforts were extended to change science curricula. One of the problems women faced in 1980 was that the science curricula had been developed by men and was not designed based on women’s needs. Women’s needs were ignored which led girls to not choose science. DeBoer (1991) and Baker (2007) note that reforming new science curricula at that time helped to stimulate women toward science.

Since the problem of women's underrepresentation in science has been recognized, researchers, educators, and policy makers have attempted to understand the cause of the problem, have tried removing barriers, and have developed initiatives to bring women into the sciences.
With all the efforts to promote gender diversity in science, more women have appeared to be making gains, earning science degrees, and moving forward in professional science. However, the number of women in science was still far below the number of men (Schiebinger, 1987; Brush, 1991; Handelsman et al., 2005). It was clear that other barriers remained. Women’s income in science (Schiebinger, 1987), availability of role models (Etzkowitz et al., 1994), ethnic and socioeconomic statuses (Baker, 1998), biological gender differences, inadequate school preparation, and higher education systems (Brush, 1991; Ceci & Williams 2007) are all factors that appeared to continue in discouraging women away from the sciences during the late decades of the twentieth century.

**Current State of Women in Science**

Over the past three decades, STEM fields have gained more global attention. These fields have been identified as critical areas for economic progress. Therefore, more workers and scientists are needed to fill the workforce. Although STEM attrition affects all students, the problem is more complicated when it comes to women. Researchers are continually reviewing the barriers women face as well as trying to enhance changes to increase women’s representation in science. Several perspectives are reported in the literature regarding the current state and the progress women are making toward the sciences.

A number of researchers have recognized the persistence of the issue that women have in science. They admit that women are still underrepresented in most science-related fields. Women are less likely than men to earn degrees in science majors as well as making headway in science careers (Hill, Corbett, & St. Rose, 2010; Chesler et al. 2010; Shen, 2013; UNESCO, 2015; Gledhill et al., 2019; International Day of Women & Girls in Science, 2020). For instance, Holman et al. (2018) reviewed recent studies regarding the gender gap in science and determined
it is not narrowing today. They do not agree that equality of women and men in the sciences exists, and the existing initiatives to recruit and retain women into science are not working either. Holman et al. (2018) studied the gender gap among science researchers which is a later stage of the science career pathway. Holman and his team aimed to estimate the number of authors, women and men, publishing in fields of STEMM (Science, Technology, Engineering, Mathematics and Medicine), and also intended to use the data to predict the time women need to be represented equally in the scientific workforce. Using two large databases of scientific literature, PubMed and ArXiv, the study collected about 10 million articles published by more than 36 million authors in 6,000 different scientific journals since 2002.

Results of this study show that women, worldwide, are making improvements, holding about 40% of the workforce in scientific research and medicine. However, the rate of this improvement is slow. The study also predicts that, at the current rate of change, women will need years until there is equal representation in most STEMM fields. For example, to fully close the gender gap, women will need about 258 years to represent equally in physics, 280 years in computer science, and 60 years in mathematics. In other areas, such as microbiology and genetics, the gender gap will close during the next decade. However, the study shows that even in some areas where the ratio of men and women authors is close, it cannot be considered equal or that sexism has been fully removed. According to the findings of this study, senior scientist researcher positions are mostly held by men. Most women authors are seen in junior scientist positions or graduate student positions which is generally known as the first listed person. Also, most of the single author articles are written by men who are senior scientist researchers. Holman et al. (2018) conclude that women are facing serious gender challenges in their workplaces which affect their career progression and sometimes lead them to quit STEM careers before
coming into senior positions. In addition, the gender gap in the sciences will not be closing soon, and additional interventions and reforms are needed to fix the current biases.

On the other hand, some researchers argue the persistence of the problem women have had in science no longer exists today. Instead, they suppose that the problem was in the past, the gender gap is narrowed now, and women and men are mostly represented equally in science-related fields (Luckenbill-Edds, 2002; Hyde & Mertz, 2009). For instance, Miller and Wai (2015) conducted a study on persistence in STEM fields. The study targets the early stage of the science career pathway, such as obtaining a bachelor’s degree, as well as the transition into advanced scientific pathways, such as obtaining a PhD degree in STEM fields. The authors investigated the STEM persistence rates for men and women from undergraduate to graduate education since the 1970s.

As proposed by Miller and Wai (2015), the STEM persistence rate means the proportion of students who obtained a Ph.D. in one of the STEM fields among students who had already earned a bachelor’s degree in that same field. To estimate the persistence rate, the authors collected the number of students who earned a bachelor’s degree and the numbers of students who also later received a Ph.D.

They used national data from the National Survey of College Graduates (NSCG) and the Survey of Doctoral Recipients (SDR), both funded by the National Science Foundation (NSF). The NSCG is used to inform users about the education and career choices of college graduates, while the SDR collects data regarding doctoral recipients, their history of education, and demographic characteristics. In this study, data collection targeted the population living in the U.S. who got their degrees between 1970 to 2000. Results indicated that the gender differences in persistence rates were statistically significant for cohorts in the 1970s and 1980s (p < 0.0005),
however, it was not significant in the 1990s ($p > 0.60$). That means among students that earned bachelor's degrees in STEM in the 1970s and 1980s, men were more likely than women to later receive a Ph.D. This gender gap is closed by the 1990s where the number of women increased at the Ph.D. level, and women and men appeared to be equally represented at that higher level of science.

However, other researchers claim that even though the percentage of women in the sciences has increased, the rate is still below other professional fields (such as Ganley et al., 2018). For instance, Glass et al. (2013) argue the appropriateness of doing men-women comparative studies to understand women’s difficulties in the science fields. Instead, women in science should be compared with women in non-science fields. Glass et al. examined the persistence of women in STEM fields and the persistence of women in other highly skilled fields such as law, medicine, and business. Also, the authors investigated where women go when they leave science (to non-science job or out of the workforce) and whether their departure differs from other women when they leave their professional fields.

Results from Glass et al. (2013) show that women in STEM fields are significantly less likely to persist in their fields over time compared to women in other professional fields. Also, women in STEM tend to move to non-STEM jobs at very high rates, while rarely moving out of the workforce entirely. Additionally, women who leave STEM fields are unlikely to come back. A few women who returned to STEM preferred management careers rather than scientific work. Family factors and characteristics cannot explain the lower persistence rate for women in STEM when compared to women in non-STEM fields. Instead, the lack of investments, rewards, and job dissatisfaction are the reasons for the loss of women STEM workers.
Other researchers consider the issue of women in the sciences to be related to particular areas of science (NCES, 2014; Wang & Degol, 2017). For example, Cheryan, Ziegler, Montoya and Jiang (2017) studied the differences among STEM fields and whether some fields differ in attracting and retaining women more than others. The authors looked to the early stages of science career paths. They investigated the percentage of bachelor’s degrees received by women, from 1985 to 2013, in six science-related fields: biological sciences, chemistry, mathematics and statistics, computer science, physics, and engineering. By accessing the National Science Foundation, National Center for Science and Engineering Statistics, Integrated Science and Engineering Resources Data System, Cheryan et al. (2017) found that the number of women in biological sciences and chemistry increased over time, where the percentages of growth were 11% and 12% respectively. At the same period of time, from 1985 to 2013, women made little improvement in earning degrees in math, physics, and engineering. The percent of growth was only about 5%. Computer science has even lost women over time, with the percentage of women dropping by 20% meeting the average of women in math, physics, and engineering. The study also indicated that there has not been much change in the percentage of women in those fields since the mid-2000s.

Looking into the literature, several studies point out the differences of the numbers of women inside STEM fields. Women tend to have high participation rates in biology and chemistry, commonly referred to as gender-balanced STEM fields. Women usually have lower participation rates in math, physics, technology, and engineering, referred to as gender-unbalanced STEM fields, math-intensive fields, or male-dominated STEM disciplines. Researchers frequently explain that differences are a result of successful recruitment and
retention done by some STEM fields, biology and chemistry (Luckenbill-Edds, 2002; Cheryan et al., 2017).

Some studies look closer to those gender-balanced STEM disciplines. For example, a recent study, published in *the International Journal of Science Education* by Fisher, Thompson, and Brookes (2020) shows that despite the high representation in gender-balanced fields, undergraduate women students in biology and chemistry still experience gender bias, which may impact their persistence in those fields. The authors investigated how undergraduate students experience the science disciplines of biology and chemistry, and how these gendered experiences affect their intentions to persist in their majors until getting a career in science.

Results from Fisher et al. (2020) indicate that women tend to have more positive responses toward science identity statements than men, for example, ‘*science is a reflection of who I am*’. However, women also agree more with statements like ‘*I don’t think I would pursue certain fields because of my gender*’. Additionally, from the qualitative analysis, Fisher et al., (2020) found that most students, men and women, believe that there are no gender issues in science (57%). However, women indicated experiencing implicit forms of discrimination (28%), for example, being ignored and not respected by their male peers. The implicit biases and discrimination were found to impact women’s belonging and persistence in biology and chemistry fields.

Moreover, researchers argue that women’s underrepresentation in science differs from country to country. Gender gaps vary cross-nationally. For example, women are less represented in STEM in advanced industrial countries (Sikora & Pokropek, 2012). In more affluent countries, women are expected to be more represented in STEM (Charles & Bradley, 2009). According to one of the more controversial studies, by Stoet and Geary (2018), countries with less gender
equality tend to have more women in STEM, while in the most gender-equal countries, women are less likely to be in STEM. The authors called that phenomenon the educational-gender-equality paradox. By using the 2015 PISA assessments in science literacy, reading comprehension, and mathematics, referred to as the *Programme for International Student Assessment*, the authors received access to the data for 519,334 students, aged between 15 and 16, from 72 countries. They found that in most countries, girls performed as well as boys do. Girls and boys have similar capacities in science. However, when the authors looked to other academic strengths (self-efficacy, interest, and enjoyment), they found that almost in all countries, science and mathematics are the preferred subjects for boys, while the girls’ preferred subject was reading. Across all nations, considering the academic strengths and preferred subjects, (24%) of girls chose science, (25%) of girls chose math, and (51%) of girls selected reading. For boys, (38%) for science, (42%) for mathematics, and (20%) for reading. By accessing the statistical reports of STEM graduation rates across countries through the United Nations Educational, Scientific and Cultural Organization (UNESCO), the authors found that the relationship between the gender differences in academic strengths and the graduation rates in STEM fields are greater in more gender equality countries. Stoet and Geary (2018) used the Global Gender Gap Index (GGGI) to indicate the gender equality for each nation. GGGI was designed to measure the gaps between women and men across 14 indicators such as earning, education, health, and politics. The authors point out that countries with low levels of gender equality have the most women graduates in STEM fields, such as Algeria. Countries like Finland, Norway, and Sweden, with high levels of gender equality, have the largest gender gap in STEM graduations. The authors suggest this pattern extends to all countries around the world. The authors also performed mediation analysis to identify the relationship between the two
variables by including a third hypothetical variable. They found that overall life satisfaction, including economic opportunity and risk, explains the variations between gender equality and women is science. Women in less gender-equal countries tend to choose STEM for financial reasons as these fields pay more than others.

Critiquing Stoet and Geary (2018), the authors minimize the issue of the gender gap in STEM when they focus only on the graduation gap in STEM. Limiting the gender gap in STEM around the undergraduate level of education is not sufficient. Looking closely at the UNESCO (2015) report for the statistic of 137 countries, is the gender gap narrowing in science and engineering? Globally, women are actively pursuing degrees in the sciences, but their numbers drop off at the PhD and research levels. In the Arab world, which Stoet and Geary indicated were countries with lower gender equality and more women in STEM, the UNESCO report showed that more women than men are in undergraduate levels of science. About 34% to 57% of women are pursuing scientific majors. However, their representation drops significantly when it comes to science careers, research, academia, and scientific decision-making. In Saudi Arabia, as a high-income country, the participation rate of women in research is the lowest in Arabic countries, at 1.4%. The report, by UNESCO, describes the proportion of women and men in STEM generally as resembling a scissor diagram (see Figure 1), and the proportion may differ from country to country because of different sociocultural factors (Fernández Polcuch et al, 2018). Additionally, according to World Bank, the high proportion of women majoring in science-related fields is not necessarily translated to the workforce in Arab countries. Many women are instead staying at home, whether by choice or because of other factors such as cultural, social, or familial pressures (El-Swais, 2016). Therefore, in countries with high level of
STEM graduation rates, the gender gap may take a different shape than those countries with low
STEM graduation rates.

![Graph showing the percentage of women and men in STEM](image)

**Figure 2.** The percentage of women and men in STEM (UNESCO, 2015; Fernández Polcuch et al, 2018)

By taking a closer look at the literature on women in science in Arab countries, unfortunately, few authors have discussed such issues. For example, Islam (2019) suggests that women in the Middle East have been breaking glass ceilings into male-dominated STEM fields, and there is now gender equality. Women consist of more of the total students involved in STEM than do men. Women are just behind in getting careers in STEM-related fields, and this problem is not limited to Middle Eastern countries but also in developed nations (Islam, 2019). The author is making this claim based on the latest statistics published by UNESCO. Also, a published report about the inclusion of women in STEM in Kuwait indicated that based on the
data, gathered from national universities, more women than men are going into STEM. However, women are having trouble getting employment in STEM and advancing in their fields (Whitacre & Najib, 2020). They describe this problem as the "bursting pipeline" where “women come into STEM fields with plans but then must give them up.”

Moreover, an exploratory study by Al Marzouqi (2011) aimed to explain the reasons for women’s underrepresentation in technology in the United Arab Emirates. The author employed a qualitative methodology to answer: why so few Emirate women choose careers in Technology, if there is discrimination because of gender, and if there a structural, cultural, and attitudinal barriers? Based on interviewing 20 women, the author noted that many young Emirati women choose not to major in Technology. The participants mentioned that their families discourage them from this area and also because they do not see it as an attractive career option.

The Pattern of Women Leaving Science

Since the problem of women’s underrepresentation in science was first recognized, researchers have been seeking to understand the paths women follow when they go into science and when they leave it. The “leaky pipeline” is the most cited metaphor used by researchers in the literature to understand the issues women have in science (NRC, 1991; Pell, 1996; Wickware, 1997; Atkin et al., 2002; Clark Blickenstaff, 2005; Mackenzie, 2015; Miller & Wai, 2015; UNESCO, 2015). The “leaky pipeline” metaphor, introduced in 1983 by Sue Berryman, refers to the assumption of a series of stages that women experience throughout their lives to successfully establish a career in science. Based on the empirical analysis in Berryman’s study, *Who will do science? Minority and Female attainment of science and mathematics degrees: Trends and Causes*, women tend to leave the sciences during specific stages: starting early in middle and high school level, through the university years, and the end of science careers. Young
women who show an interest in science sometimes tend to choose other majors of study for postsecondary education. Other women who start college or university in science fields change their majors to other areas during the university years. At the end of the pipeline, some women leave science after graduation and choose to work in another field. Cronin and Roger (1999) describe the stages of women leaving as progressive (gradual decline for women over each stage of higher education) and persistent (the problem has not changed over time). For many years in the literature, research has shown that the farther along the pipeline, the more women leak out of science. For example, Rees (2001) found that the greatest leak of women was associated with their greater family responsibilities. Researchers tend to use the leaky pipeline model as a guide in their study to investigate gender differences across science career paths (McDonnell, 2005; Naizer, 2014; Eddy et al., 2014) as well as to establish appropriate policy interventions that support women at certain stages (Linnenbrink-Garcia et al., 2018; Bos et al., 2019).

Xie and Shauman (2003), in a large study, Women in Science: Career Processes and Outcomes, challenged the leaky pipeline metaphor. They claim that this model does not fully capture the complexity of the problem women have in science. The linear stages proposed by the leaky pipeline to measure success in science does not make sense for students who are taking other pathways toward science. Xie and Shauman added that the leaky pipeline model disregards the students' life events, such as individual choice and family influence, that may impact the path women taken toward or away from science.

Instead of using the leaky pipeline model, Xie and Shauman (2003) proposed a life-course model as an attempt to understand the pathway women follow to establish a career in science. The scholars empirically analyzed a large existent dataset (1960 to 1990) from the United States to examine women’s persistence in science and to investigate the critical transition
periods in the lives of women who are in science. Summarizing the findings through the various science career stages, Xie and Shauman found that differences between men and women in math and science achievement in middle and high school are minimal. Men and women participated equally in high school math and science coursework, except in physics. However, they found that women generally intended to pursue majors outside of science and math, and men were more likely to choose science-related fields. At higher levels of education, Xie and Shauman found that more women than men enter science and math programs after starting a non-science major. Moreover, the transition to the workforce is a critical stage for women’s persistence in science. Women with families are less likely to work in scientific careers than men with families. However, in terms of academic productivity, both married women and men publish more than other single individuals.

The life-course perspective suggests that individual’s life transitions are interrelated across education, work, family events, and that later transitions are contingent on (but not determined by) earlier transitions and societal forces (Xie & Shauman, 2003). Therefore, the processes of establishing a career in science are not linear as suggested by the leaky pipeline; instead, the processes are inherent to life course events that typically shape individual transitions. Xie and Shauman (2003) recommend some changes in order to improve women representation in science, for example, providing students with multiple entry points to science-related fields. Also, because female scientists face the difficulty of family responsibilities more than male scientists, Xie and Shauman recommend establishing family-friendly institutional policies. For instance, such policies encourage stopping the delaying of pregnancies for those who wish to become parents, providing on-site childcare, providing supportive service at times of changing
life events, and encouraging employment for dual-career couples at the same institution or company.

Some researchers who seek to understand the experiences women have in science have used the life-course perspective as their conceptual model in their study (Main & Schimpf, 2017; Sikora, 2019). For example, Gayles and Ampaw (2016) examined the differences between women and men in selecting and persisting in science majors and the factors that lead to those differences. The authors analyzed existent data from the longitudinal survey of 2004/2009 Beginning Postsecondary Students (BPS). The authors found that women were less likely than men to select science-related fields in the first year of college. Also, women were less likely than men to select and persist in the sciences by the third year. Women who left science by their third year switched to majors outside of science. Another interesting finding was that most students, men and women, who joined science by the third year of university were undecided about their future majors during the first year of university. This study supports the importance of providing various starting points for students to join science which was argued previously from work that took the life-course perspective (Xie & Shauman, 2003). Gayles and Ampaw’s (2016) study also put light on the value of recruiting undecided students to enter science fields.

**Factors Related to Women’s Underrepresentation in Science**

Researchers have been actively seeking explanations for gender differences in science. Over time, an extensive literature has been developed on the factors that affect women’s participation and their progress in science-related fields (Blaisdell, 1994; Geary, 1996; Clark Blickenstaff, 2005; Baker, 2007; Ceci & Williams, 2007; Yazilitas et al., 2013; Wang & Degol, 2017; Williams, 2018; Avolio et al., 2020). Many studies classified these factors as micro-level and macro-level effects (Yazilitas et al., 2013) or internal and external influences (Gayles &
Ampaw, 2016); other studies assorted the factors in multiple domains such as: individual, family, social, education, and labor-economic (Avolio et al., 2020).

Most discussed factors affecting women’s underrepresentation in science were generally related to cognitive, affective, and cultural or institutional aspects. Factors related to cognitive aspects were mostly discussed in terms of biological differences between the sexes, the differences in the math ability, in spatial-visualization ability, or on the standardized tests (such as SAT). Studies focusing on cognitive factors tend to seek answers for how women academically perform compared to men, and whether these differences, if they exist, can explain the underrepresentation of women in science. For example, Hyde (1990) looked into IQ tests and found that there are no gender differences in general intelligence. However, women are generally better in verbal ability and men are generally better in mathematical and spatial abilities. Hyde also found that those gender differences were not significant enough to play a role in the problem women have in science. Other studies measured the differences in abilities using SAT-Mathematics and SAT-Verbal; however, no clear evidence was found to predict if the differences in those abilities could affect women in science (Heilbronner, 2013). However, many researchers in the domain of gender and science, do not agree that women and men are cognitively different, and such an idea is not accepted as an explanation to the lack of women in science (Xie & Shauman, 2003; Clark Blickenstaff, 2005; Ceci & Williams, 2007).

While cognitive factors have been heavily discussed in the past, researchers recently tend to focus more on affective factors to explain why women are less represented in science. Based on the literature, affective factors were found in terms of attitude, motivation, science identity, belonging, self-perception, self-efficacy, enjoyment, interest, confidence, and expectations. For example, Ainscough et al., (2016) examined the levels of self-efficacy (the belief in a person's
ability to succeed in a certain task – Bandura, 1977) among students in a first-year biology course. A total of 614 students were asked to complete the published Biology Self-Efficacy Scale (Baldwin et al., 1999) at the beginning and end of the semester. The instrument included 21 Likert scale questions asking about confidence in performing biology-related tasks. Ainscough et al., (2016) found that levels of self-efficacy were generally high at the beginning of the semester for all students. However, by the end of the semester, low levels of self-efficacy among students were found. Women students were significantly less confident than men to perform well in the course. Even high-performing women tended to underestimate their academic ability more than men did. Finally, most of the studies conducted on the affective domain show a significant relevance to women's underrepresentation in science. Those studies also advocate for more effective intervention programs to retain more women in science-related fields.

In addition to the cognitive and affective aspects, the literature includes the importance of cultural and institutional aspects on women's underrepresentation in science. Cultural or institutional factors might include gender role socialization, stereotypes of science professionals, gender discrimination, lack of role models, and pedagogy in science. For example, gender role socialization refers to sets of behaviors and attitudes that are expected from a person based on their sex. Many studies mentioned the indirect effect of gender roles on why women are underrepresented in the science fields. Such socialization practice found to appear at an early age when young girls view science as a boy's role. Eccles (2015) considered this practice as a result of families’ influences on their children and their early STEM activity choices (Eccles et al., 1990). Another cultural belief that contributes to women and science is the stereotype about science and scientists. Women usually hold negative expectations about the culture of STEM fields, including the kind of people and the value of their work. For example, Deemer et al.,
(2014) found that stereotype threat had a significant negative effect on 439 undergraduate women and on their intentions to choose a career in science fields, especially in physics. Moreover, educational or institutional factors were also found to be related to the lack of women in science. For example, the quality of teaching science has a fundamental impact on students’ attitude toward science and their persistence in later school years. Seymour (1995) identified that over 90% of students, who switched out of science, were concerned about the pedagogy and they had difficulty dealing with science instructors. Women particularly faced being underestimated or felt they were not taken seriously by their science instructors (Warrington & Younger, 2000).

The combined effects of cognitive, affective, cultural, or institutional barriers has been discussed extensively in the literature. Researchers in gender and science examined how some factors (such as stereotypes, interest, and academic performance) are interrelated and impact each other to cause women’s underrepresentation in science. This dynamic interaction refers to the social-cognitive career theory which is the most common theoretical framework used to explain the continued underrepresentation of women in science-related fields.

The social-cognitive career theory (SCCT) was developed by Lent et al. (1994) and derived originally from Bandura’s (1986) general social cognitive theory. Bandura in his theory emphasized the importance of the interaction between personal factors, behavioral patterns, and environmental events as all affecting thoughts, feeling, and subsequent actions of individuals. By applying Bandoura’s theory to career behavior and choice, SCCT particularly focuses on the interrelationships among self-efficacy beliefs, outcome expectations, and goal selections, and how they all may interrelate with other person inputs (e.g., gender and race), contextual influences (e.g., support system), and learning experiences. These three influences, personal inputs, contextual influences, and learning experiences, usually occur in early life and still have
an impact on individuals’ choices of action in the present. For example, considering the influence of gender role socialization, adolescent girls are socialized to view science as a boy's role, and that can negatively influence their science career choice in later life (Eccles et al., 1990; Eccles, 2015).

In addition to SCCT, the expectancy-value theory is another motivational theory developed by Wigfield and Eccles (2000) and focuses mainly on the expectancies for success and the value attached to a certain task; both aspects together determine an individual’s task choice, persistence, and motivation. The expectancy-value theory has been discussed by a number of authors in the literature to explain women’s career choice and development in science (Wigfield & Eccles, 2000). For example, a student may believe that they have great mathematical-related skills that can lead to a belief they can do very well on math-related tasks in the future. At the same time, that student values this math-related choice based on whether it is important, interesting, usefulness, and affordable. This form of expectancy of success and task values may result in the selection of math-related fields in college and persistence in later years. Wang & Degol (2013) indicated that gender differences in science-related field selection are associated with gendered differences in these motivational beliefs (expectancy of success and task values).

The expectancy-value theory was mostly used as the main theoretical framework for researchers studying gender differences in science in the context of secondary school (e.g., Robnett, 2016; Lauermann et al., 2017) or in elementary school (e.g., Xiang et al., 2003; Ball et al., 2017). The expectancy-value theory was used along with the social-cognitive career theory when the researchers attempt to explain women’s underrepresentation in science at higher levels of education (e.g., Broadley, 2015; Kelly, 2016; Guo, 2016; Wang & Degol, 2017; Marsh, 2019).
Both theories are well established and provide researchers with important explanations regarding gender gaps in students’ intentions to choose and persist in the sciences. Both theories also helped researchers to suggest essential intervention programs to prevent women from dropping out of STEM education (Ceci & Williams, 2007; Wang & Degol, 2017; Van den Hurk et al., 2019).

**Women in Saudi Arabia and STEM Fields**

For historical background, the Kingdom of Saudi Arabia was established in 1932. The discovery of oil in 1938 marked a crucial development in the country. The Kingdom has since become one of the world’s largest oil producers and exporters. The Kingdom has been identified as a high-income economy with a very high Human Development Index (The World Bank, 2019; Human Development Report, 2020). Oil and its resulting high-income made significant changes in Saudi society. One remarkable change was starting education. According to Al Rawaf and Simmons (1991), the Ministry of Education was established in 1954. At that time, education was offered only for men. Women’s education raised no concern among Saudi society. However, middle- and upper-class women were sometimes offered education at home by private tutors, as well as were able to join informal schools to learn about the Islam religion including the history, beliefs, practices, and how to read the holy book of Islam—the Quran (Al Rawaf & Simmons, 1991; Al-Bakr, 1990).

In 1959, in a formal speech presented on the radio and published in the newspapers, the king of Saudi Arabia, Saud bin Abdulaziz Al Saud, introduced women’s education and his intentions of opening schools for girls to learn Islamic studies and other subjects such as home economics and parenthood (Al Rawaf & Simmons, 1991; Al-Bakr, 1990). The announcement of starting formal education for women was supported by the Ulama. The Ulama are the Muslim
scholars who are knowledgeable theoretically and practically in Islam’s sciences as well as work to ensure applying Islamic laws, which is the basic principles in Saudi Arabia. Al Rawaf and Simmons (1991) point out that the Saudi society responded to that announcement in three ways: Some people were completely unwilling to send their daughters to formal schools, except allowing them to attend basic informal Islamic lessons. Another group of people were interested to send their daughters to formal schools to learn Islamic studies and other subjects but not allowing them to attend higher levels of education. The third group of people, which was the smallest, supported their daughters to attend formal school as well as going into the college level. According to Al Rawaf and Simmons, it was thought that women’s education would threaten the foundation of family and conflict with the traditional home-based role of women, so such ideas were refused by parents who wanted their daughters to turn into good wives and mothers.

During the 1960s, formal schools opened for girls at three levels of education: elementary, intermediate, and secondary. However, girls’ education at that time was supervised by General Presidency for Girls' Education (GPGE), and that was not under the Ministry of Education which was in charge of boys’ education. The goal of GPGE was to ensure women’s education and the curriculum followed the traditional values in society and maximized women’s primary role in family (Al-Bakr, 1990). According to Al Rawaf and Simmons (1991), elementary and intermediate education served those families who wanted their daughters to be successful wives and mothers, where girls learned about sewing, cooking, literacy, and numeracy. Secondary education was offered for families who wanted to prepare their daughters for higher education. The authors point out that the increased demand for secondary education was a sign for accepting a wider role for women than that of domestic roles.
The first college for Saudi women opened in 1970 in the capital city, Riyadh. Following that, 10 colleges opened in different regions of Saudi Arabia during the 1980s. The colleges admitted women who completed secondary education. The colleges offered a variety of subjects, such as education, arts, religion, Arabic, English, history, psychology, home economics, and sciences, including mathematics, biology, physics, botany, and chemistry (Al Rawaf & Simmons, 1991; Al-Bakr, 1990; Hamdan, 2005).

Between the 1970s and 1980s, universities in Saudi Arabia established separate campuses for women. For example, in 1979, the King Saud University in Riyadh opened a women’s campus that had many colleges offering studies in Arabic, English, history, geography, medicine, nursing, and education. Al Rawaf and Simmons (1991) indicate that all colleges in the King Saud University opened centers or branches in the women’s campus, except the college of engineering and architecture. Thus, women were not able to enjoy the full academic facilities, such as libraries and laboratories, as offered in the main campus attended only by men. Also, the King Abdulaziz University, in Jeddah, opened a campus for women to study mathematics, biology, computer science, medicine, and humanities. Moreover, King Khalid University, in Abha, offered women subjects like computer science, biology, and English, in 2002. Women in Saudi Arabia were allowed to study medicine in 1975 and dentistry in 1980 (Al Rawaf & Simmons, 1991; Hamdan, 2005). King Fahad University of Petroleum and Minerals, in Dhahran, is a public university that did not admit women until 2021.

Currently in Saudi Arabia, all levels (elementary [6 years], intermediate [3 years], secondary [3 years], and higher education [4 to 5 years]), are available with free tuition. The K-12 education of both boys and girls is under the supervision of the Ministry of Education with similar curriculum. There are more than 25 public universities and 14 private universities and
colleges; most universities have two campuses: one for men and another for women. The extensive number of universities in Saudi Arabia have extended the educational options for women as well as increased their opportunities to access higher education. For instance, in 2007, the largest women’s university in the world, Princess Nourah Bint Abdulrahman University (PNU), opened in Riyadh. The university offers a wide range of undergraduate and graduate degree programs. Women at PNU can study medicine, dentistry, pharmacy, nursing, business, administration, law, computer sciences, physics, chemistry, mathematical sciences, biology, art, design, education, languages, and home economics (Princess Nourah Bint Abdulrahman University, 2021). Moreover, the first mixed-gender university in Saudi Arabia, King Abdullah University of Science and Technology (KAUST), opened in Thuwal in 2009. KAUST offers only graduate degree programs with intense focus on science and technology fields. KAUST supports female inclusion, helps women to pursue their higher education, and encourages women to develop their careers in the science and technology disciplines (King Abdullah University of Science and Technology, 2021). In addition, all students, men and women, who are attending public universities in Saudi Arabia get paid roughly $270/mo. (1000 SR) for majoring in sciences and medicine, and $230/mo. (850 SR) for liberal arts, humanities, and other fields.

Women also have equal opportunities to men when it comes to study abroad. In 2005, the Saudi government initiated the King Abdullah Scholarship Program (KASP) which aimed to prepare Saudi nationals with essential knowledge and skills needed to enhance the country’s development and future economy (Bukhari & Denman, 2013). KASP is under the supervision of the Ministry of Education. To join the program, students must meet particular academic standards that are set by the Ministry. The selected process in not gender-based. Qualified students are sent to pursue undergraduate and graduate degrees. The Ministry of Education
encourage all students to study in high quality universities within 50 countries worldwide as well as specializing in fields such as medicine, dentistry, medical sciences, pharmacy, nursing, mathematics, physics, chemistry, biology, engineering, computer science, accounting, finance, insurance, and marketing. According to Bukhari and Denman (2013), more than 25,000 Saudi women were supported by the government to study abroad in 2011. The number of women increased to 40,859 who are studying abroad during the 2015-2016 academic year (Ministry of Education, 2021).

Despite the obvious progress that has been made toward equal education, women are still restricted from studying some fields in Saudi universities. Not all programs in Saudi universities are offered for women (Alamri, 2011). Fields such as engineering, petroleum, and geology were thought by society as not suitable by nature for women (Hamdan, 2005). King Abdulaziz University was the first Saudi university that opened engineering education for women, in 2013. However, not all engineering programs are available for women, only industrial and electrical engineering. Engineering including civil engineering, architectural engineering, mechanical engineering, chemical engineering, and environmental engineering are only offered for men at all Saudi public universities. In addition, some science-related fields, such as marine science, earth sciences, meteorology, and environmental science, are not options for women to major at the university level. Therefore, gender differences in education still exist in Saudi Arabia, and women still face challenges to fully access STEM fields.

More recently, empowering women and increasing their opportunities in the labor market is a priority for the kingdom’s Vision 2030 reform program. Toward a knowledge-based economy, women as well as men are both encouraged by the government to be involved in research and innovation in the fields of mathematics, engineering, computer science, and natural
sciences. Thus, the Kingdom’s requests for more qualified national professionals in STEM disciplines to equip the country’s needs and reach Vision of 2030.

The Kingdom of Saudi Arabia is one of the world’s youngest populations of both men (58%) and women (42%), according to The World Bank (2019). In their report Koyame-Marsh (2017) found that Saudi women represented 47.3% of undergraduate education in 2012, while Saudi men represented 52.7%. However, women are less likely than men to find jobs. For instance, in 2015, the Saudi women unemployment rate was (33.8%) while men were (5.3%). 68% of unemployed Saudi women acquired a bachelor degree or higher in comparison with 21% of unemployed men.

Based on the literature, researchers mention the low quality of education for Saudi women as a contributing factor to their high unemployment rate. Higher education is not efficiently preparing women for high-demand jobs as well as not providing women with essential skills and training programs to enhance their capabilities (Al Munajjed, 2010; Hamdan, 2005). Onsman (2011) emphasized that Saudi women represented a significant number in higher education; however, the majority of them were found in humanities and social sciences which may affect the availability of getting jobs in those crowded fields. Onsman also pointed out that because women are more in humanities and social sciences, universities tend to support and invest more resources to develop women in those fields. In addition, so much focus in humanities and social sciences is leaving a gap between national skills and the country’s needs for economic development (Al Munajjed, 2010), especially with recent goals for the Kingdom, such as enhancing scientific research and innovation through qualified national professionals in STEM.
According to the Education Statistics Center in the Ministry of Education (2021), in the 2016-2017 academic year, a total of 256,363 students graduated from colleges and universities in Saudi Arabia, with 136,189 women and 120,174 men. The percentage of graduated women was 53.1% compared to 46.9% men. As shows in Table 1 and 2 below, most students, men and women, graduated with degrees in law, commerce, and business. Also, more men majored in law, commerce, business, and engineering while women are remarkably more present in the fields of humanities, arts, and education (Ministry of Education, 2021).

Looking closer at STEM fields, the percentages for women are: 8.78% in sciences and mathematics, 5.48% in technology, and only 0.40% in engineering. For men, the percentages are: 4.80% in sciences and mathematics, 7.28% in technology, and 16.41% in engineering. Therefore, there are more women in natural science and mathematics, while there are more men in technology and obviously in engineering (Ministry of Education, 2021).

Looking at women’s majors, it is clear that STEM is not among the top three fields. Women are more likely in fields such as law, business, humanities, arts, and education. STEM fields are coming after social sciences, communication, and media. The lowest percentage of women are in engineering (Ministry of Education, 2021).

Table 1. Number of Saudi women graduated in the 2016-2017 academic year and their majors

<table>
<thead>
<tr>
<th>Area of Study</th>
<th>Number of Women</th>
<th>Percentage of Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Law, Commerce and Business</td>
<td>34,403</td>
<td>25.26%</td>
</tr>
<tr>
<td>Humanities and Arts</td>
<td>30,593</td>
<td>22.46%</td>
</tr>
<tr>
<td>Education</td>
<td>24,776</td>
<td>18.19%</td>
</tr>
<tr>
<td>Social sciences, Communication, and Media</td>
<td>13,913</td>
<td>10.22%</td>
</tr>
</tbody>
</table>
Table 2. Number of Saudi men graduated in the 2016-2017 academic year and their majors

<table>
<thead>
<tr>
<th>Area of Study</th>
<th>Number of Men</th>
<th>Percentage of Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Law, Commerce and Business</td>
<td>41,228</td>
<td>34.31%</td>
</tr>
<tr>
<td>Engineering</td>
<td>19,717</td>
<td>16.41%</td>
</tr>
<tr>
<td>Humanities and Arts</td>
<td>15,493</td>
<td>12.89%</td>
</tr>
<tr>
<td>Social sciences, Communication, and Media</td>
<td>11,577</td>
<td>9.63%</td>
</tr>
<tr>
<td>Education</td>
<td>9,213</td>
<td>7.67%</td>
</tr>
<tr>
<td>Technology and Informatics</td>
<td>8,749</td>
<td>7.28%</td>
</tr>
<tr>
<td>Health</td>
<td>6,263</td>
<td>5.21%</td>
</tr>
<tr>
<td>Natural sciences, Mathematics, Statistics</td>
<td>5,767</td>
<td>4.80%</td>
</tr>
</tbody>
</table>

Even though Saudi women appear to major in some STEM fields more than men, the report of the World Bank emphasizes that women’s graduation with a science-related major is not necessarily translated to the workforce in Arab countries. Many women are instead staying at home, whether as their choice or because of other factors such as cultural, social, or familial pressures (El-Swais, 2016). Also, Saudi women have difficulties traveling along science career paths. According to a report by UNESCO (2015), the participation rate of women researchers in...
STEM is the lowest among Arab countries, at 1.4%. The highest levels of science-related research are particularly going to men.

In addition, Al Munajjed (2010) emphasizes the importance of ensuring the high quality of STEM education for women in Saudi Arabia. The author argues that the current educational system is mostly built on rote learning and does not productively enhance skill development, analysis, problem solving, creativity, and communication. The author recommends the Ministry of Education to use new educational strategies and essential training programs to help women become active members in their fields while keeping up with the Kingdom's need for qualified professionals in STEM.

As women with STEM majors experience low employment rate, the government of Saudi Arabia tried to find solutions. For instance, in 2015, the government announced their intentions for re-preparing women who graduated from science facilities to participate in health sectors. Therefore, women with degrees in fields such as biology and chemistry can be adapted to work in health disciplines such as medical sterilization, blood work, and infection prevention (Saudi Commission for Health Specialties, 2017). Such steps may help women to find jobs, but working in medical technician fields is moving women away from being scientists and practicing scientific research. Saudi women that graduate in STEM fields should receive more support to be represented in STEM related careers as well as more promotion to make progress in their fields and participate in the scientific research.

Conclusion

Women's underrepresentation in science is a complex phenomenon. Researchers hold diverse perspectives regarding the gender gap in science as well as the progress women are
making toward the sciences. There are various conclusions on whether the gender gap still exists or if the gender gap is already closed. Some researchers believe that even if the rate of women in science has increased recently, it still falls well below other professional fields. Other researchers consider this problem to depend on the area of science—there are more women in biology and chemistry fields but less in math, technology, and engineering. While other researchers look more broadly and consider this problem to vary cross-nationally.

Based on the literature review, the largest body of research on women in science comes from the USA, Europe, and Australia. Other countries, especially Arab nations, have paid little attention to the area of women in science. Researchers from Arab countries tend to believe there is a high level of gender equality in STEM, based on the high graduation rate of women in STEM indicated by UNESCO statistics. However, when a qualitative study was conducted to explain women’s underrepresentation in technology, women avoided such fields for personal or familial reasons. Moreover, both UNESCO and the World Bank marked the significant drop that happens among Arab women when it comes to science careers, research, and high levels of practicing science. So, even though statistics suggest that there are a large number of women graduating with STEM degrees, when it comes to being in the scientific workplace, there is no gender equality yet.

Therefore, the literature shows that the gender gap in STEM exists with different degrees across all nations, even in the countries that have high levels of college graduation rates such as Arab countries. It is just a matter of where or at what point of the STEM career path women are unequal to men. The gender gap appears clearly at later stages of being in STEM. But that also could be a consequence of undergraduate STEM education, and that level should not be ignored. Also, it is important to take into account socio-cultural factors. In Saudi Arabia, for example,
some scientific fields, such as marine science, earth sciences, and environmental science, are not choices for women to study. Therefore, it can be beneficial to study how women experience STEM majors in Arab countries and look closely at the decision women make to either go into science or avoid it.

Moreover, the leaky pipeline and the life-course perspectives are both models that appeared in the literature to explain the educational pathway for a professional science career as well as to clarify the process of women leaving sciences. The “leaky pipeline” is the most used model in the literature, while the life-course perspective is not often used in gender and science research. The difficulty of using the life-course model lies in the need for more population-representative longitudinal data. Such data is not easily available especially in countries other than the USA, Canada, and Australia.

The majority of prior research has applied motivational theories, such as the social-cognitive career theory and the expectancy-value theory, to examine gender differences in science-related fields. Researchers, who seek to study gender differences in Arab countries, may use such theories to gain better understanding of the factors related to Arabic women’s underrepresentation in sciences.
CHAPTER III

METHODS

Study Design

This study consists of two parts in an attempt to provide more information about the undergraduate years within the STEM trajectory in Saudi Arabia. The study is designed to explore the impact of external (environmental) factors on first-year students as well as the internal (affective) factors on STEM students from second year on. The purpose of this study is to understand Saudi STEM students’ experiences throughout their undergraduate degree and what influences them to stay or leave the STEM trajectory.

Study Part I

This part of the study focuses on first-year students who experience intensive introductory science courses in the STEM track in Saudi Arabia. The study measures student behavioral, environmental engagement experiences along eight scales: academic perseverance, collaborative learning, student-faculty interaction, academic difficulty, academic help-seeking, academic preparation, importance of campus support, and active learning.

Research Questions

1) What are the behavioral, environmental engagement experiences of students within the science-track at the beginning of their first year at a university in Saudi Arabia?
   c. Do the behavioral, environmental engagement experiences of Saudi students change by the end of their first year?
d. Are there differences between men’s and women’s behavioral, environmental engagement experiences by the end of their first year at a university in Saudi Arabia?

2) Are there differences in the total behavioral, environmental engagement experiences between students who determine or do not determine majors in their first year, within the science track, at a university in Saudi Arabia?

3) What are the academic major choices declared by Saudi students who have made their decision in their first year, within the science track, at a university in Saudi Arabia?

4) What reasons are given by Saudi students who have decided to major in STEM or other fields?

**Research Instrument**

Students who experience introductory science courses during the first year of university were asked to complete a self-report questionnaire, referred to as the M-BCSSE-Arabic. It is a modified survey derived and translated from The Beginning College Survey of Student Engagement (Kuh, 2001; Kuh et al., 2008; Kuh, 2009). The M-BCSSE-Arabic went through a validation process and is considered appropriate to be used in measuring first-year students’ engagement behaviors in Saudi Arabia (Almalki & Pleasants, 2021). The M-BCSSE-Arabic measures student behavioral engagement along eight scales: academic perseverance, collaborative learning, student-faculty interaction, academic difficulty, academic help-seeking, academic preparation, importance of campus support, and active learning. The last part of this survey contains an open-ended question, asking students about their major decision. The response options in this survey are a continuous 4-point Likert scale. Appendix A shows the
English version of the instrument in study part I. Appendix B shows the Arabic version of the instrument in study part I.

Data Collection

First-year students within the science-track at King Abdulaziz University (KAU) in Jeddah, Saudi Arabia were asked to complete the Modified-BCSSE-Arabic survey electronically. The survey was completed anonymously. The survey was available in English and Arabic. The survey was administered in pre/post forms during the 2020-2021 school year. The pre-survey was given to first-year students in the Fall semester 2020. The post-survey was distributed at the end of the academic year, Spring 2021. The deanship of graduate studies in King Abdulaziz University helped distribute the survey through sending it to students’ school emails. About 500 students randomly invited to complete the pre-survey, with response rate: 42%. In the post-survey, also about 500 students randomly invited to participate, with response rate: 25%. Both response rates are considered adequate as the typical range for the online surveys between 10% to 40%. A total of 336 first-year students completed the survey. Table 3. shows the distribution of participants.

Table 3. The distributions of the study part I participants

<table>
<thead>
<tr>
<th>Survey completed</th>
<th>Women participants</th>
<th>Men participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-survey: 212</td>
<td>88</td>
<td>124</td>
</tr>
<tr>
<td>Post-survey: 124</td>
<td>43</td>
<td>81</td>
</tr>
<tr>
<td>Total: 336</td>
<td>131</td>
<td>205</td>
</tr>
</tbody>
</table>
Data Analysis

The surveys were run through Microsoft Forms which is available on Office 365 within Microsoft Western Michigan University. Quantitative data was cleaned, transferred, and analyzed using IBM SPSS Statistics (version 28). Following research in social sciences and educational settings, Likert scale is ordinal data by nature and also can be treated as interval data for practical purposes. Therefore, descriptive statistics, a one-sample t-test, and an independent sample t-test were used to answer the research questions, after meeting the assumptions for each test. Mann-Whitney was also used when the sub-scales violated the assumption of normality. Open-ended survey responses were analyzed using a priori codes based on the survey scales.

Table 4. demonstrates the Chronbach’s alpha for each of the eight survey scales.

Table 4. The Chronbach’s alpha for the survey scales in study part I

<table>
<thead>
<tr>
<th>Survey scales</th>
<th>Chronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall composite behavioral, environmental engagement scales</td>
<td>.91</td>
</tr>
<tr>
<td>Student-faculty interaction</td>
<td>.78</td>
</tr>
<tr>
<td>Academic difficulty</td>
<td>.72</td>
</tr>
<tr>
<td>Academic preparation</td>
<td>.89</td>
</tr>
<tr>
<td>Importance of campus support</td>
<td>.80</td>
</tr>
<tr>
<td>Active learning</td>
<td>.73</td>
</tr>
<tr>
<td>Academic perseverance</td>
<td>.42</td>
</tr>
<tr>
<td>Collaborative learning</td>
<td>.58</td>
</tr>
<tr>
<td>Academic help-seeking</td>
<td>.54</td>
</tr>
</tbody>
</table>
**Ethical Considerations**

The survey in this study went through several lines of instrument validity (Almalki & Pleasants, 2021); a forward-backward procedure (face validity), cognitive interviews (response process validity), and meaning equivalence review (content validity). The survey questions were considered appropriate and in clear Arabic language. All respondents are relevant to the survey topic. Also, the study sample was collected randomly from the first-year students’ population. Moreover, that data was collected anonymously, so there was no need for names or other identification information. Appendix C shows Western Michigan University Institutional Review Board Letter for Study Part I Approval and Anonymous Survey Consent in English & Arabic.


Study Part II

This part of the study targets ongoing STEM students who are majoring in one of the STEM disciplines. The study focuses on the internal affective factors to examine student’s motivation and persistence in STEM fields. The study measures affective engagement experiences along seven scales: academic self-efficacy, science identity, sense of belonging, gender biased science majors, compatibility between gender and major, intention to leave, and expectancy for science career.

Research Questions

5) What are the affective engagement experiences of second year and beyond students majoring in STEM at a university in Saudi Arabia?
   
   c. Are there differences in the affective engagement experiences between students across university years?
   
   d. Are there differences between men’s and women’s affective engagement experiences?

6) What reasons are given by Saudi students who intend to leave the STEM trajectory at any time during university?

7) What do students think about gender differences in STEM in Saudi Arabia?

Research Instrument

Students who are in STEM majors at their second/third/fourth/fifth years and above at a university were asked to complete several survey items that were translated and adapted by Almalki and Pleasants (2022). Those survey items were chosen because they have been found in the literature as practical indicators to represent different dimensions of STEM attrition in higher
education (e.g., Findley-Van Nostrand & Pollenz, 2017; Fisher et al., 2020). For example, Fisher et al. (2020) used the Cronbach's alpha to estimate internal consistency reliability and found to be in the accepted level for all survey items (α of 0.6 to 0.9). The survey scales include academic self-efficacy, science identity, sense of belonging, gender biased science majors, compatibility between gender and major, intention to leave, and expectancy for science career. The survey went through a validation process with high test-retest reliability, the correlations for the two datasets mostly were over 0.9 (Almalki & Pleasants, 2022). Open-ended questions were also included to gain more in-depth student responses about their affective experience and their persistence intentions. The response options in this survey contain a continuous 5-point Likert scale. Appendix D shows the English version of the instrument in study part II. Appendix E shows the Arabic version of the instrument in study part II.

**Data Collection**

Students in STEM majors at King Abdulaziz University in Jeddah, Saudi Arabia were asked to complete the psychological survey items that were translated and adapted by Almalki and Pleasants, (2022). The survey was administered one time only during Spring semester 2022. The survey was available in English and Arabic. The deanship of graduate studies in King Abdulaziz University helped distribute the survey through sending it to students’ school emails. About 500 students invited to complete the survey, 150 responses received, and 47 excluded because they did not match the target sample. Therefore, the study sample includes only 103 participants (Male 72, and Female 31). Table 5 shows distributions of students in STEM majors. Table 6 shows students across the university years.
Table 5. Students’ distributions in STEM majors in study part II

<table>
<thead>
<tr>
<th>Current Academic Major</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer science or Information technology</td>
<td>24</td>
<td>23.3 %</td>
</tr>
<tr>
<td>Engineering (Industrial, Civil, Electrical, Mechanical,</td>
<td>23</td>
<td>22.3 %</td>
</tr>
<tr>
<td>Chemical…)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics or Statistics</td>
<td>4</td>
<td>3.9 %</td>
</tr>
<tr>
<td>Sciences (Chemistry, Biology, Physics, Biochemistry,</td>
<td>52</td>
<td>50.5 %</td>
</tr>
<tr>
<td>Astronomy, Earth Sciences …)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>103</td>
<td>100.0 %</td>
</tr>
</tbody>
</table>

Table 6. Students’ distributions across university years in study part II

<table>
<thead>
<tr>
<th>University Year</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second Year</td>
<td>53</td>
<td>51.5 %</td>
</tr>
<tr>
<td>Third Year</td>
<td>16</td>
<td>15.5 %</td>
</tr>
<tr>
<td>Fourth Year</td>
<td>11</td>
<td>10.7 %</td>
</tr>
<tr>
<td>Fifth Year</td>
<td>10</td>
<td>9.7 %</td>
</tr>
<tr>
<td>Above</td>
<td>13</td>
<td>12.6 %</td>
</tr>
<tr>
<td>Total</td>
<td>103</td>
<td>100.0 %</td>
</tr>
</tbody>
</table>

Data Analysis

Similar to the study part I, the survey in this part was also run through Microsoft Forms which is available on Office 365 within Microsoft Western Michigan University. Quantitative
data was cleaned, transferred, and analyzed using IBM SPSS Statistics (version 28). Because researchers in social sciences and educational settings tend to treat Likert scale data as interval data, descriptive statistics, an ANOVA test, and an independent sample t-test were used to answer the research questions in study part II, after meeting the assumptions for each test. Also, reverse coding was completed as the survey contains some negative statements. Open-ended survey responses were analyzed using *a priori* codes based on the survey scales. Table 7 demonstrates the Chronbach’s alpha for the survey scales.

Table 7. The Chronbach’s alpha for the survey scales in study part II

<table>
<thead>
<tr>
<th>Survey scales</th>
<th>Chronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall composite affective engagement scales</td>
<td>.88</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>.84</td>
</tr>
<tr>
<td>Science identity</td>
<td>.86</td>
</tr>
<tr>
<td>Sense of belonging</td>
<td>.81</td>
</tr>
<tr>
<td>Gender biased science majors</td>
<td>.89</td>
</tr>
<tr>
<td>Compatibility between gender and major</td>
<td>.72</td>
</tr>
<tr>
<td>Expectancy for science career</td>
<td>.88</td>
</tr>
<tr>
<td>Intention to leave</td>
<td>.51</td>
</tr>
</tbody>
</table>

**Ethical Considerations**

The survey was adapted through the following several stages to ensure the validity of the research instrument. The survey items were translated and modified to ensure cultural relevance by multiple bilingual speakers. The translated survey was given to a sample of the target group to
evaluate the questions’ clarity and to receive necessary revision suggestions. Also, a constant meaning equivalence review was completed by a content expert to ensure the revised survey items are still asking the same as in the original version (Almalki & Pleasants, 2022). Moreover, all respondents are relevant to the survey topic, and the study sample was collected randomly from the STEM student population. Also, the data was collected anonymously, with no need for names or any other identification information. Appendix F shows Western Michigan University Institutional Review Board Letter for Study Part II Approval and Anonymous Survey Consent in English & Arabic.
CHAPTER IV

RESULTS

Study Part I

Results

1) What are the total behavioral, environmental engagement experiences of students within the science-track at the beginning of their first year at a university in Saudi Arabia?

a. Do the total behavioral, environmental engagement experiences of the Saudi students change by the end of the first year?

A one-Sample t-test procedure was used to answer the above research questions. The mean score for student engagement at the beginning of the first year (Pre) is $M=1.544$, and this score considered as a Known mean. The mean and standard deviation for student engagement at the end of the first year (Post) is $M = 1.465$ and $SD = .3504$ and we were testing if the mean is statistically significantly different than $M = 1.544$ (known mean).

The one sample t-test tells that the mean of the sample (Post) is statistically significantly different than the known mean since the $p$-value < .05 ($t(123) = -2.512$, $p = .013$, $D = -.226$). The effect size of Cohen's $D$ is small since $D$ is between $.2$ and $.5$ ($D = -.226$).

The study revealed that students’ engagement at the end of their first year was statistically significantly lower than students’ engagement at the beginning of the first year. For normality, the scale meets the assumption of normality according to both the Kolmogrov-Smirnov and Shapiro-Wilkes tests which allows us to do a t-test.
b. Are there differences between men’s and women’s behavioral, environmental engagement experiences by the end of their first year at a university in Saudi Arabia?

An Independent Samples t-test procedure was used to answer this part of the research questions. The mean and standard deviation for women was $M = 1.515, SD = .275$. The mean and standard deviation for men was $M = 1.439, SD = .383$. The t-test shows that the difference in the means between men and women is not statistically significant since $p > .05$ ($t(122) = -1.149, p = .253$). The study found that there is no difference between men’s and women’s behavioral engagement experiences during the first year of the university. For normality, the scale meets the assumption of normality according to both the Kolmogrov-Smirnov and Shapiro-Wilkes tests which allows us to do a t-test.

2) Are there differences in the total behavioral, environmental engagement experiences between students who determine or do not determine majors in their first year at a university in Saudi Arabia?

An Independent Samples t-test procedure was used to answer the second research question. The mean and standard deviation for undecided students were $M = 1.343, SD = .294$. The mean and standard deviation for major-decided students were $M = 1.560, SD = .388$. The t-test shows that the difference in the means was statistically significant since the p-value < .05 ($t(146.378) = -4.548, p < .001$). The study showed that those who decided their major in their first year of university have a statistically significant higher engagement than undecided students. For normality, the scale meets the assumption of normality according to both the Kolmogrov-Smirnov and Shapiro-Wilkes tests which allows us to do a t-test.
a. Are there differences in any of the 8 engagement areas between undecided students and major-decided students?

Those who decided their major had higher scores for all engagement measures except Important of Campus Support. Results are listed below:

For academic perseverance, the scale violates the assumption of normality according to both the Kolmogrov-Smirnov and Shapiro-Wilkes tests, and we therefore do not use a t-test. We use the Mann-Whitney U non-parametric test. The mean rank for undecided students were MR = 91.21. The Mean Rank for major-decided students MR = 125.30. The Mann-Whitney U showed that the difference in the mean was statistically significant since the p-value < .05 (U = 3730.0, p < .001). Those who decided their major have a statistically significantly higher mean score.

For collaborative learning, the scale violates the assumption of normality according to both the Kolmogrov-Smirnov and Shapiro-Wilkes tests, and we therefore do not use a t-test. We use the Mann-Whitney U non-parametric test. The Mean Rank for undecided students were MR = 101.28. The Mean Rank for major-decided students were MR = 121.52. The Mann-Whitney U showed that the difference in the mean was statistically significant since the p-value < .05 (U = 4364.5, p < .039). Those who decided their major have a statistically significantly higher mean score.

For student-faculty interaction, the scale violates the assumption of normality according to both the Kolmogrov-Smirnov and Shapiro-Wilkes tests, and we therefore do not use a t-test. We use the Mann-Whitney U non-parametric test. The Mean Rank for undecided students were MR = 98.95. The Mean Rank for major-decided students were MR = 121.13. The Mann-Whitney U showed that the difference in the mean was statistically significant since the p-value
< .05 (U = 4211.5, p = .018). Those who decided their major have a statistically significantly higher mean score.

For academic difficulty, the scale violates the assumption of normality according to both the Kolmogrov-Smirnov and Shapiro-Wilkes tests, and we therefore do not use a t-test. We use the Mann-Whitney U non-parametric test. The Mean Rank for undecided students were MR = 94.22. The Mean Rank for major-decided students were MR = 122.08. The Mann-Whitney U showed that the difference in the mean was statistically significant since the p-value < .05 (U = 3888.5, p = .004). Those who decided their major have a statistically significantly higher mean score.

For academic help-seeking, the scale violates the assumption of normality according to both the Kolmogrov-Smirnov and Shapiro-Wilkes tests, and we therefore do not use a t-test. We use the Mann-Whitney U non-parametric test. The Mean Rank for undecided students were MR = 95.80. The Mean Rank for major-decided students were MR = 123.57. The Mann-Whitney U showed that the difference in the mean was statistically significant since the p-value < .05 (U = 4019, p < .005). Those who decided their major have a statistically significantly higher mean score.

For academic preparation, the scale violates the assumption of normality according to both the Kolmogrov-Smirnov and Shapiro-Wilkes tests, and we therefore do not use a t-test. We use the Mann-Whitney U non-parametric test. The Mean Rank for undecided students were MR = 89.92. The Mean Rank for major-decided students were MR = 123.68. The Mann-Whitney U showed that the difference in the mean was statistically significant since the p-value < .05 (U = 3622.0, p < .001). Those who decided their major have a statistically significantly higher mean score.
For importance of campus support, the scale violates the assumption of normality according to both the Kolmogrov-Smirnov and Shapiro-Wilkes tests, and we therefore do not use a t-test. We use the Mann-Whitney U non-parametric test. The Mean Rank for undecided students were MR = 118.30. The Mean Rank for major-decided students were MR = 113.12. The Mann-Whitney U showed that the difference in the mean was NOT statistically significant since the p-value > .05 (U = 4969.0, p < .607). Those who decided their major did not have a statistically significantly higher mean score.

For active learning, the scale violates the assumption of normality according to both the Kolmogrov-Smirnov and Shapiro-Wilkes tests, and we therefore do not use a t-test. We use the Mann-Whitney U non-parametric test. The Mean Rank for undecided students were MR = 99.52. The Mean Rank for major-decided students were MR = 120.10. The Mann-Whitney U showed that the difference in the mean was statistically significant since the p-value < .05 (U = 4217.0, p = .035). Those who decided their major have a statistically significantly higher mean score.

3) What are the academic major choices declared by Saudi students who have made their decision in their first year, within the science-track, at a university in Saudi Arabia?

The research question was answered by showing the proportion of students’ answers in the Pie chart based on the response frequency. The total number of students who were undecided about their major is 117. The total number of major-decided students is 219 (103 of them into STEM, and 116 of them into non-STEM). Major-decided students by gender found to be (into STEM: female 27, male 76) (into non-STEM: female 62, male 54).
Figure 3. The academic major choices declared by all first-year students

Figure 4. The academic major choices for decided first-year students
4) **What explanations are given by Saudi students who have decided to major in STEM or other fields?**

To answer this research question, qualitative content analysis, coding system, and category were employed. The data analyzed using *a priori* codes based on the survey scales. Students’ responses assorted into three categories: into STEM, undecided, into non-STEM. Table 8. shows first-year students who explained their major choices.

Table 8. The first-year students’ major choices and their explanations.

<table>
<thead>
<tr>
<th>Category</th>
<th>Code/reason</th>
<th>Examples:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Into STEM (7 students)</td>
<td>Academic perseverance</td>
<td>“Cyber security or anything related to computers”</td>
</tr>
<tr>
<td></td>
<td>Primary choice (6 students)</td>
<td>“Information technology or mathematics which get most job offers” *</td>
</tr>
<tr>
<td></td>
<td>Career opportunity (1 student)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5. The academic major choices for decided first-year students by gender
<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Issues</th>
<th>Quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undecided</td>
<td>Academic difficulty</td>
<td>Feel lost/can’t navigate first year demands (4 students)</td>
<td>“I don't know what major is right for me and I feel a lot of chaos in my thoughts” *</td>
</tr>
<tr>
<td></td>
<td>Academic help-seeking</td>
<td>Lack of institutional guides (1 student)</td>
<td>“I don't really know since I need the university guides and I need people to help”</td>
</tr>
<tr>
<td></td>
<td>Women opportunities in STEM fields</td>
<td>Academic major unavailable (3 students) * all are Women</td>
<td>“Astronomy but unfortunately the university does NOT have it for females which is very disappointing”</td>
</tr>
<tr>
<td>Into non-STEM</td>
<td>Women opportunities in STEM fields</td>
<td>Academic major unavailable (3 students) * all are Women</td>
<td>“Medicine, although I really wished that my dream major is exists in KAU but there isn’t an Aerospace Engineering for females”</td>
</tr>
<tr>
<td>(10 students)</td>
<td>Academic difficulty</td>
<td>Difficult first-year courses (2 students)</td>
<td>“First-year is critical and hard …” * going to health</td>
</tr>
<tr>
<td></td>
<td>Academic help-seeking</td>
<td>Lack of institutional guides (1 students)</td>
<td>“Unfortunately, they don’t answer any questions so that makes me a bit unclear” going to dentistry</td>
</tr>
<tr>
<td></td>
<td>Student-faculty interaction</td>
<td>Issues with professor/teaching (2 students)</td>
<td>“My grades are bad because of the lack of information and unavailability to talk with the professor” * going to law</td>
</tr>
<tr>
<td></td>
<td>Pull factors</td>
<td>Find a more desirable major (2 students)</td>
<td>“Was anything to do with science. but lastly, I would probably think about either translator or announcer majors”</td>
</tr>
</tbody>
</table>

* Translated from Arabic into English
Discussion

The findings show a low of the total behavioral, environmental engagement experiences mean score among first-year students who are joining the science track at the beginning of their first year at a university in Saudi Arabia. The behavioral, environmental engagement experiences decline even more by the end of their first year at the university. The finding is similar to a study conducted at another Saudi university which found that first-year students in the scientific track had a low-moderate satisfaction level regarding their experience (Alghamdi, 2015). While first-year university students within the science track in Saudi Arabia go through intensive introductory science courses that are intended to prepare them for higher education, the negative experiences in the first year raises the alarming loss of many potential capable STEM students. As the literature on STEM attrition shows, the majority of students who leave STEM paths do not persist after their first years in higher education. Particularly, the negative experience of gatekeeper courses along with teaching and curriculum controlled by faculty and institutions found to push capable students out of STEM (Tinto, 1987; Seymour & Hewitt, 1997; Eagan et al., 2014; Seymour et al., 2019).

Even though the introductory science courses are intended to serve as gateways to continue science studies and are supposed to stimulate students’ interest to major in STEM, this has not been the case. Opened ended questions about major selection decision shows that the majority of first-year students did not select STEM related majors. While 35% of students were undecided about their majors and 34% chose non-STEM fields, there were only 31% that declared STEM for their majors. Considering that first-year students within the scientific track come to university with a prior preparation of essential STEM courses in secondary education as well as were academically qualified to enter the university, their leaving of the STEM track
cannot be explained by academic inability. As the literature frequently emphasizes, it is a mistake to assume that leaving STEM is caused by students’ academic, intellectual, or personal inadequacies; rather, the problems were found to be linked to STEM learning experiences in the early years of higher education (Seymour & Hewitt, 1997; Seymour et al, 2019).

Looking into students’ explanations about their major selections, students who are going into STEM found to follow their primary choice of STEM fields. Despite the low behavioral, environmental engagement experiences for all students, students who select STEM majors chose to persist in STEM track, which means they have academic perseverance and cope with the difficulties of their first year. As Seymour et al. (2019) explained, those who persist and switch found to have similar concerns regarding their negative learning experiences in STEM; the difference is that those who persisted were found to deal with the difficulties.

Students who select non-STEM majors explained some problems they have experienced during their first year of university. Difficulty of first-year courses, lack of institutional guides, and issues with professor/teaching were identified by first-year students within the science track. Those problems along with others were described in the literature as ‘Push Factors’ where university students experience such problems which make it difficult for them to stay in the STEM path. Thus, such problems found to push potential students out of STEM fields (Seymour et al., 2019). Also, the students who select non-STEM majors explained alternative choices of majors which the literature described as ‘Pull Factors’ where students entertained attractions to other majors while they struggled with STEM learning experiences (Seymour et al., 2019).

Even though all students show low behavioral, environmental engagement experiences in their first year of university, undecided students, who did not make a decision about their major choice, have a statistically significant lower engagement than others. By looking into all the eight
sub-scale engagement areas between undecided students and major-decided students, the study finds that undecided students have a statistically significantly lower mean score in all sub-scales, except the importance of campus support. While Gayles and Ampaw’s (2016) study found that most students who joined the sciences by the third year of university were undecided during the first year of university, other studies emphasized that undecided students are considered to be at a greater risk for attrition and dropping out of university (Tampke & Durodoye, 2013). Also, Dwyer et al. (2020) found that 78% of undecided students turned to major in a non-STEM discipline. Being an undecided student is sometimes a predictor for non-STEM choice, according to Belser et al. (2018). Our findings indicated that first-year students mentioned the difficulty of navigating first year and lack of institutional guides as an explanation for being undecided about their major. Further investigation needs to be conducted about undecided students and their next steps in the STEM path: whether they go into STEM, if so, do they persist; switch into non-STEM; or quitting completely without obtaining a degree.

The results demonstrate that there is no significant difference between men’s and women’s behavioral, environmental engagement experiences by the end of their first year of the university. However, by looking into major selection, women are less likely to major in STEM than men in their first year. The majority of women choose non-STEM majors. An emergent code regarding the opportunities of Saudi women in STEM fields appeared. Women mention the unavailability of desired STEM majors as explanations for being undecided or going into non-STEM majors. As the literature review shows, not all programs in Saudi universities are offered for women (Alamri, 2011). That can be explained by the sociocultural barriers faced by Arab women (El-Swais, 2016). Therefore, despite the obvious progress that has been made toward
equal education and opportunities enhanced by Saudi Arabia’ Vision 2030, women are still facing challenges to fully access STEM fields in Saudi universities.

Finally, the results show that the first year of university within the STEM trajectory in Saudi Arabia is an attrition critical point that needs more attention. The findings agree with other studies that described first-year students struggling in their courses which caused them to change their intended majors away from the sciences (Khoshaim, 2017; Khoshaim et al., 2018). In this study, first-year students within the STEM track had low behavioral, environmental engagement scores in all engagement scales, including academic perseverance, collaborative learning, student-faculty interaction, academic difficulty, academic help-seeking, academic preparation, importance of campus support, and active learning. Negative learning experiences result in losing many potential capable STEM students.

The findings support the environmental perspective on undergraduate retention, which highlights the importance of the context around first-year students, university environments, faculty, peers, and area of study as all play an important role in students’ major selection and subsequent persistence (Tinto, 1987; Astin, 1975, 1984; Kuh, 2009). Learning experiences in the introductory science courses found to impact first-year students’ decision to drop out of the STEM pathway, the results in consonance with Brown et al. (2017); Akiha et al. (2018); and Seymour et al. (2019). Therefore, first-year students within the STEM trajectory in Saudi Arabia need more supportive learning environment to help improve their learning experiences and enhance their retention in STEM.
Study Part II

Results

5) What are the affective engagement experiences of second-year and beyond students majoring in STEM at a university in Saudi Arabia?

a. Are there differences in the affective engagement experiences between students across university years?

First, the mean and standard deviation for each scale of affective engagement were calculated. Table 9. shows the mean and standard deviation for affective engagement sub-scales.

Table 9. The mean and standard deviation for affective engagement scales.

<table>
<thead>
<tr>
<th>Affective engagement scales</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic self-efficacy</td>
<td>4.10</td>
<td>.783</td>
</tr>
<tr>
<td>Science identity</td>
<td>3.87</td>
<td>.953</td>
</tr>
<tr>
<td>Sense of belonging</td>
<td>3.64</td>
<td>.648</td>
</tr>
<tr>
<td>Gender biased science majors</td>
<td>3.34</td>
<td>1.27</td>
</tr>
<tr>
<td>Compatibility between gender and major</td>
<td>3.37</td>
<td>.937</td>
</tr>
<tr>
<td>Expectancy for science career</td>
<td>4.19</td>
<td>.955</td>
</tr>
<tr>
<td>Intention to leave</td>
<td>3.02</td>
<td>1.24</td>
</tr>
</tbody>
</table>

Second, a one-way analysis of variance (ANOVA) was conducted to compare the effect of university years on the affective engagement experiences of students at a university in Saudi Arabia. The mean and standard deviation for second-year students was M = 3.577, SD = .482. The mean and standard deviation for third-year students was M = 3.607, SD = .486. The mean and standard deviation for fourth-year students was M = 4.060, SD = .637. The mean and
standard deviation for fifth-year students was M = 3.734, SD = .527. The mean and standard
deviation for above fifth year students was M = 3.846, SD = .602. There was a nearly significant
effect, F(4, 98) = 2.421, p = .053.

The data met the assumption of homogeneity of variances. Post hoc comparisons using
the LSD test indicated that the mean score for second-year students was significantly different
than the fourth-year students p = .006. Also, the mean score for third-year students was
significantly different than the fourth-year students p = .029. The study found that there is a
significant difference between the lowest group (second year) and highest group (fourth year) as
well as a significant difference between third year and fourth year students.

b. Are there differences between men’s and women’s affective engagement experiences?

An Independent Samples t-test procedure was used to answer this part of the research
questions. The mean and standard deviation for women was M = 3.707, SD = .587. The mean
and standard deviation for men was M = 3.672, SD = .514. The t-test shows that the difference in
the means between men and women is not statistically significant since p > .05(t(101) =-.306, p
= .760). The mean score between the two groups is not significantly different. The study found
that there is no difference between men’s and women’s affective engagement experiences.
For normality, the scale meets the assumption of normality according to both the Kolmogrov-
Smirnov and Shapiro-Wilkes tests which allows us to do a t-test.

6) What reasons are given by Saudi students who intend to leave the STEM trajectory at
any time during university?

The research question was answered by showing the proportion of students across
university years who thought about leaving STEM. The total number of participants who though
at some point to leave their STEM majors was 20 students. Table 10 shows the distributions of participants across university years.

Table 10. The distributions of students who though at some point to leave their STEM majors

<table>
<thead>
<tr>
<th>Student’s school year</th>
<th>Frequency</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second year</td>
<td>14</td>
<td>70%</td>
</tr>
<tr>
<td>Third year</td>
<td>3</td>
<td>15%</td>
</tr>
<tr>
<td>Fourth year</td>
<td>2</td>
<td>10%</td>
</tr>
<tr>
<td>Fifth year</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Above</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>100%</td>
</tr>
</tbody>
</table>

Qualitative content analysis, coding system, and category were employed. The data analyzed using a priori codes based on the survey scales. Students’ responses assorted based on their current university year. Table 11 shows students’ reasons to leave the STEM fields.

Table 11. Students’ reasons to leave STEM fields.

<table>
<thead>
<tr>
<th>Category</th>
<th>Code/reason</th>
<th>Examples:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second-year</td>
<td>Affective Factors</td>
<td>“I feel like I don't belong to my current major, actually I don't like it at all, and I don't want to study this science.”</td>
</tr>
<tr>
<td>Students</td>
<td>Low Sense of Belonging</td>
<td>“I feel like I don't belong to my current major, actually I don't like it at all, and I don't want to study this science.”</td>
</tr>
<tr>
<td></td>
<td>(5 students)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low Academic Self-efficacy</td>
<td>“Some subjects are hard, and getting low grades made me thinking that this major is not</td>
</tr>
<tr>
<td></td>
<td>(7 students)</td>
<td></td>
</tr>
<tr>
<td>Behavioral, Environmental Factors</td>
<td>Academic Difficulty (4 students)</td>
<td>“Differences in the level of subjects between first year and major courses, can’t deal with it.” * Male (Engineering)</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Low Career Expectation (3 students)</td>
<td>“I don't think my major can provide a good job to me” * Male (Engineering)</td>
<td></td>
</tr>
<tr>
<td>Low Science Identity (1 student)</td>
<td>“Humanities subjects are better than sciences.” * Male (Sciences)</td>
<td></td>
</tr>
<tr>
<td>Student-Faculty Interaction (1 student)</td>
<td>“First, major subjects are hard, and I know if I continue in this major, I can graduate but not with high grades. Secondary, the instructors are rarely good</td>
<td></td>
</tr>
<tr>
<td>Third-year Students</td>
<td>Affective Factors</td>
<td>Low Academic Self-efficacy (1 student)</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Academic Help-Seeking (1 student)</td>
<td>“Facing some difficulties in the study, the lack of resources and not clear if any are available.” *Female (Computer science)</td>
<td></td>
</tr>
<tr>
<td>Male (Mathematics)</td>
<td></td>
<td>in teaching.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Mathematics)</td>
</tr>
</tbody>
</table>

Table 11 - continued
Fourth-year Students  Affective Factors Low Sense of Belonging (1 student) “I felt like I would prosper more in another field.”  Male (Sciences) 

Low Career Expectation (1 student) “Want a major that has more opportunities in labor market” * Male (Sciences)

Above Fifth-year Students  Affective Factors Low Academic Self-efficacy (1 student) “I was facing pressure that I should transfer to another major for a better future, and also because I have difficulties in studying the subjects so my grades are bad.” * Female (Sciences)

7) What do students think about gender differences in STEM in Saudi Arabia?

When STEM students asked about the percentage of women that they expect in their academic major, about 51% of students think that women are under-represented (women are fewer than 50% of the people in their major). About 28% of students think that women are equally represented in their major, and 20% of students think that women are highly-represented (women are more than 50% of the people in their major). Table 12, shows more details about the proportion of responders.
Table 12. Students’ expectations about the percentage of women in STEM

<table>
<thead>
<tr>
<th>The expected percentage of women in STEM</th>
<th>The total number of responses</th>
<th>Response by gender:</th>
<th>Response by gender:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Women students</td>
<td>Men students</td>
</tr>
<tr>
<td>Women are fewer than 50% of the people in their major</td>
<td>53 (51%)</td>
<td>9 (29%)</td>
<td>44 (61%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sciences: 1</td>
<td>Sciences: 21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Engineering: 2</td>
<td>Engineering: 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Math: 0</td>
<td>Math: 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tech or Computer: 6</td>
<td>Tech or Computer: 6</td>
</tr>
<tr>
<td>Women are equally represented in their major</td>
<td>29 (28%)</td>
<td>10 (32%)</td>
<td>19 (26%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sciences: 6</td>
<td>Sciences: 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Engineering: 0</td>
<td>Engineering: 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Math: 1</td>
<td>Math: 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tech or Computer: 3</td>
<td>Tech or Computer: 3</td>
</tr>
<tr>
<td>Women are more than 50% of the people in their major</td>
<td>21 (20%)</td>
<td>12 (38%)</td>
<td>9 (12%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sciences: 10</td>
<td>Sciences: 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Engineering: 0</td>
<td>Engineering: 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Math: 0</td>
<td>Math: 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tech or Computer: 2</td>
<td>Tech or Computer: 4</td>
</tr>
<tr>
<td></td>
<td><strong>103 (100%)</strong></td>
<td><strong>31 (100%)</strong></td>
<td><strong>72 (100%)</strong></td>
</tr>
</tbody>
</table>
The open-ended question about gender differences in STEM shows the nature of gender issues in Saudi Arabia. Three STEM students, one female and two males, think that Saudi women have limited access and less opportunities in STEM fields than men. The qualitative content analysis shows as below in table 13.

Table 13. Students’ explanations for gender differences in STEM

<table>
<thead>
<tr>
<th>Category</th>
<th>Code/reason</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Women in STEM</td>
<td>Less opportunities in</td>
<td>“Since CS students are mostly males, the jobs offer tends to be more for men which is totally not fair.” <em>Female (Computer Science)</em></td>
</tr>
<tr>
<td></td>
<td>STEM fields</td>
<td>“There is difference in the number of students accepted into my college between males and females, as males are twice as many as females.” <em>Male (Engineering)</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>“My major is not available for women with no reason.” <em>Male (Sciences)</em></td>
</tr>
</tbody>
</table>
Discussion

The findings show a moderate mean score in the total affective engagement experiences for second-year and beyond students majoring in STEM fields at a university in Saudi Arabia. Fourth-year students had the highest affective scores, while the second-year students had the lowest affective scores. It is surprising to find that the affective engagement experiences are not growing in a linear manner; in other words, the experiences are not positively increasing in STEM as students’ progress in their academic career from second year to fifth year and beyond. Fifth-year students and above had a lower mean score than fourth-year students. As mentioned in the literature, students’ interests may strengthen or weaken in different points along their pathways in STEM (Seymour et al., 2019). However, a question rising from the results: is the longer students need to complete a degree in STEM, the lower affective engagement they have? Will that impact their persistence in the future beyond the undergraduate years?

In the open-ended question, asking students about their intentions to leave STEM, there are a total of 20 students that expressed their intentions to leave. This means about 20% of the study sample thought at some point to leave their STEM majors. From those 20 students, 14 responders were second-year students. Concerns related to the affective aspects as well as the behavioral/environmental aspects were raised among second-year students who expressed intentions to leave their STEM majors. They showed issues regarding their sense of belonging (5 students), low academic self-efficacy (7 students), low career expectation (3 students), and low science identity (1 student). They also came across academic difficulty (4 students) as well as having concerns related to the student-faculty interaction (1 student) and academic help-seeking (1 student). Considering that second-year students had the lowest affective scores, and about 26% expressed intentions to change their major out of STEM, the second year of university,
therefore, was found to be critical for students’ persistence in STEM. Those second-year students experience a variety of challenges, including affective or emotional difficulties in belonging, self-efficacy, and career expectations as well as challenges that extend into other university environmental aspects such as academic difficulty and student-faculty interaction. Therefore, the findings suggest that those students need more social and academic support to be able to retain and thrive in STEM, which is in agreement with Seymour et al.’s (2019) recommendations for STEM retention.

Moreover, our findings noted that out of the 20, three were third-year students that expressed intentions to leave their STEM majors. Their explanations for thinking about leaving were found to be related to the affective aspects, particularly their low academic self-efficacy (1 student) and the low career expectation (2 students). Also, in the fourth year and above, students showed concerns related to the low sense of belonging (1 student), the low career expectation (1 student), and the low academic self-efficacy (1 student). Therefore, STEM students need more social support along their pathways in STEM, as their interests and confidence may strengthen or weaken along the way (Seymour et al., 2019). The findings of this study support other research in the field which highlighted the significant impact of those affective factors on students’ attrition in STEM fields (Ceci & Williams, 2007; Yazilitas et al., 2013; Wang & Degol, 2017; Williams, 2018; Park et al., 2019; Avolio et al., 2020).

Furthermore, the findings revealed that there is no significant difference between men and women in their affective engagement experiences at a university in Saudi Arabia. When those STEM students asked about the percentage of women that they expect in their academic major, about 51% of students think that women are under-represented, 28% of students think that women are equally represented in their major, and 20% of students think that women are highly-
represented. Of the male participants, 61% believe that women are underrepresented in STEM majors, especially in the sciences and engineering. Looking more closely into students’ perceptions regarding the gender differences in STEM in Saudi Arabia, three students (a woman and two men) expressed the less opportunities for Saudi women in STEM fields. Even though the number of responders is low, they all mention the same problem, which is Saudi women have limited access to be fully represented in STEM. This finding is also aligned with the results of the study part I, where women expressed the unavailability to join some STEM fields in Saudi universities. Therefore, gender differences in pursuing STEM majors is still a persistent problem today, similar to a research paper by Alamri (2011). Furthermore, the findings add to Stoet and Geary’s (2018) study that less gender equality could mean less opportunities for women in STEM fields, it is not necessarily to be an indication for the high number for women in STEM as supposed by Stoet and Geary (2018).

Finally, the data indicates that STEM students across the university years had a moderate level of affective engagement experiences among the seven scales that include self-efficacy, science identity, sense of belonging, gender biased science majors, compatibility between gender and major, intention to leave, and expectancy for science career. However, second-year students showed the lowest affective scores followed by third-year students. Those students in particular expressed intentions to leave their STEM fields. The findings align with what is reported frequently in the literature—the majority of students who leave STEM fields do not persist because of their experiences in the early years (Seymour & Hewitt, 1997; Eagan et al., 2014, Seymour et al., 2019). The findings support the importance of motivational theories (Lent et al., 1994; Wigfield & Eccles, 2000) to study the affective aspects and determine student’s motivation, career behavior/choice, and career persistence in STEM.
CHAPTER V

CONCLUSIONS

Conclusion

Because of the importance of STEM fields in creating the future knowledge-based economy the Kingdom of Saudi Arabia is striving for, this study was conducted to provide more information about the undergraduate years within the STEM trajectory in Saudi Arabia. It explored the impact of external (environmental) factors on first-year students as well as internal (affective) factors on STEM students to understand their experiences along the way and what influences them to stay or leave the STEM trajectory. Results of this study indicate that improving learning experience in STEM is key if we want more students to persist and thrive in STEM fields.

First, the research concludes that the first year of university within the STEM trajectory in Saudi Arabia is an attrition critical point that needs more attention. The study revealed a low level of behavioral, environmental engagement experiences among first-year students within the scientific track in Saudi Arabia. For major selection decision, the majority of first-year students did not select STEM related majors. While 35% of students were undecided about their majors and 34% chose non-STEM fields, there were only 31% that declared STEM for their majors. This study illustrates that undecided students had a significant lower engagement than others, and also raises the question of their next step in the STEM trajectory. First-year students shared their concerns related to academic difficulty, academic help-seeking, and interactions with their faculty as explanations for being undecided about their majors or going into non-STEM fields. Based on data analysis of first-year students in the STEM trajectory, it can be concluded that
negative learning experiences during the first year of university led in losing many potential capable STEM students in Saudi Arabia.

Moreover, this research concludes that the second year of university is also critical for students’ persistence in STEM. The study revealed a moderate mean score in the total affective engagement experiences for second-year and beyond students majoring in STEM fields at a university in Saudi Arabia. While students across the university showed moderate levels of affective engagement, the second-year students had the lowest affective scores followed by third-year students. Second-year students are found to be at a higher risk for leaving, as 26% expressed intentions to change their major out of STEM. Those students experience a variety of challenges, including affective or emotional difficulties in belonging, self-efficacy, and career expectations as well as challenges that extend into other university environmental aspects such as academic difficulty and interactions with faculty. Unexpectedly, fifth-year students and above had a lower mean score than fourth-year students, which raises a question about their persistence in STEM careers beyond the undergraduate years.

Furthermore, the study revealed that there is no significant difference between men and women in their behavioral, environmental engagement experiences nor in their affective engagement experiences. The nature of the gender gap in STEM was found to be related to the less opportunities for Saudi women in STEM fields. Despite the obvious progress that has been made toward equal opportunities enhanced by Saudi Arabia’ Vision 2030, women are still facing challenges to fully access STEM fields in Saudi universities.

Finally, the study recommends placing more attention on the influential aspects of students’ experiences and providing students with more social and academic support, especially
during the early years of the STEM trajectory, as well as offering women in Saudi Arabia with more opportunities in STEM fields.

**Implications**

This study highlights that there is no one single factor that can explain the reasons behind students leaving the STEM trajectory; rather, it is a set of problems related to the lack of institutional support, faculty and their pedagogical practices, the difficulties of weed-out courses, and its curricular design. Additionally, other personal concerns including less career opportunities, loss of confidence, and changing attitudes toward STEM, also played a role in students’ attrition. Therefore, to enhance students’ retention in STEM, a systemic approach should be considered as emphasized by Seymour et al. (2019).

The study recommends paying more attention to students’ experiences in STEM courses and their connection with the university environment in Saudi Arabia. Faculty-student interactions are found in the literature to positively enhance students’ engagement, success, and retention in STEM. Both inside and outside of the classroom, faculty-student interactions are important considerations for faculty and universities in Saudi Arabia. Creating a more welcoming learning environment in introductory science courses and enhancing supportive relationships are the role of STEM professors. Also, extending the study content into informal contexts outside the classroom had a significant association with students’ engagement and success. Talking with STEM professors during office hours, joining their laboratories, and working on scientific research are great interactions to promote students pursuing STEM majors.

In addition to the critical role of positive interactions between students and faculty, instructional practice, content delivery, and curriculum design also take part in students’
persistence in STEM. The poor quality of teaching in early science courses led high qualified students to leave STEM (Seymour & Hewitt, 1997; Seymour et al., 2019). Instead of the typical lecturing, faculty may use more active learning teaching techniques which are found to promote positive learning experiences and retention in STEM. Faculty also can enhance student-student interaction in the classroom by encouraging questions and class discussion.

Universities are also play an important role to enhance students’ engagement, success, and retention in STEM fields. Universities are responsible for encouraging faculty to use interactive teaching strategies as well as offering undergraduate research opportunities to stimulate students’ interest in STEM. Assigning early intervention programs is important to support students who need more academic help in STEM courses. It will be worthwhile for universities to provide students with more academic and career advising and let students learn how STEM fields contribute to the future progress of the country. Finally, universities should increase STEM access for women and encourage them to achieve their full potential. Even though the Kingdom of Saudi Arabia is making significant improvements in terms of gender equality, universities are still slow in doing their part and opening all STEM fields for women.

**Future Work**

There are many future directions raised from the results of this study. The following areas could be tested in the future.

First, this study demonstrates that undecided students had a lower level of behavioral, environmental engagement experiences than others. Undecided students are often considered to be at a greater risk for attrition; therefore, there is a need to investigate their next steps in the
STEM trajectory—whether they go into STEM, if so, do they persistence? Do they switch into non-STEM? Or do they quit completely without obtaining a degree?

Moreover, this study shows that affective engagement experiences do not progress positively all the way from second year to fifth-year students and beyond, as fifth-year students and above had a lower mean score than fourth-year students. Therefore, a question remains to be answered is if the longer students need to complete a degree in STEM, the lower affective engagement they have? Will that impact the persistence in the future beyond the undergraduate years?

Finally, this study involves participants from only one single university in Saudi Arabia. Directions for important future work include adding other universities to have a larger picture, increasing the sample size, and conducting interviews to hear students’ voices.
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domains reproduces itself at subsequent stages of education: evidence from longitudinal PISA in


APPENDICES

Appendix A: The English version of the instrument in study part I

1- During the upcoming school year, to what extent do you expect to do the following:
Response options: never, sometimes, often, always
a. Study when there are other interesting things that you could do
b. Search for extra information to do assignments when you don’t understand the subjects
c. Participate in class discussion even if you don’t feel like to do it
d. Ask your professor for help when you face difficulties with assignment
e. Complete an educational task you started even when you face some difficulties
f. Think positively even if your performance is poor on a test or an assignment

2- During the upcoming school year, to what extent do you expect to do the following:
Response options: never, sometimes, often, always
a. Ask other students for help when you don’t understand academic subject
b. Explain academic subject for other students
c. Prepare for exams by joining group study
d. Participate in group work when you do project or assignment

3- During the upcoming school year, to what extent do you expect to do the following:
Response options: never, sometimes, often, always
a. Discuss your career plans with faculty
b. Work with faculty in activities outside the classroom
c. Discuss your academic performance and your grade with faculty
d. Discuss the course material with faculty outside the classroom (e.g. during office hours)

4- During the upcoming school year, how do you expect the difficulty of the following:
Response options: very difficult, difficult, easy, very easy

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a. Learning and understanding the academic subjects
b. Managing your time
c. Finding help regarding academic subjects
d. Communicating with faculty

5- What do you expect most of your grades will be through the upcoming school year? (select only one answer)

Response options:

a. A⁺
b. A
c. B⁺
d. B
e. C⁺
f. C or less

6- During the upcoming school year, to what extent do you expect to request help from the following sources?

Response options: never, sometimes, often, always

a. Faculty
b. Academic guide
c. Free educational supportive services such as additional lessons, teaching assistant, programs in English language, writing center, etc.
d. Friends or other students
e. Family member
f. Private lessons or other persons
g. Internet

7- How prepared are you for the upcoming school year to do the following:

Response options: not prepared at all, somewhat unprepared, somewhat prepared, well prepared

a. Writing clearly and accurately (in English)
b. Speaking clearly and fluently (in English)
c. Think analytically and critically
d. Analyze statistical and numerical information
e. Work effectively with others
f. Use computers and technology
g. Self-learning in an effective way

8- How important is to you that the university offers you the following:
Response options: not important at all, somewhat unimportant, somewhat important, very important
a. A challenging atmosphere during your academic year
b. Support to help you succeed academically
c. Help managing your non-academic responsibilities (family, work, etc.)
d. Opportunities to be socially active
e. Various activities on campus
f. Free educational supportive services (e.g. additional lessons, programs in English language, counselors to discuss raising educational performance, etc.)

9- During the upcoming school year, to what extent do you expect to do the following:
Response options: never, sometimes, often, always
a. Asking questions in the classroom
b. Participate in class discussions
c. Doing a class presentation (such as a PowerPoint presentation etc.)
d. Working with other students in a research project or a scientific experiment in the classroom

10- Do you expect to graduate from this university?
Response options: Yes. No, Uncertain

11- Do you know what major you will be in?
Response options: No, Yes. Please explain your major decision
Appendix B: The Arabic version of the instrument in study part I

1. خلال العام الدراسي القادم، ما مدى توقعاتك للقيام بالرألي؟
   خيارات الإجابة: نهائياً، أحياناً، غالباً، دائمـاً
   أ. القيام بالمهام الدراسية في ظل وجود أمور أخرى تثير إهتماك خارج إطار الدراسة
   ب. البحث عن معلومات إضافية لأداء المهام الدراسية عند الشعور بعدم فهم المحتوى الدراسي
   ج. المشاركة في النقاشات حول المواد الدراسية حتى عند الشعور بعدم الرغبة في ذلك
   د. طلب المساعدة من أستاذ المادة الدراسية عندما يصعب أداء المهام الدراسية
   ه. إنهاء مهمة دراسية قد بدأها حتى ولو واجهت بعض الصعوبات
   و. البقاء متفانياً حتى وإن كان أداء ضعيف في اختبار أو مهمة دراسية

2. خلال العام الدراسي القادم، ما مدى توقعاتك للقيام بالرألي؟
   خيارات الإجابة: نهائياً، أحياناً، غالباً، دائمـاً
   أ. طلب المساعدة من طلاب آخرين عندما يصعب فهم المادة الدراسية
   ب. شرح المادة الدراسية لطلاب أو أكثر
   ج. الاستعداد للختامات من خلال المناكرات أو المراجعة الجماعية
   د. الارتداد في عمل جماعي عند أداء مشروع بحثي أو مهمة دراسية

3. خلال العام الدراسي القادم، ما مدى توقعاتك للقيام بالرألي؟
   خيارات الإجابة: نهائياً، أحياناً، غالباً، دائمـاً
   أ. التحدث عن الخطط الوظيفية مع إحدى أعضاء هيئة التدريس
   ب. مشاركة إحدى أعضاء هيئة التدريس في أنشطة مختلفة خارج نطاق الفصل الدراسي
   ج. التحدث عن أداءك الدراسي ومناقشة درجاتك مع إحدى أعضاء هيئة التدريس
   د. مناقشة مواضيع ومفاهيم المادة الدراسية مع إحدى أعضاء هيئة التدريس خلال الصور المكتبية

4. خلال العام الدراسي القادم، ما مدى توقعاتك لصعوبة ما يلي?
   خيارات الإجابة: صعبا للغاية، صعبا، سهلا، سهلا جدا
   أ. تعلم وفهم المواد الدراسية
   ب. أدارة وقتك
   ج. الحصول على مساعدة بما يتعلق بالمواد الدراسية
   د. التواصل مع أعضاء هيئة التدريس
5- لماذا تتوقع أن تكون معظم درجاتك خلال العام الدراسي القادم؟ (اختيار أجابه واحدة فقط)

خيارات الإجابة:
- A⁺
- A
- B⁺
- B
- C⁺
- C و ما أقل

6- خلال العام الدراسي القادم، ما مدى توقعاتك لطلب المساعدة في المواد الدراسية من المصادر التالية؟

خيارات الإجابة: نهائياً، أحياناً، غالباً، دائمـاً
- A. الأساتذة وأعضاء هيئة التدريس
- B. المرشد الأكاديمي
- ج. خدمات الدعم التعليمية المجانية (مثال: دروس إضافية، أستاذ مساعد، برامج الدعم الأكاديمي في اللغة الإنجليزية، مركز الكتابة للغة الإنجليزية)
- د. أصدقاء أو طلاب آخرون
- هـ. أفراد الأسرة
- و. أشخاص آخرون
- ز. الإنترنت

7- ما مدى استعدادك للعام الدراسي القادم للفيما يلي:

خيارات الإجابة: غير مستعد إطلاقاً، غير مستعد، مستعد، مستعد للغاية
- أ. الكتابة بوضوح ودقة (باللغة الإنجليزية)
- ب. التحدث بوضوح وطلاقة (باللغة الإنجليزية)
- ج. التفكير بشكل تحليلي ونتقددي
- د. تحليل المعلومات الإحصائية والعدنية
- هـ. العمل بفعالية مع الآخرين
- و. استخدام الحاسب الآلي وتطبيقات البيانات
- ز. التعلم الذاتي بطريقة فعالة

8- ما مدى أهمية أن تقدم الجامعة لك ما يلي:

خيارات الإجابة: غير مهم أطلاقاً، غير مهم، مهم جداً
- أ. خلق جو من التحدي والمنافسة حيث يتطلب منك بذل أفضل ما عندك خلال السنة الدراسية
ب. تقديم الدعم لمساعدتك على النجاح دراسياً
ج. المساعدة في إدارة مسؤولياتك غير الدراسية (فيما يخص الأسرة أو العمل وما إلى ذلك)
د. توفير لك الفرص لتكون نشطاً اجتماعياً
ه. توفير فعاليات وأنشطة مختلفة داخل الحرم الجامعي
و. توفير خدمة تعليمية مجانية (مثال: دروس إضافية، برامج دعم في تعليم اللغة الإنجليزية، دورات تدريبية لرفع أدائك الأكاديمي وما إلى ذلك)

9. خلال العام الدراسي القادم، ما مدى توقعاتك للقيام بالتالي:
خيار الإجابة: نهائياً، أحياناً، غالباً، دائمياً
أ. طرح أسئلة داخل الفصل الدراسي
ب. المشاركة في مناقشات الفصل
ج. تقديم عرض دراسي (مثل عرض بوربوينت وما إلى ذلك)
د. العمل مع طلاب أخرون في مشروع بحثي أو تجربة علمية داخل الفصل الدراسي

10. هل تتوقع التخرج من هذه الجامعة؟
خيار الإجابة: نعم، لا، غير متأكد

11. هل تعرف ماذا سيكون تخصصك؟
خيار الإجابة: لا، الرجاء شرح قرارك للتخصص

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Date: October 27, 2020

To: Brandy Pleasants, Principal Investigator
   Manal Almalki, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair

Re: IRB Project Number 20-10-14

This letter will serve as confirmation that your research project titled "Measuring Students' Behavioral Engagement During the First Year of University and Their Choice of Academic Majors: A Study in A Saudi Context" has been approved under the exempt category of review by the Western Michigan University Institutional Review Board (IRB). The conditions and duration of this approval are specified in the policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may only be conducted exactly in the form it was approved. You must seek specific board approval for any changes to this project (e.g., add an investigator, increase number of subjects beyond the number stated in your application, etc.). Failure to obtain approval for changes will result in a protocol deviation.

In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the IRB for consultation.

The Board wishes you success in the pursuit of your research goals.

A status report is required on or prior to (no more than 30 days) October 26, 2021 and each year thereafter until closing of the study.

When this study closes, submit the required Final Report found at https://wmich.edu/research/forms.

Note: All research data must be kept in a secure location on the WMU campus for at least three (3) years after the study closes.
Anonymous Survey Consent in English

Western Michigan University
Mallinson Institute for Science Education

Principal Investigator: Dr. Brandy Pleasants

Student Investigator: Manal Almaki

You are invited to participate in this research project titled "Measuring Students' Behavioral Engagement during the First Year of University and Their Choice of Academic Majors: A study in a Saudi context"

STUDY SUMMARY: This consent form is part of an informed consent process for a research study and it will provide information that will help you decide whether you want to take part in this study. Participation in this study is completely voluntary. You may choose to not answer any question. The purpose of the research is to measure student engagement during the first year of university. This project will serve as Manal Almalki’s dissertation research for the requirements of the Ph.D. in science education. If you take part in the research, you will be asked to fill out a survey. Your time in the study will take about 10 minutes to complete the survey. Your replies will be completely anonymous, so do not need to put your name on the survey. Possible risk and cost to you for taking part in the study may be your time to complete the survey, and you can stop any time without penalty. There is no direct benefit to you for participating in the study. However, the results of the study using this survey may help Saudi Universities better understand factors that impact student retainment in the sciences. Your alternative to taking part in the research study is not to take part in it.

The survey for this research will not be used by or distributed to other investigators for another research. The data may be kept in case of future questions regarding the result of the study.

Should you have any questions prior to or during the study, you can contact the principal investigator: Dr. Brandy Pleasants at [+1(269) 387-3336] or [brandy.pleasants@wmich.edu] or the student investigator: Manal Almalki at [+1 (269) 271-4731 / +966530111915] or [manalajrans.almalki@wmich.edu]. You may also contact the Chair, Institutional Review Board at 269-387-8293 or the Vice President for Research at 269-387-8298 if questions arise during the course of the study.

This consent has been approved by the Western Michigan University Institutional Review Board (WMU IRB) on (October 27, 2020).

Participating in this survey indicates your consent for use of the answers you supply.

I agree to participate in this research study (Survey following upon clicking)
I do not agree to participate in this research study (Browser closes)
تمت دعوتكم للمشاركة في مشروع بحثي بعنوان "قياس المشاركة السلوكية لطلاب السنة التحضيرية المسار العلمي والتوجه التخصصي المرغوب".

ملخص الدراسة: يعد نموذج الموافقة هذا جزءًا من عملية الموافقة المسبقة لدراسة بحثية وسوف يوفر معلومات ستساعدك في تحديد ما إذا كنت ترغب في المشاركة في هذه الدراسة. المشاركة في هذه الدراسة طوعية تمامًا. الغرض من البحث هو قياس مشاركة طلاب السنة التحضيرية في المسار العلمي ومعرفة توجهاتهم التخصصية. سيكون هذا المشروع البحثي بمثابة الرسالة العلمية للباحثة منال المالكيぶりتيل ثلاثية الدكتوراه في تعليم العلوم. إذا شاركت في البحث، سيطلب منك ملء الاستبيان ويستغرق أعمالك 10 دقائق تقريبا. ستكون إجاباتك محفوظة المصدر تمامًا، لذلك لا تحتاج لمعرفة اسمك. لا توجد تكلفة لهذه الدراسة باستثناء وقت، ويمكنك التوقف في أي وقت أردت. لا توجد فائدة مباشرة لك للمشاركة في الدراسة. ومع ذلك، فإن نتائج الدراسة قد تساعد الجامعات السعودية على فهم العوامل التي تؤثر على بقاء الطلاب في مجالات العلوم بشكل أفضل. إن البديل عن المشاركة في الدراسة البحثية هو عدم المشاركة فيها.

لا توجد تكلفة لهذه الدراسة باستثناء وقتك، ويمكنك التوقف في أي وقت أردت. لا توجد فائدة مباشرة لك للمشاركة في الدراسة. ومع ذلك، فإن نتائج الدراسة قد تساعد الجامعات السعودية على فهم العوامل التي تؤثر على بقاء الطلاب في مجالات العلوم بشكل أفضل. إن البديل عن المشاركة في الدراسة البحثية هو عدم المشاركة فيها.

إذا كنت لديك أي أسئلة قبل أو أثناء الدراسة يمكنك التواصل مع رئيس البحوث د. براندي بلانتس رقم هاتف: +1 269-387-3336 أو بريد إلكتروني: brandy.pleasants@wmich.edu

أيضاً تستطيع التواصل مع الباحثة منال المالكي رقم هاتف: +966530111 أو بريد إلكتروني: manalajrans.almalki@wmich.edu

في حال تواجد أسئلة أثناء الدراسة، يمكنك أيضًا الاتصال برئيس مجلس مراجعة البحوث المؤسسية على الرقم +1 269-387-8293 أو نائب الرئيس للبحوث على الرقم: +1 269-387-8298


تشير المشاركة في هذا الاستطلاع إلى مواقفك على استخدام الإجابات التي تقدمها.

أوافق على المشاركة في هذه الدراسة البحثية (الاستبيان يتبع عند النقر)

لا أوافق على المشاركة في هذه الدراسة البحثية (يغلق المنصفح)
Appendix D: The English version of the instrument in study part II

1. What is your current academic major?
   a) Sciences (Chemistry, Biology, Physics, Biochemistry, Astronomy, Earth Sciences …)
   b) Mathematics or Statistics
   c) Computer science or Information technology
   d) Engineering (Industrial, Civil, Electrical, Mechanical, Chemical…)
   e) Other; specify your major……

2. What year are you in at university?
   a) Second-year student
   b) Third-year student
   c) Fourth-year student
   d) Fifth-year student
   e) Above

3. What is your gender?
   a) Male
   b) Female

4. What is your GPA?
   a) 4.50 and above
   b) Between 3.75 to 4.49
   c) Between 2.75 to 3.74
   d) Between 2 to 2.74
   e) 1.99 and below

5. Based on your feelings and study experiences in your current major, how much do you agree or disagree with the following statements:
   Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree
   a) I feel confident in my ability to learn my coursework
   b) I am able to learn my coursework
   c) I can reach my academic goals in my coursework
   d) I feel that I can face the challenges and do well in my courses

6. Based on your feelings and study experiences in your current major, how much do you agree or disagree with the following statements:
   Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree
   a) In general, being in my current major is an important part of my self-image.
b) My interest in my current major reflects an important aspect of my personality.
c) I feel like I belong to the scientific field.
d) I have a strong sense of belonging to the community of scholars in my major.
e) I am a scientist in my field.

7. A “scientific community” is a community of experts, researchers, and scientists in a specific area of study. Based on your feelings and study experiences in your current major, how much do you agree or disagree with the following statements:

Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree

a) I feel like I belong to the scientific community
b) I consider myself a member of the scientific community
c) I feel like I am a part of the scientific community
d) I feel connected to the scientific community
e) I feel respected by people in my major
f) I feel ignored by people in my major
g) I feel appreciated by people in my major
h) I feel compatible with people in my major

i) I feel comfortable in my classes
j) I feel nervous in my classes
k) I feel satisfied by my classes

l) I hope no one notices me
m) I try to talk as little as possible
n) I enjoy being an active student

8. “Gender identity” means an individual’s self-perception as male or female. Based on your feelings and study experiences in your current major, how much do you agree or disagree with the following statements:

Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree

a) I think my gender identity will impact how others view me in my major.
b) I think my gender identity will impact how well my academic performance in my major.
c) I think my gender identity and my major are very compatible.
d) I think I had difficulties in my major because of my gender identity.
e) I think my gender identity will play an important role in the kind of career I decide to have.
f) I think I wouldn't want to work in some fields because of my gender identity.
9. “Sexism” occurs when a person is treated unfairly by others because of his/her gender identity. Based on your feelings and study experiences in your current major, how much do you agree or disagree with the following statements:

Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree

a) Women in my major are suffering from sexism because they are female.
b) Women face difficulties in achieving success in my major.
c) My major welcomes men more than women.

10. Please, explain if you have had a similar experience of sexism during your educational years, whether you are a male or a female?

11. What is the approximate percentage of women that you generally expect in your academic major?

a) Fewer than 50% of the people in my major are women.
b) About 50% of the people in my major are women.
c) More than 50% of the people in my major are women.

12. “Intention to leave” means that planning to leave a major or searching for alternative area of study during university years. Based on your feelings and study experiences in your current major, how much do you agree or disagree with the following statements:

Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree

a) During my university years, I thought about transferring to another non-scientific major. (E.g., from the college of science to the college of economics and administration, from the college of science to the college of arts and humanities...etc.)
b) During my university years, I thought about transferring to another scientific major. (E.g., from sciences to engineering, from engineering to computer, from chemistry to biology...etc.)

13. Please, explain why did you want to transfer?...

14. Do you have a friend or colleague who transferred from a scientific major to another non-scientific major?
   Yes, No

15. Please explain why your friend left the scientific disciplines?...
16. Based on your feelings and study experiences in your current major, how much do you agree or disagree with the following statements:

Strongly disagree; Somewhat disagree; Neither agree nor disagree; Somewhat agree; Strongly agree

a) I will enjoy working in my field of study.
b) I have good feelings about working in my field of study.
c) It would be interesting to have a career in my major.
d) I want to get a job in my field of study.
Appendix E: The Arabic version of the instrument in study part II

1- ما هو قسمك الدراسي الحالي؟
أ. علوم (كيمياء، أحياء، كيمياء حيوية، فيزياء، فلك، علوم الأرض...)
ب. رياضيات أو أبحاث
ج. حسابات أو تقنية معلومات
د. هندسة (صناعية، مدنية، كهربائية، ميكانيكية، كيميائية...)
هـ. غير ذلك: أذكر التخصص...

2- انت الآن في السنة الجامعية.....؟
أ. الثانية
ب. الثالثة
ج. الرابعة
د. الخامسة
هـ. السادسة
و. أكثر من ذلك

3- ما هو جنسيك؟
أ. ذكر
ب. أنثى

4- ما هو معدلك التراكمي؟
أ. 4.50 وما أعلى
ب. ما بين 3.75 إلى 4.49
ج. ما بين 2.75 إلى 3.74
د. ما بين 2 إلى 2.74
هـ. 1.99 وما أقل

5- بناءً على مشاعرك وتجربتك الدراسية في تخصصك الحالي، ما مدى اتفاقك أو اختلافك مع العبارات التالية:
أختلف بشدة.. أختلف بعض الشيء.. محبب.. أتفق نوعا ما.. أتفق بشدة
أ. أشعر بالثقة في قدرتي على تعلم المقررات الدراسية
ب. أنا قادر على تعلم المقررات الدراسية
ج. أستطيع الوصول لأهدافي الدراسية
د. أشعر بأنني قادر على مواجهة التحديات والقيام بالأداء الجيد في المقررات الدراسية

6ـ بناءً على مشاعرك وتجربتك الدراسية في تخصصك الحالي، ما مدى اتفاقك او اختلافك مع العبارات التالية:
أختلف بشدة.. أختلف بعض الشيء.. محبب.. أتفق نوعا ما.. أتفق بشدة
أ. بشكل عام، وجودي في قسمي الحالي يعتبر جزء مهم من صورتي الذاتية عن نفسي
ب. اهتمامي بخصصي الحالي يمكن جانب مهم في شخصيتي
ج. أشعر وكأنني أنتمي للعالم العلمي
د. لدي شعور قوي بالانتماء لمجتمع العلماء في تخصصي
ه. أنا عالم/بة في تخصصي

7ـ "المجتمع العلمي" هو مجتمع من الخبراء والباحثين والعلماء في نطاق علمي محدد.
بناءً على مشاعرك وتجربتك الدراسية في تخصصك الحالي، ما مدى اتفاقك او اختلافك مع العبارات التالية:
أختلف بشدة.. أختلف بعض الشيء.. محبب.. أتفق نوعا ما.. أتفق بشدة
أ. أشعر بأنني أنتمي إلى المجتمع العلمي
ب. أعتبر نفسي عضواً في المجتمع العلمي
ج. أشعر أنني جزء من المجتمع العلمي
د. أشعر بارتباط نحو المجتمع العلمي
د. أشعر باحترام الناس لي في تخصصي
د. أشعر بالانتماء بالدا للفصل الدراسي
د. أشعر بالراحة داخل الفصل الدراسي
ب. أشعر بالتوتر داخل الفصل الدراسي
ه. أنا عالم/بة في تخصصي

ج. أشعر بالرضا داخل الفصل الدراسي

أ. أتمنى ألا يلاحظني أي شخص
ب. أحاول أن أقلل حديثي قدر المستطاع
ج. أستمتع بكوني طالب/ة نشيط

8-"الهوية الجنسية" تعني نوع جنسك ذكر أو أنثى. بناءً على مشاعرك وتجربتك الدراسية في تخصصك الحالي، ما مدى اتفاقك أو اختلافك مع العبارات التالية:

أختلف بشدة.. أختلف بعض الشيء.. محايد.. أتفق نويا ما.. أتفق بشدة
أ. أعتقد أن هويتي الجنسية لها تأثير على نظرة الآخرين لي في تخصصي
ب. أعتقد أن هويتي الجنسية لها تأثير على أدائي الأكاديمي الجيد في تخصصي
ج. أعتقد أن هويتي الجنسية وخصصي الدراسي متواقيين جداً
د. أعتقد أنني واجهت صعوبات في تخصصي بسبب هويتي الجنسية
ه. أعتقد أن هويتي الجنسية سيكون لها دور مهم في نوع المهنة التي سأمارسها
و. أعتقد أنني لن أرغب بالعمل في بعض المجالات بسبب هويتي الجنسية

9-"التحيز الجنسي" يحدث عندما يعامل الآخرون الشخص بشكل غير عادل بسبب هويته الجنسية. بناءً على مشاعرك وتجربتك الدراسية في تخصصك الحالي، ما مدى اتفاقك أو اختلافك مع العبارات التالية:

أختلف بشدة.. أختلف بعض الشيء.. محايد.. أتفق نويا ما.. أتفق بشدة
أ. المرأة في تخصصي تعاني من التحيز الجنسي لكونها أنثى
ب. تواجه المرأة صعوبات في الوصول للنجاح في تخصصي
ج. تخصصي يرحب بالرجال أكثر من النساء

10- سواء كنت طالب أو طالبة، من فضلك، اشرح/ي إذا مررت بتجربة مماثلة للتحيز الجنسي خلال مسيرتك التعليمية؟

الإجابة: .......

11- ما هي النسبة المئوية التقديرية التي تتوقع/ي أن تشكلها المرأة بشكل عام في تخصصك الدراسي؟

أ. تشكل النساء في تخصصي نسبة أقل من 50%
ب. تشكل النساء في تخصصي نسبة تعاون 50%
ج. تشكل النساء في تخصصي نسبة أكثر من 50%

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"نية المغادرة" تعني التفكير في التحويل من تخصص لأخر، أو البحث عن مجال دراسي بديل خلال سنوات الدراسة الجامعية.

بناءً على مشاعرك وتجربتك الدراسية في تخصصك الحالي، ما مدى اتفاقك أو اختلافك مع العبارات التالية:

أ. خلال سنوات دراستي، فكرت بالتحويل لتخصص آخر غير علمي (AMPLE: التحويل من كلية العلوم إلى كلية الاقتصاد والإدارة، التحويل من كلية العلوم إلى كلية الآداب والمعرفة الإنسانية...) إلخ.

ب. خلال سنوات دراستي، فكرت بالتحويل لتخصص علمي آخر (AMPLE: التحويل من العلوم إلى الهندسة، التحويل من العلوم إلى الهندسة...) إلخ.

الحاسب، التحويل من الكيمياء إلى الأحياء...) إلخ.

أختفت بشدة.. أختلف بعض الشيء.. محابيد.. أتفق نوعا ما.. أتفق بشدة

أ. سوف أستمتع بالعمل في مجال دراسي

ب. لدي مشاعر جيدة حول العمل في مجال دراسي

ج. سيكون من الممتع الحصول على مهنة في تخصصي

د. أرغب في الحصول على وظيفة في مجال دراسي

الإجابة: ........

هل لديك صديق أو زميل قام بالتحويل من تخصص علمي إلى تخصص آخر غير علمي؟

الإجابة: نعم، لا

من فضلك، أذكر لماذا غادر صديقك التخصص العلمي؟

الإجابة: .......

بناءً على مشاعرك وتجربتك الدراسية في تخصصك الحالي، ما مدى اتفاقك أو اختلافك مع العبارات التالية:

أ. أختلف بشدة.. أختلف بعض الشيء.. محابيد.. أتفق نوعا ما.. أتفق بشدة

أ. سوف أستمتع بالعمل في مجال دراسي

ب. لدي مشاعر جيدة حول العمل في مجال دراسي

ج. سيكون من الممتع الحصول على مهنة في تخصصي

د. أرغب في الحصول على وظيفة في مجال دراسي

من فضلك، اشرح لي رغبتك في التحويل وسببها؟

الإجابة: ........

هل لديك صديق أو زميل قام بالتحويل من تخصص علمي إلى تخصص آخر غير علمي؟

الإجابة: نعم، لا

من فضلك، أذكر لماذا غادر صديقك التخصص العلمي؟

الإجابة: .......

بناءً على مشاعرك وتجربتك الدراسية في تخصصك الحالي، ما مدى اتفاقك أو اختلافك مع العبارات التالية:

أ. أختلف بشدة.. أختلف بعض الشيء.. محابيد.. أتفق نوعا ما.. أتفق بشدة

أ. سوف أستمتع بالعمل في مجال دراسي

ب. لدي مشاعر جيدة حول العمل في مجال دراسي

ج. سيكون من الممتع الحصول على مهنة في تخصصي

د. أرغب في الحصول على وظيفة في مجال دراسي

الإجابة: ........
Appendix F: Western Michigan University Institutional Review Board Letter for Study Part II

Approval and Anonymous Survey Consent in English & Arabic

Date: September 30, 2021

To: Brandy Pleasants, Principal Investigator
   Manal Almalki, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair

Re: IRB Project Number 21-09-24

This letter will serve as confirmation that your research project titled “Undergraduate Saudi Students’ Experiences in STEM Fields and their Future Career Plans” has been approved under the exempt category of review by the Western Michigan University Institutional Review Board (IRB). The conditions and duration of this approval are specified in the policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may only be conducted exactly in the form it was approved. You must seek specific board approval for any changes to this project (e.g., add an investigator, increase number of subjects beyond the number stated in your application, etc.). Failure to obtain approval for changes will result in a protocol deviation.

In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the IRB for consultation.

The Board wishes you success in the pursuit of your research goals.

A status report is required on or prior to (no more than 30 days) September 29, 2022 and each year thereafter until closing of the study. The IRB will send a request.

When this study closes, submit the required Final Report found at https://wmich.edu/research/forms.

Note: All research data must be kept in a secure location on the WMU campus for at least three (3) years after the study closes.
Anonymous Survey Consent in English

Western Michigan University
Mallinson Institute for Science Education

Principal Investigator: Dr. Brandy Pleasants

Student Investigator: Manal Almalki

You are invited to participate in this research project titled "Undergraduate Saudi students’ experience in STEM fields and their future career plans"

STUDY SUMMARY: This consent form is part of an informed consent process for a research study and it will provide information that will help you decide whether you want to take part in this study. Participation in this study is completely voluntary. You may choose to not answer any question. The purpose of the research is to measure your experiences and feelings in your current major and looking to know your future career plane. This project will serve as Manal Almalki’s dissertation research for the requirements of the Ph.D. in science education. If you take part in the research, you will be asked to fill out a survey. Your time in the study will take about 10 minutes to complete the survey. Your replies will be completely anonymous, so do not need to put your name on the survey. Possible risk and cost to you for taking part in the study may be your time to complete the survey, and you can stop any time without penalty. There is no direct benefit to you for participating in the study. However, the results of the study using this survey may help Saudi Universities better understand factors that impact student retainment in STEM. Your alternative to taking part in the research study is not to take part in it.

The survey for this research will not be used by or distributed to other investigators for another research. The data may be kept in case of future questions regarding the result of the study.

Should you have any questions prior to or during the study, you can contact the principal investigator: Dr. Brandy Pleasants at [+1(269) 387-3336] or [brandy.pleasants@wmich.edu] or the student investigator: Manal Almalki at [+1 (269) 271-4731 / +966530111915] or [manalajrans.almalki@wmich.edu]. You may also contact the Chair, Institutional Review Board at 269-387-8293 or the Vice President for Research at 269-387-8298 if questions arise during the course of the study.

This consent has been approved by the Western Michigan University Institutional Review Board (WMU IRB) on (September 30, 2021).

Participating in this survey online indicates your consent for use of the answers you supply.

I agree to participate in this research study (Survey following upon clicking)

I do not agree to participate in this research study (Browser closes)
نموذج الموافقة المسبقة - جامعة ميشيغان الغربية

رئيس البحث: د. براندي بلاستنس
طالب البحث: منال المالكي

تمت دعوتك للمشاركة في مشروع بحثي بعنوان "قياس تجربة الطلاب الحاليين في الأقسام العلمية والتعرف على خططهم المستقبلية".

ملخص الدراسة: يعد نموذج الموافقة هذا جزءًا من عملية الموافقة المسبقة لدراسة بحثية وسوف يوفر معلومات ستساعدك في تفهيم ما إذا كنت ترغب في المشاركة في هذه الدراسة. المشاركة في هذه الدراسة طوعية تمامًا. الهدف من الدراسة هو قياس تجربة الطلاب في هذه الدراسة وتحديد ما إذا كنت ترغب في المشاركة. سينتهي الطلب في الدراسة بمجرد اجابةك، أو إذا لم ترغب في المشاركة، يمكنك الانتظار حتى تبينك التوقيت، وربما ترغب في المشاركة في الدراسة في وقت لاحق.

الدراسة قد تساعد الجامعات السعودية على فهم العوامل التي تؤثر على بقاء الطلاب في المجالات العلمية بشكل أفضل. إن البديل عن المشاركة في الدراسة البحثية هو عدم المشاركة فيها.

لا يتم استخدام أو توزيع بيانات هذه الاستبيان لأي أبحاث أخرى. قد يتم الاحتفاظ بالبيانات لدى الباحث فقط في حالة وجود أسئلة في المستقبل من نتائج الدراسة.

إذا كانت لديك أي أسئلة قبل أو أثناء الدراسة يمكنك التواصل مع رئيس البحث د. براندي بلاستنس رقم هاتف:

+269-387-3336  أو بريد إلكتروني:
[brandy.pleasants@wmich.edu]

أيضاً تستطيع التواصل مع الباحثة منال المالكي رقم هاتف:

+269-271-4731  أو بريد إلكتروني:
[manalajrans.almalki@wmich.edu]

في حال تواجد أسئلة أثناء الدراسة، يمكنك أيضا الاتصال برئيس مجلس مراجعة البحوث المؤسسية على الرقم

+269-387-8293  أو نائب الرئيس للبحوث على الرقم:
+269-387-8298

تمت الموافقة على وثيقة الموافقة المسبقة هذه من قبل مجلس المراجعة المؤسسية لجامعة غرب ميشيغان بتاريخ 09-30-2021

تشير المشاركة في هذا الاستطلاع إلى موافقتك على استخدام الإجابات التي تقدمها.

أوافق على المشاركة في هذه الدراسة البحثية (لا تغلق المتصفح)
أوافق على المشاركة في هذه الدراسة البحثية (الاستبانة تغلب عند النقر)
لا أوافق على المشاركة في هذه الدراسة البحثية (تغلق المتصفح)