DROPOUTS OF WOMEN IN ENGINEERING STUDIES: A COMPARABLE CASE

Neta Kela-Madar, SCE Engineering College, Israel
Avshalom Danoch, Sami Shamoon College of Engineering, Israel
Lorenzo Salas Morera, University of Cordoba, Spain

ABSTRACT

In this longitudinal study, factor analysis was used to determine the reasons why female engineering students elect to dropout. Data was collected over five years from students at SCE Engineering College. The various reasons for dropping out were documented through a questionnaire that students were obligated to submit before dropping out. The analytical results allude to broad socio-cultural factors such as gender roles in the Middle East, the fact that the population of the college is largely from a low-middle socioeconomic background, and the rigor of the academic and subsequent professional trajectory. These findings serve as a basis for developing a gender cognitive engineering curriculum for female students to increase female representation in the field and make engineering studies more welcoming for female students.

Keywords: Educational Data Mining (EDM), Science Technology Engineering and Mathematics (STEM)

INTRODUCTION

Engineering permeates today's world and is found in activities and industries as diverse as construction, technology, manufacturing, energy, computers, information technology, and electronics, to name a few. This underscores the importance of engineering studies and education, and the need for student retention, degree completion, and successful entrance into and advancement in the engineering labor market for graduates (Kuley et al., 2015).

Despite the clear need for successful engineering students and professionals, engineering degree programs face a markedly high dropout rate (Böttcher et al., 2020), and a staggering gender imbalance (OECD, 2020). This gender imbalance is reflected in engineering professions as well (Buse, 2018). There are many studies that have been conducted to explain these phenomena. Most basically, the very nature of engineering as a rigorous and difficult field of study is cited as a reason for high student dropout rates and a gender imbalance, especially in light of engineering's required competence in mathematics and physics - disciplines historically and persistently underrepresented by women (Paura & Arhipova, 2016).

Gender, socioeconomic factors, financial limitations, poor class attendance, early marriage, parental pressure, job opportunity, and demographics have been studied to explain the difficulty of successful degree completion in engineering and subsequent gainful employment (Meyer & Marx, 2014). Women accounted for an almost negligible percentage of engineering students for the first seven decades of the 20th century, with a rise in the 1970s and 80s, then a decline after 1986. The gender gap in the engineering profession - in the post-education labor market - is even starker. While women comprise nearly 50 percent of the general population and just under half of the workforce in the United States, as of 1988 women represent only four

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percent of practicing engineers (Felder et al., 1995). According to a recent study, women make up approximately 47% of the US workforce, but remain underrepresented in engineering, computer sciences, and the physical sciences (Mostafa, 2019; White & Massiha, 2016).

What's prima facie contradictory is that, according to Castagnetti & Rosti (2010), we are experiencing a worldwide change in academic outcomes between genders in OECD countries, with female graduates now exceeding male graduates and, on average, female students outperforming male students in academic achievement (Parajuli & Thapa, 2017).

This paper analyzes dropout's rates, gender differences and reasons for dropouts during the years 2014-2018 in the largest engineering college in Israel, SCE engineering college in comparison with Córdoba University, Spain. The theoretical background focuses particularly on the difference in male and female entrance into engineering programs, retention, academic performance, degree completion, and success in engineering professions. In general, dropouts refer to discontinuing the coursework in studies due to their own decision or the education institute decision (Morrow, 1986).

THE CHALLENGE OF CURBING STUDENT DROPOUT

Student dropout rate is a fascinating subject and a challenging problem and is a major concern in education and policy-making communities. Roughly 40% of students seeking bachelor's degrees do not finish within six years, with universities losing tens of billions of dollars as a result, and without recourse to recover lost resources spent on students who do not complete their degrees. Approximately 30% of first-year students at American baccalaureate institutions dropout before their second year, costing these institutions nearly nine billion dollars in wasted resources (Aulck et al., 2016).

The student dropout rate is especially alarming, and perplexing, among students of engineering. Even in developed European countries, engineering students face a staggering 40-50 percent dropout rate in their first year, and in some engineering disciplines, this percentage jumps to as high as 80 percent (Sultana et al., 2017). In the United States, according to the American Society for Engineering Education, this high percentage of dropout found in European countries is practically the same in American universities (Paura & Arhipova, 2016).

Established reasons for dropouts include financial strain and limitation, insufficient class attendance, parental pressure, job opportunity, early marriage, demographic attributes, and poor academic performance (Meyer & Marx, 2014). Literature shows that these reasons for dropout in higher education are on average similar in both advanced and developing countries (Sultana et al., 2017).

In a recent study focusing on Electrical Engineering, Sultana, et al. (2017) utilized cognitive and noncognitive features of students for predicting their results, as well as individual cognitive features that should be considered by students and universities. Their research suggests that incorporating cognitive features increases prediction accuracies in some analytical techniques, and that identifying individual cognitive features will help curb dropouts.

Another resource to help improve decision making in the educational process to curb dropouts is Educational Data Mining (EDM). EDM is a relatively new field and explores educational data from educational systems to meaningfully generate information to improve the educational process, including retention. EDM involves selecting desired data and processing that data, transforming it into correct formatting, applying data mining methods and techniques on that data, then interpreting and evaluating the results (Nagy & Molontay, 2018).

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Previous research focusing only on cognitive features diminishes the accuracy of insight into performance and dropout rates of students and specifically women students in engineering. Cognitive features include gender, age, marital status, number of children, occupation, computer literacy, marks in face-to-face meetings and in examinations, country, achievement scores, and university majors (Alban & Mauricio, 2019).

Non-cognitive features are equally if not more important to consider as they consider the impact of behavior, attitude, environment of the student, time management, self-concept, self-appraisal, community support, self-image, leadership, motivation, creativity, extroversion, among other factors (Salas-Morera et al., 2019). Combining cognitive and noncognitive features into studies proves the most accurate and effective.

THE UNDERREPRESENTATION OF WOMEN IN ENGINEERING

As mentioned before, women account for an almost negligible percentage of engineering students and therefore there is a gender gap in the engineering, although we are experiencing a worldwide change in academic outcomes between genders in UE countries, with female now exceeding male enrollments (Eurostat, 2020). As a matter of fact, women are more likely to achieve tertiary education than men in all OECD countries but there are important gender disparities in fields of study. In most countries, women are a clear majority in health and welfare, while they are under-represented in STEM (OECD, 2020). However, male graduates still outperform female graduates in terms of outcomes in the labor market (Francesconi & Parey, 2018). Despite getting a smaller return on their efforts than their male counterparts, thus decreasing their motivation for high academic achievement, female students put more effort into their studies even while realizing their chances in the post-academic labor market are less, in order to "*signal*" their ability to potential employers.

WOMEN STUDENTS IN ENGINEERING

Consistent in the literature is that engineering degree programs and the engineering labor market and professions are heavily male dominated, despite female students outperforming their male counterparts in their academic studies. Wages for women are lower, even at the beginning of their careers, and this observation holds even after controlling for education level and other factors (Leuze & Strauß, 2016).

There are many studies documenting the underrepresentation of women students of engineering and in the profession, with numerous factors shown to contribute to this imbalance. What's initially perplexing is that nearly all studies show female students performing well if not better than their male counterparts in their college years, even when controlling for university, course, and degree program selectivity, and within degree programs, which vary in terms of their grading and performance standards, e.g., in science, technology, engineering, and mathematics (STEM) vs. non-STEM fields of study (Vossensteyn et al., 2015).

There are intrinsic difficulties to studying female dropout rates. Studies differ in terms of country context, operation, and methodological design. Moreover, it is difficult to isolate dropout decisions versus changes in fields of study. While women's grades in higher education are on average higher than men's, in gender atypical fields of study such as engineering, factors play against women that influence dropout, such as disproportionate self-criticism of personal abilities and performance, which can be reinforced institutionally and amongst peers (Meyer & Strauß, 2019). In this sense, women leave engineering degrees partially due to low self-assessment of

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their skills in STEM's intellectual tasks (Sax et al., 2015), not because of their performance (Cech et al., 2011).

In conclusion, there are varied factors that explain why, despite performance and qualifications, women are studying engineering fields and entering engineering professions at a lesser rate than men. Factors include: women lacking in information and mentors at the time of deciding upon majors; the negative perception of women in engineering (Sherwen, 2017); the male-dominate atmosphere in business and industries; as well as disadvantages in terms of physical strength and ability to handle machine-tools. Other studies have cited the "*domestic factor*" - time dedicated to household help (Young & Choi, 2015), and family factors, such as the inability to obtain help from family members, as well as pressures to enroll in degrees of a more "*traditional female field*" (Cordova-Wentling & Camacho, 2006).

The literature has shown that future research needs to focus on a multitude of diverse factors to explain and develop correctives to the gender imbalance of women studying engineering and working in engineering professions. Some of the most promising factors identified for future study include: social and cultural norms; support networks at home and at institutions of study; self-assessment of ability and performance; disproportionate household responsibilities; gender stereotypes; and cognitive and non-cognitive features of students.

DESIGN/ METHODOLOGY/ APPROACH

A collection of 19,527 students data was analyzed for five years (year 2014-3894 students, year 2015-3869 students, year 2016-3906 students, year 2017-3923 students, year 2018-3935 students) in a SCE engineering college. The drop out student's data was analyzed and quantified to learn about the gender difference and reasons for dropouts. The data of reasons for dropouts was collected from a form that students were obligated to complete before dropping out. The dropout data collected was contrasted with comparable data from Cordoba University (Spain) engineering degrees. In this case, data from a total of 1973 students entering between 2014 and 2017 (522, 509, 505, and 437, respectively).

In this longitudinal research we analyzed the percentage of dropout's from a main group of 19,527 students from SCE engineering college in Israel and from a secondary group of 1973 students from Cordoba University engineering degrees, between 2014 and 2017. Figures 1 and 2 shows the total number of male and female students entering SCE and Córdoba University during the period analyzed. As expected, the vast majority of students were male. Figures 3, 4, 5 and 6 show the number of students dropouts in absolute numbers and in percentages respectively, showing the major tendency of women to abandon their studies.

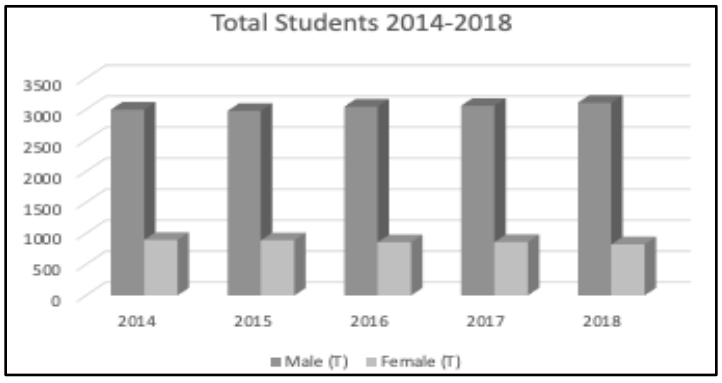

FIGURE 1

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NUMBER OF THE TOTAL NUMBER OF MALE AND FEMALE STUDENTS ENTERING SCE DURING THE PERIOD ANALYZED

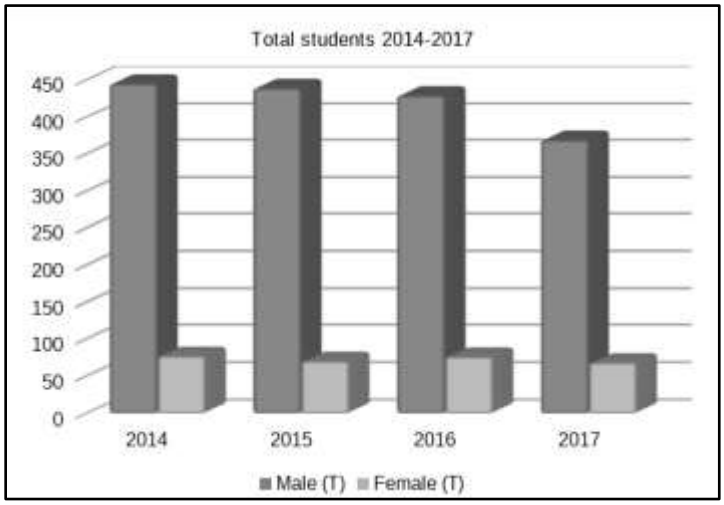

FIGURE 2
NUMBER OF THE TOTAL NUMBER OF MALE AND FEMALE STUDENTS CÓRDOBA UNIVERSITY DURING THE PERIOD ANALYZED

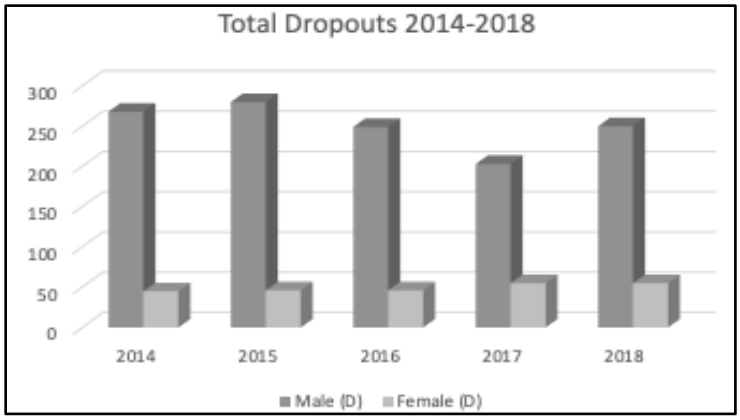

FIGURE 3
THE TOTAL NUMBER OF DROPOUTS, MALE AND FEMALE, ENTERING SCE DURING THE PERIOD ANALYZED

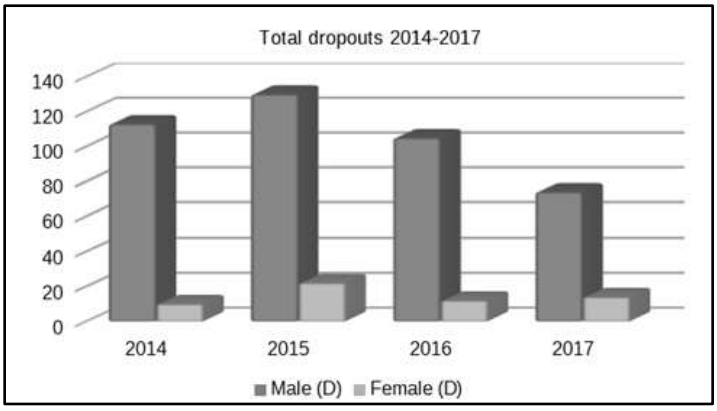

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FIGURE 4
THE TOTAL NUMBER OF DROPOUTS, MALE AND FEMALE, ENTERING CÓRDOBA UNIVERSITY DURING THE PERIOD ANALYZED

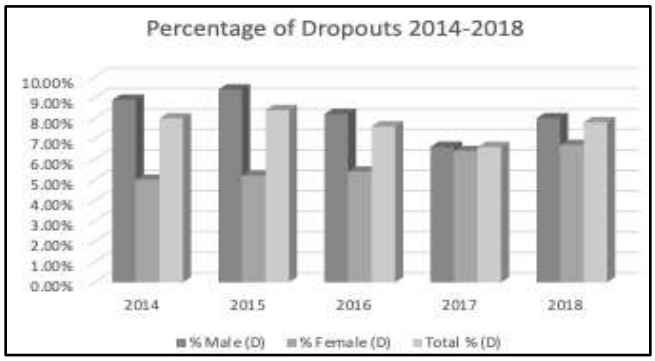

FIGURE 5
THE TOTAL NUMBER OF DROPOUTS, MALE AND FEMALE, ENTERING SCE DURING THE PERIOD ANALYZED IN PERCENTAGES

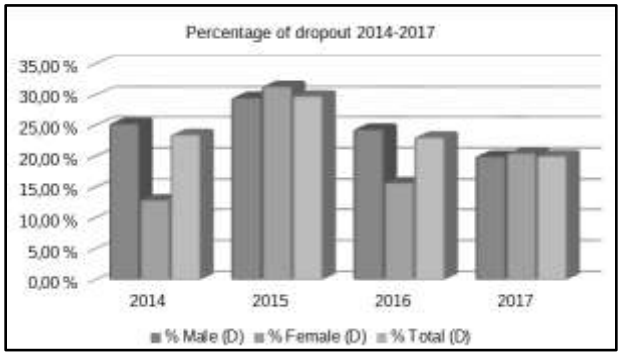

FIGURE 6
THE TOTAL NUMBER OF DROPOUTS, MALE AND FEMALE, ENTERING CÓRDOBA UNIVERSITY DURING THE PERIOD ANALYZED IN PERCENTAGES

Most students at SCE are from the country's periphery, come from a low-middle socioeconomic background, and are largely the first generation in their families to receive a college education. These are all factors that are significant because they can impact dropout rate, however they do not necessarily factor in student gender. Receiving a college education can be quite costly and that is one of the main reasons why students choose to leave school, representing 12.96% of total dropouts (Table 1). In addition, first generation students may have the capacity to thrive in school, but their parents may be unable to help them or provide the structure needed to stay on such a rigorous track. That can be another factor that contributes to the dropout rate among students (Berkner et al., 2002). SCE puts great effort into reducing the dropout rate of its students, both by providing students struggling with their studies with private assistance from teachers, and by awarding scholarships to students with financial difficulties. Despite the significant assistance that SCE provides, 7-8% of student's drop out of their studies every year. For some, this is initiated by the students. However, college-initiated terminations are made at the end of the academic year after examining students' academic achievements. Student-initiated terminations are made at any point throughout the year when the student makes a request and states their reason for quitting their studies. The analytical results of the in-depth research

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revealed that there were a multitude of factors that contribute to the dropout rate of engineering students. For some, student gender did not impact the rate of student dropout. Despite all of this, data still shows that fewer females drop out compared to male students. In the years 2014, 2015, 2016, and 2018, the dropout rate amongst male students was 8-9%, while the dropout rate amongst female students was 5-6%. Only in 2017 was the dropout rate 6.5% for both groups of students (Figure 5). That is why it is important to look at percentages rather than raw dropout rate. Although still higher than female, the male dropout rate looks less alarming compared to female when analyzing as a percentage rather than a numerical quantity. The data that summarize the reason for dropouts, were collected from questionnaires that the students who dropped out were obligated to fill before leaving the college. As can be seen in Table 1, throughout the years 2014-2018, the primary reason for student dropout was pedagogical, 40-50% discontinued their studies at college due to poor academic achievement (pedagogical break). This percentage is similar for female and male students. In this case, the decision was made by the academic institution, due to students' performance. The second most common reason for dropping out of the program was due to financial difficulties, a factor that makes a lot of sense, considering the socio-economic status of the student population at SCE. The third most common reason was related to the first, as it was a student-made decision to leave the program due to its difficulty. Other reasons for dropping out of the program include: changes in professional trajectory; moving to a different place; changing learning institutions; drafting into the army; personal reasons; or because students did not participate in the college consultation service (Table 1). Of all factors, the one whose dropout rate did not vary much between men and women was choosing a different learning institution. However, many of these factors can be grouped with one another, or can be descriptive of one another. For example, if a student was having difficulty with their course work, they may have dropped out in the middle of the semester or switched to a different area of study. But those same students may well have been removed from the program for pedagogical reasons at the end of the semester, had they waited till then. As such further analysis may be necessary.

Table 1
REASONS FOR DROPOUTS

Reasons for Dropping Out	2014		2015		2016		2017		2018	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Financial Situation	47	5	43	6	36	7	26	3	19	2
Choosing a Different Profession	7	2	20	5	14	2	10	3	17	4
Moving Apartments/ Countries	12	1	5		4	1	5	1	6	
Switching Learning Institutions	8		4		7	2	3	1	4	4
Drafting into the Army	3		8		8		2	1	2	
Difficulty in Studies	30	3	34	3	29	3	17	2	23	2
Personal Reasons	14	5	18	5	16	4	15	3	18	6
Other	14	4	15	3	15	4	15	10	23	6
Did not Participate in College Consultation Service	22	7	22	4	26	3	12	2	10	3

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Pedagogical	109	18	110	20	87	20	96	29	126	27
Discipline Committee	2		1		7		2		2	1
Total	268	45	280	46	249	46	203	55	250	55

Either way, the statistics clearly show that engineering programs are densely saturated with male students and consistently have a larger number and percentage of male students who drop out from the program. Female students are less likely to be in the program, but are also less likely to drop out once they are in it, perhaps because they feel the need to prove themselves and figure the gender disparity in the academic field and workforce.

A chi-square test of independence was performed to examine the relationship between gender and dropout ratio. The relation between these variables was significant, $\chi^2(1,N=19527)=30.45$, p=3.42e-08, so women were less likely than men to abandon their studies. Reason by reason, no significant differences were found, except for "*Difficulty in Studies*" where women were found to be significantly less likely than men ($\chi^2(1,N=1497)=6.77$, p=9.25e-03). This data corroborates the idea that women abandon their engineering studies proportionately less often than men. Those who do abandon for different reasons than their male counterparts, such as no specified social and personal reasons.

When analyzing data from Cordoba University (Spain), where socio-economic conditions are rather different, similar results were found. Specifically, 25.09% of men abandoned their engineering studies from 2014-2017, while only 19.59% of women did so, and these differences were found to be significant too ($\chi^2(1,N=1973)=3.84$, p=4.33e-02).

CONCLUSION

Women are disproportionately underrepresented in STEM fields and this study seeks to highlight the role higher education plays on gender inequality in terms of dropout rate among engineering students. Data collected from two universities indicates fewer women are admitted to engineering undergraduate programs than men, but once enrolled, they drop out at a lower rate than their male counterparts. Both groups of students face the challenges of a rigorous curriculum and financial obstacles to achieving success; however, women have additional cultural and stereotypical external influences. These can include responsibilities at home as well as the lack of a familial support system while navigating their engineering studies. Women that dropout, predominantly cite not being able to sustain the required academic standing to remain in the program. This indicates that women in engineering programs such as those within this study require further institutional support because of the competing demands on their time.

In addition, women in engineering programs would benefit from women mentors in their discipline, which are few and far between within the male dominated industry. Women are making great strides in STEM fields but need to feel that their environment is inclusive and supportive of their efforts for them to succeed. Higher education institutions need to allocate funds to provide the necessary resources to support their engineering students that are women as well as provide learning opportunities from other women. Learning as a minority can be difficult for any vulnerable group seeking to achieve.

Future research should consider a case study approach to provide qualitative insight into the experiences of women both in engineering jobs and academic studies while they attempt to juggle their additional responsibilities. Also, higher education engineering programs that do offer support to students that are women, should be evaluated regarding what works for varying

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cultures and traditions and what can be applied elsewhere. Recommendations for implementing such programs would also be beneficial.

REFERENCES

Alban, M., & Mauricio, D. (2019). Factors that influence undergraduate university desertion according to students perspective. *International Journal of Engineering and Technology*, *10*(6), 1585-1602.

Aulck, L., Velagapudi, N., Blumenstock, J., & West, J. (2016). Predicting student dropout in higher education.

Berkner, L., He, S., & Cataldi, E.F. (2003). Descriptive summary of 1995-96 beginning postsecondary students: Six years later. NCES, 151, 61.

Böttcher, A., Thurner, V., & Häfner, T. (2020). Applying data analysis to identify early indicators for potential risk of dropout in cs students. In *2020 IEEE Global Engineering Education Conference (EDUCON)*, IEEE, 827-836.

Buse, K. (2018). Women's Under-representation in Engineering and Computing: Fresh Perspectives on a Complex Problem. *Frontiers in psychology*, *9*, 595.

Castagnetti, C., & Rosti, L. (2010). *Gender stereotyping and wage discrimination among Italian graduates* (No. 122). Quaderni di Dipartimento.

Cech, E., Rubineau, B., Silbey, S., & Seron, C. (2011). Professional role confidence and gendered persistence in engineering. *American Sociological Review*, *76*(5), 641-666.

Cordova-Wentling, R.M., & Camacho, C. (2006). Women engineers: Factors and obstacles related to the pursuit of a degree in engineering. In *2006 Annual Conference & Exposition*, 11-1454.

Eurostat. (2020). Tertiary education statistics - Statistics explained.

Felder, R.M., Felder, G.N., Mauney, M., Hamrin Jr, C.E., & Dietz, E.J. (1995). A longitudinal study of engineering student performance and retention. III. Gender differences in student performance and attitudes. *Journal of Engineering Education*, *84*(2), 151-163.

Francesconi, M., & Parey, M. (2018). Early gender gaps among university graduates. *European Economic Review*, *109*, 63-82.

Kuley, E.A., Maw, S., & Fonstad, T. (2015). Engineering student retention and attrition literature review. *Proceedings of the Canadian Engineering Education Association (CEEA)*, 1-7.

Leuze, K., & Strauß, S. (2016). Why do occupations dominated by women pay less? How 'female-typical'work tasks and working-time arrangements affect the gender wage gap among higher education graduates. *Work, employment and society*, *30*(5), 802-820.

Meyer, J., & Strauß, S. (2019). The influence of gender composition in a field of study on students' drop-out of higher education. *European Journal of Education*, *54*(3), 443-456.

Meyer, M., & Marx, S. (2014). Engineering dropouts: A qualitative examination of why undergraduates leave engineering. *Journal of Engineering Education*, *103*(4), 525-548.

Morrow, G. (1986). Standardizing practice in the analysis of school dropouts. *Teachers College Record*, *87*(3), 342-355.

Mostafa, T. (2019). Why Don't More Girls Choose to Pursue a Science Career? PISA in Focus No. 93. *OECD Publishing*.

Nagy, M., & Molontay, R. (2018, June). Predicting dropout in higher education based on secondary school performance. In *2018 IEEE 22nd international conference on intelligent engineering systems (INES)*, IEEE, 000389-000394.

OECD. (2020). Education at a glance 2020: OECD indicators.

Parajuli, M., & Thapa, A. (2017). Gender Differences in the Academic Performance of Students. *Journal of Development and Social Engineering*, *3*(1), 39-47.

Paura, L., & Arhipova, I. (2016). Student dropout rate in engineering education study program. *Engineering for Rural Development*, *2016*, 641-646.

Salas-Morera, L., Molina, A.C., Olmedilla, J.L.O., García-Hernández, L., & Palomo-Romero, J.M. (2019). Factors affecting engineering student's dropout: A case study. *The International Journal of Engineering Education*, *35*(1), 156-167.

Citation Information: Madar, N.K., Danoch, A., & Morera, L.S.(2022). Dropouts of women in engineering studies: A comparable case. *Journal of Entrepreneurship Education, 25*(1), 1-10.

Sax, L.J., Kanny, M.A., Riggers-Piehl, T.A., Whang, H., & Paulson, L.N. (2015). But I'm not good at math: The changing salience of mathematical self-concept in shaping women's and men's STEM aspirations. *Research in Higher Education*, *56*(8), 813-842.

Sherwen, E. (2017). Girls put off a career in engineering by inaccurate and negative perceptions.

Sultana, S., Khan, S., & Abbas, M.A. (2017). Predicting performance of electrical engineering students using cognitive and non-cognitive features for identification of potential dropouts. *International Journal of Electrical Engineering Education*, *54*(2), 105-118.

Vossensteyn, H., Kottmann, A., Jongbloed, B., Kaiser, F., Cremonini, L., Stensaker, B., … Wollscheid, S. (2015). Drop-out and completion in higher education in Europe - Main report. European Commission.

White, J.L., & Massiha, G.H. (2016). The retention of women in science, technology, engineering, and mathematics: A framework for persistence. *International Journal of Evaluation and Research in Education*, *5*(1), 1-8.

Young, J., & Choi, S. (2015). Factors of women engineering students' dropouts in South Korea. *The Online Journal of Quality in Higher Education*, *2*(4), 24-34.

Citation Information: Madar, N.K., Danoch, A., & Morera, L.S.(2022). Dropouts of women in engineering studies: A comparable case. *Journal of Entrepreneurship Education, 25*(1), 1-10.