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Factors Affecting Women's Choice of Learning Engineering and Technology Education in Ethiopia

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ABSTRACT Recently, women in engineering and technology education have been given due importance in academic studies. In this background, the study has been carried out with two objectives. The first is to compare women's participation in engineering and technology vis-à-vis other STEM subjects. It has been done based on secondary data of enrollment, and the second one is to discuss the factors affecting their choice of pursuing engineering and technology. The average registration of women in engineering and technology is 24%, lower than any other study field. The second objective has been analyzed based on primary data collected from 384 women students learning engineering and technology and other science subjects (i.e., chemistry, biology, mathematics, statistics, physics). The result of Logit regression on factors affecting women's choice of learning engineering and technology reveals that expected salary is the most influencing factor. Other factors, high school education performance (results of grade 12 exam), the presence of an engineer and technologist in the family, access to role models, and the family's annual income, positively affect women's choice of learning engineering and technology education. All stakeholders, such as the government, teaching institutions, and associations dealing with women in engineering and technology education, must have appropriate measures for making role models more visible.

INDEX TERMS Women, choice of field stream, engineering and technology education, Ethiopia.

I. INTRODUCTION

Achieving gender equality and empowering women through education is one of the primary objectives of Sustainable Development Goal five (SDGs). Education is crucial for empowering women because it enables them to survive the challenges, have better access and opportunities in the workforce, reduce economic dependency on others, and the best investment for the country's development. Engineering and technology education will also help women's empowerment through the knowledge of science and technology. Therefore, women in engineering and technology education have been given due importance in academic studies [1].

In the Ethiopian context, before 1960, Ethiopian Orthodox Church played a vital role in reducing illiteracy. Even though women are highly respected in the community, girls' social solid and cultural pressures for early marriage. Hence, they did not go to school. Even though they went, because of various problems such as harassment, violence, and natural phenomena of adolescence age, they drop out of school. This situation leads to low education and professional employment participation in national development. To encourage women in education and employment participation, the Ethiopian newly established government has adopted affirmative action policy in the 1990s. Since then, women's involvement increases in education and employability in various positions. However, they are still small in engineering and technology fields. The finding of Melak and Singh [2] confirms this low participation of women in Ethiopia. The undergraduate degree program concluded that women's enrollment in public universities from 2007 to 2016 was 23.34% on average. In the same year, 13.4% of women were enrolled in a postgraduate degree. Egne [3] were also indicated, women students are highly underrepresented in the science field of higher education in Ethiopia. Therefore, increasing women students' participation is one of the present policy objectives of higher institutions in a country [4].

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II. REVIEW OF LITERATURE

A. WOMEN PARTICIPATION IN STEM EDUCATION

We began our discussion by describing what STEM stands for. According to Xie *et al.* [5], the abbreviation STEM usually stands for a set of educational and occupational fields related to science. STEM education is closely associated with the math and science curriculum that is required for all students. STEM education becomes more specialized and detailed at higher levels. According to Bybee [6], STEM education means only science and mathematics, even though technology and engineering products have greatly influenced everyday life. Since engineering is directly involved in problem-solving and creativity, which are high priorities on every nation's topic, STEM education should also incorporate more engineering and technology subjects.

The engineering and technology profession makes essential contributions to the economy's GDP and high social value. The engineers deal with creating, improving, and protecting the environment, providing living facilities, industry, and transportation, which produces high economic values. Findings from various countries support the positive effect of technology on economic growth through job creation, providing new services and industries, workforce transformation, and business innovation. A study by Cebr [7] confirmed such a positive correlation between GDP per capita and engineering and technology.

However, the number of women in this profession is under-represented in various countries of the world. According to Casallas *et al.* [8], women's participation in undergraduate STEM education programs in Colombia has been declining, and it is only about 11%. This phenomenon has been evidenced in many universities worldwide, and several collaborative projects and networks are trying to understand the causes to find mitigation actions in the future. Wuhib and Dotger [9] also conducted a study on why so few women in STEM at Syracuse University, New York. Even though there is a gradual increase in their participation, women are still underrepresented in science, technology, engineering, and mathematics (STEM) fields. In the 21^{st} century, where the global economy and national security needs STEM expertise more than ever, the area is not benefiting from the talent of half of the world's population, i.e., women.

Another study by Marginson *et al.* [10] argued that countries generally are grappling with the issue of under-representation of women in STEM fields and pursue a variety of gender equity policies and strategies to address this. Villa and Gonzalez [11] investigated the percentage of women students in engineering and technology in Mexico. They found a lower rate of women enrollment in the field, which has achieved parity with male enrollment. Vidal *et al.* [12] also showed that the number of women enrollment in software engineering in Peru from 2010 to 2015 was only 20% compared to men. Moreover, women in the U.K. also remain underrepresented in engineering and technology, that in 2010, women enrollment in these field accounts only 15%, from 57% of the total university students [13].

There is also an imbalance distribution between the two genders in African countries, as in other parts of the world. Women engineers are few and unable to participate in national development fully. A study by Imasogie *et al.* [14] indicates that the total number of women engineering students enrolled in 2011-2016 was 15% in Nigeria. They suggest the possible reason that socio-cultural and labor market gender preconceptions, psychosocial influences, formulation and implementation of gender insensitive policies, and lack of awareness of engineering opportunities. Longe *et al.* [15] also studied women's engineering education experiences in Nigeria using primary and secondary data. They found that female engineering students' enrollment has a decreasing trend from the 2011-2017 academic year. Hammout and Hosseini [16] studied students' involvement in online master's engineering and science studies to minimize the gender gap in Morocco's STEM education. They have collected data from 5,000 participants of online master's studies in business, engineering, and other fields to find the gender gap between the candidate's participation with a specific emphasis on science, technology, engineering, and mathematics (STEM). They found that lower participation of women in the field.

Melak and Singh [17] also investigated the percentage of women enrollment in the engineering, manufacturing, and construction field of study. Most African countries, such as Burundi, Burkina Faso, etc., are below 25% from 2015 to 2017. In contrast, statistics for Tunisia have shown better performance. Colomo-Palacios *et al.* [18] also examine gender gap narrowing in higher education computing studies in the case of three countries (i.e., Norway, Spain, and Tunisia). They have collected data based on student enrollment and macroeconomic aspects such as gross domestic product, unemployment data, the quality-of-life index of the Organization for Economic Cooperation and Development (OECD), the gender equality index, and a set of information. They found the percentage of female students in 2018 was 12.7% in (Norway), 26.32% in (Spain), and 50% (Tunisia). Results show that there is a gender gap in computing studies in these countries except Tunisia.

There is an identical situation in Asian countries also. One study conducted by Singh and Fenton [19] found women's participation is low in India and Australia. However, currently, India and Oman have better performance than other countries [17]. Another study by Abdullah *et al.* [20] in Malaysia also shows women's participation in the engineering sectors is comparatively lower. Women's representation in engineering and computer science is much lower. A study from 14 countries shows that the probability for women graduating with an undergraduate program in a science field is 18%, compared to 37% for male counterparts [21]. This under-representation of women in engineering and technology education leads to gender inequality in this profession's working place [22]. This low proportion is an important issue that needs investigation about factors contributing to their under-representation in the area.

B. FACTORS AFFECTING WOMEN's CHOICE OF LEARNING ENGINEERING AND TECHNOLOGY EDUCATION

1) THE NATURE OF SCIENTIFIC QUERIES AND SOCIO-CULTURAL FACTORS

The previous studies identify the factors affecting women student's choice of learning engineering and technology fields in higher education. Based on traditional socialization and traditional roles of the sexes, young women in many parts of the world view engineering and technology as a masculine field populated with males [23]. Kolmos *et al.* [24] confirmed that social motivations are the most important motivational factors for attracting students to engineering and technology education.

Another study by Casey *et al.* [25] studied motivating STEM+C learning with the social impact of cybersecurity and digital forensics in the U.S. The finding shows young women appear to be more motivated by social issues such as safety and privacy. Moreover, Melak and Singh [17] found that sexual harassment harms women students' academic performance in STEM education, which leads to gender gaps in this field. Vidal *et al.* [12] also believe that stereotypes, cultural barriers, lack of confidence, lack of knowledge of career opportunities, and lack of vision of possibilities are more than enough reasons for students who do not pursue studies in engineering or drop out from university.

Longe *et al.* [15] also studied women's engineering experiences in Nigeria using primary and secondary data. They found that 69 participants agreed on the question "wrong perceptions about engineering limit women participation in engineering." Fifty-two respondents agreed that "women participation in engineering is limited by the dominance of men in the field," and 57 participants also agreed that "women participation in engineering is limited by lack of career awareness." A study by Wuhib and Dotger [9] conducted why few women in STEM using 296 participants in New York. They consider the chilly climate of STEM fields and present social perception's role as the factors affecting undergraduate women's STEM education success. Their findings show that undergraduate women reported greater use of social supporting than did men. They also found that social support is a better predictor of commitment for women than men. Therefore, they suggest that STEM fields should consider this in creating a more collaborative and comfortable environment for women to participate better, retain and succeed in these fields.

2) ROLE MODEL AND ENCOURAGEMENT

The lack of female engineering faculty role models and the failure to account for women's different cognitive styles are cited as contributing factors to the shortages of women students pursuing engineering degrees. Ross and Thomas [23] argued that one of the most effective ways to accomplish this is with a composite mentoring activity. Developing a mentoring relationship can be a challenge. The mentor can advise the mentee on career, academic, psychosocial, and role modeling functions and positively influence underrepresented students in the STEM discipline. They also argued that country's public and private sectors need to establish and maintain incentives for students to pursue high technology carer. They suggested providing opportunities to gain research experience is one of the more fundamental ways to retain students from underrepresented groups in the STEM areas.

Vidal *et al.* [12] also studied closing the gender gap in Peru's engineering. Their objective was to create a community of female students who became role models who share their motivation to STEM with new female students and participate in the recruitment process. The main activities were divided into two branches: a) exposure to role models at the student level and b) participation in the international community of Django girls. Implementing exposure to role models and participating in the international community of Django girls from 2016 to 2019 increase women's interest in the software engineering field. A study by Simmonds *et al.*, [26] examined the impact of affirmative action on female computer science/software engineering undergraduate enrollment using 10% of students enrolled in all Chilean universities. They found that affirmative action programs, such as the gender equity program (GEP), successfully attract more young women to study in STEM fields.

Marginson *et al.* [10] reported international comparisons of science, technology, engineering, and mathematics (STEM) education. They showed that mentoring programs were positively evaluated as improving women's STEM participation. Examples of mentoring programs include: bringing together young women and successful female STEM professionals (including scientists, engineers, mathematicians, and computing specialists) to provide an authentic understanding of STEM careers and access to female role models.

3) ACCESSIBILITY OF AWARENESS ABOUT FIELD SELECTION AND INTERVENTION BY STAKEHOLDERS

According to Watermeyer [27], science outreach programs and informal learning interventions for young women help develop awareness in science subjects. Another study by Sauer *et al.* [28] conducted a study in Brazil to promote student enrollment in engineering and technology, based on workshops, a science and astronomy club, science and technology, and others. The results show how the activities are being promoted by encouraging women's participation and training for careers in the exact sciences, engineering, and information technology. These contribute to reducing the impact of gender inequalities on elementary and high school career choices students. Großkreutz *et al.* [29] also argued that media is essential to create women's awareness about STEM education. They found from the literature that active and successful females in technology regarded as positive by society should be introduced through media, increasing women's choice of learning STEM education.

Aeschlimann *et al.* [30] also studied how to improve women's interest in holding science, technology, engineering, and mathematics. They found that classroom assistants of the motivation of learners can increase the possibility of choosing STEM education.

4) SELF-PERCEPTION AND INTEREST OF WOMEN STUDENTS

According to Baytiyeh [31], a genuine interest in the field appeared to be the primary influence in the participants' decisions to choose the study's engineering field. Besides, the potential for professional growth was the leading motivator for choosing engineering education. Balakrishnan and Low [32] also reveal that learning experience is directly related to female students' intention to pursue a career in engineering and technology. Abdullah *et al.* [20] also studied the factors affecting women's participation in engineering sectors and future intention to choose engineering degrees in Malaysia using 161 participants. They found that learning experience, educational choice, and opportunity inequality are the top factors affecting women's engineering education choice. Their finding is also confirmed by Jayawardena *et al.* [33] argued that the most influential factor was the learners themselves.

Main and Schimpf [34] reviewed the literature on women's underrepresentation in computing fields across four life levels, i.e., pre-high school, high school, primary college choice, and employment after graduation. Gender disparities in interest and attitudes toward computers correlate with access to and usage of computing tools at the pre-high school and high school levels. Environmental context (classroom architecture, experiences with peers and role models, cues from stereotypical images) determines whether students want to major in computing in college. In contrast, psychosocial factors (e.g., sense of belonging and self-efficacy) and departmental culture play a role in persistence in computing.

5) THE ROLE OF FAMILIES ON WOMEN STUDENT's CHOICE OF LEARNING

Rankin *et al.* [35] conducted a study on familial influences in African American women's persistence in STEM education in the USA using 34 African American women participants. The finding reveals that 20 (59%) of women participants believe that families play a positive role in African American women's persistence in STEM education through early exposure and access to computing, support for women's self-efficacy, education as a family value, career guidance, and advice, etc. They also argued that parents become mentors who offer career advice to help their daughters succeed. They function as role models and a source of inspiration.

Zamora-Hernández *et al.* [36] explore strategies for attracting more women into engineering in Mexico taking official data from the Mexican government of student enrollment from 2009-2019. They found that 93% of women participants positively responded from their families on learning engineer education. In contrast, 63% of female students were influenced by negative social perceptions when choosing the study's engineering field. On the other hand, 46% of participants answered that peer pressure is the most crucial factor affecting women's decision to study engineering, 41% said low job opportunity was the factor affecting women's choice of engineering. They also found that 52% of women participants agreed that there should be more information regarding women in engineering and their success story to reduce negative social and cultural perceptions about women's engineering education. They conclude that family and successful stories of women in engineering are the most critical factors encouraging women's choice of learning engineering education. They also suggest strategies to attract more women in engineering; these are: organize ongoing communication events such as women in engineering, create a discussion with women lecturers in engineering and students and the families, continuous assessment and follow up by the faculty, establish associations who encourage women in engineering education, women faculty members can be the best cooperates to encourage women students in engineering education.

Großkreutz *et al.* [29] also studied the influence on the career choice to increase female students' participation in STEM. They noticed that the importance of family, career, and income is a crucial factor in advancing women in engineering. They also argued that girls, who had contact with technology through their father from early childhood, significantly more often choose a technical career path. Therefore, it is safe to presume that developing an interest in technology during childhood can increase women's technical fields percentage.

6) RECRUITMENT AND RETENTION

Kranov *et al.* [37] women's participation in engineering is an issue worldwide for many years. They identify the factors contributing to women's education in engineering and computing in Jordan, Malaysia, Saudi Arabia, Tunisia, and the USA. Their research questions were: (a) What motivates women's engineering choice as an educational path? (b) How do women perceive professionals in these fields and the work they do? (c) What societal, cultural, legal, and policy factors are perceived to support or constrain women's participation in engineering or computing fields of study and occupations? They found that the recruitment and retention of women in these fields continue to face substantial challenges. Sulaiman and AlMuftah [38] also discussed that recruitment was the reason behind the under-representation of women undergraduate engineering students. However, Haworth *et al.* [39] investigated no difference between boys and girls when selecting courses. Findings by Semali and Mehta [40] reveal many students' barriers to joining science, technology, engineering, and mathematics education. These factors include overcrowding number of students, insufficient access to education material, inappropriate curriculum, poor learning performance, and the problem of unemployment after graduation. According to each factor affecting women's

TABLE 1. Summary of review of literature on factors affecting women's choice of learning engineering and technology education.

Authors Name	Their Finding
Ross and Thomas [23]; Kolmos et al. [24]; Casey et al. [25]; Melak and Singh [17]; Vidal et al. [12]; Longe et al. [15]; Wuhib and Dotger [9]	They found that the nature of scientific queries and socio-cultural factors affecting women's choice of learning engineering and technology.
Ross and Thomas [23]; Vidal et al. [12]; Simmonds et al. [26]; Marginson et al. [10]	These authors also studied role models and encouragement can affect women's choice.
Watermeyer [27]; Sauer et al. [28]; Großkreutz et al. [29]; Aeschlimann et al. [30]	The listed authors also examine the impact of accessibility of awareness about field selection and intervention by stakeholders.
Baytiyeh [31]; Balakrishnan and Low [32]; Abdullah et al. [20]; Jayawardena et al. [33]; Main and Schimpf [34]	These authors found that self-perception and interest of women students are also other factors.
Rankin et al. [35]; Zamora-Hernández et al. [36]; Großkreutz et al. [29]	Studied the role of families on women student's choice of learning engineering and technology.
Kranov et al. [37]; Sulaiman and AlMuftah [38]; Haworth et al. [39]; Semali and Mehta [40]	The author investigated recruitment and retention are also factors.

TABLE 2. Hypothesis of the study.

Factors that will have a positive effect on women's choice of learning engineering and technology	Factors that will hurt women's choice of learning engineering and technology.
High school education performance (results of grade 12 exam) [41], [42] Availability of engineering and technology professionals in the families [43], [44] Family suggestions to study engineering and technology [29], [35], [36] Peer pressure [36] The accessibility of role models [24], [46] The expectation of a high monthly salary Annual income of the family [29], [41]	long-time education curriculum in engineering and technology [45]

choice of learning engineering and technology, the reviewed papers are summered in Table 1.

Many papers are reviewed related to factors impacting women's choice of learning engineering and technology education in several countries worldwide. Hence, we found that the previous studies did not investigate these factors empirically. Consequently, we want to analyze factors affecting women's choice of learning engineering and technology education through regression analysis of primary data gathered in the Ethiopian context. These can add value to the scope of the literature on women's participation in STEM. There is also a need for more women's participation in engineering and technology in Ethiopia's development and poverty reduction.

III. MATERIALS AND METHODS

A. THE OBJECTIVE OF THE STUDY

The study has two purposes. These are:

- To analyze the status of women in STEM education with the help of enrollment data collected from the Ethiopian Ministry of Education; and
- To investigate whether (a) high school education background of students, (b) existence of engineering and technology professionals in the family, (c) family suggestion to study engineering and technology education, (d) peer pressure, (e) duration of the program or curriculum, (f) accessibility of role model, (g) annual income of the family, and (h) expected salary are factors affecting women's choice of learning engineering and technology education.

The study has hypothesized on factors affecting women's choice of learning engineering and technology education based on the specified objective. These are given in Table 2.

B. AREA OF THE STUDY

This study has been conducted in Ethiopia based on women's primary and secondary data in engineering and technology education. Nine states and two city administrations are found. Higher education has been started in the 1950s in a country. Before this year, the number of higher education institutions was only five. Presently, progress has been observed in expanding higher education institutions until introducing the current education and training policy in 1994 [47]. Most engineering and technology universities, which is 26% of the total, are found in Addis Ababa, followed by Oromia and Amhara regions.

C. DATA COLLECTION PROCEDURE

Stratified sampling data collection procedures have been used to collect primary data. In the first step, the sample state, the Amhara region, was randomly selected. The state has ten government-owned higher education organizations.

In the second step, these ten public higher institutions are categorized into four groups based on their work experience. The first group includes Gondar University (G.U.) and Bahir Dar University (BDU), recognized as a university in 2000. The second group comprises Wollo Universities (W.U.), Debre Birhan University (DBU), and Debre Markos University (DMU), which were established in 2005. Debre Tabor University (DTU) and Woldia University (W.U.) were

TABLE 3. Sample respondents in the selected universities.

	Bahir Dar University		Debre Tabor University		Wollo University		Total
	engineering and technology	natural science	engineering and technology	natural science	engineering and technology	natural science	
No. of students	2212	451	935	272	521	288	4679
No. of respondents	181	37	77	22	43	24	384
Percentage	47%	9.6%	20%	6%	11.2%	6.2%	100%

TABLE 4. Statistical summary of demographic and socio-economic status of respondents.

Demographic and socio-economic variables	Responses	
Having engineering and technology professionals in the family	No = 215	Yes = 169
Access of role model	No = 156	Yes = 228
Effect of duration of the program	No = 246	Yes = 138
Family suggestion for selection of fields	No= 285	Yes = 99
Peer pressure for selection of filed	No = 330	Yes = 54
Place of residence	Rural = 130	Urban = 254
Family educational background	No = 122	Yes = 262
Number of family members	Less than six = 100 More than ten = 8	Six to ten = 213 Unknown = 1
Marks of students grade 12 exam	Respondents from natural science Respondents from Engineering and technology	Mean =358.6 Mean =392.9
Income of the family	Respondents from natural science Respondents from Engineering and technology	Mean = 51522.9 Mean = 73823.9
Number of respondents decided to study engineering and technology Number of respondents decided to study natural science	301 83	

included in the third group established in 2008. Moreover, Mekdela Amba, Injibara, and Debark University were established in 2015 and included in the fourth group.

In the third step, we select three universities from each group except the fourth category. These are BDU, W.U., and DTU. Sample Universities from each group were purposively selected. The choice of Universities within a group was random. Fourth group universities were not included in the sample since they are newly established. In Ethiopia, the cost of higher education of students is encouraged via the government through agreements. Students are placed to university through placement by the ministry of education. Hence, students come from all country directions representing different economic statuses, religions, cultures, languages, etc., so that sample is reasonable.

The next step is determining the sample size from the total population of women students in STEM faculty in the selected universities, 4679. From these entire populations, we have chosen 384 sample respondents based on equation one [48]

$$n = \frac{Z^2.p.q.N}{e^2(N-1) + Z^2.p.q}. \quad (1)$$

Which is valid where n is the sample size, $N = 4679$ (the total population), Z^2 is z-score at a specified confidence level of 95.5% $= (2.01)^2$, $e = 45\%(0.045)$ is the desired level of precision (acceptable error) the range in which the population's true value is estimated. The (P = 30%) population has a characteristic proportion, and q is (1-p).

Finally, proportions according to universities have been provided in Table 3, i.e., 218 (56.6%) respondents from Bahir Dar University, 99 (26%) respondents from Debre Tabor University, and 67(17.4%) respondents from Wollo University. Based on this sapling procedure, primary data have been collected from 301 women students enrolled in engineering and technology faculty and 83 students enrolled from other science departments (i.e., physics, chemistry, mathematics, biology, and statistics) using the specified questions in May 2018.

D. SAMPLE DESCRIPTION

As shown in Table 4, out of 384 samples, 301 respondents are female students from the engineering and technology departments. The remaining 83 sample respondents are from other science (biology, chemistry, physics, mathematics, and statistics). One hundred sixty-nine respondents have engineering and technology professionals in their family members, but 215 respondents do not have such professionals. The 228 respondents have access to a role model from the total sample, and 246 respondents are not affected by the program's duration. Only 99 and 54 respondents have been influenced via family suggestion and friend suggestion to select field of study, respectively. Regarding the place of residence of respondents, 254 are living in urban areas. On the other hand, 262 respondents have a family educational background.

Most of the respondents have six to ten family members, while 100 respondents have less than six members in their family. Respondents from natural science have on average 358.6 marks in the grade 12 entrance exam. Similarly, respondents in engineering and technology have 392.9 scores on average in the same grade. When we see the family of respondents' annual income in natural science, their family income is birr 51522.9 on average, and family income of engineering and technology students is birr 73823.9. Similarly, out of 384 sample respondents, 250 (65.1%) respondents decided to study engineering and technology education, whereas only 6 (1.56%) respondents chose to study natural science via expecting higher salary income.

E. DEFINITION OF VARIABLES AND INSTRUMENTS

Women student's choice of learning engineering and technology education is the dependent variable. It is measured by 1 = women students who decided to study engineering and technology, and 0=if not, using the questionnaire "Are you studying engineering and technology education or not?"

The availability of engineering and technology professionals in the family is an explanatory variable valued as 1 =' yes I have engineering and technology professionals in my family, and 0 = if not by asking the question "Do you have engineering and technology professionals in your family?"

Accessibility of role model is also an explanatory variable valued as 1 =' yes, I have role model, and 0 = I have no role model' using the questionnaire "Do you have a role model to choose your department?" Kolmos *et al.* [24] studied motivational factors of gender and education and found that women are significantly more influenced by mentors (role models). Smith and Dengiz [49] also support the idea of the impact of role models for the study area's choice that women students believe that they have fewer opportunities than male peers and acutely feel the lack of role models.

The grade 12 entrance examination, which is offered for all Ethiopian universities in natural science subjects, is used to measure high school education performance. Exam results are evaluated on a zero-to-hundred-point scale, with a maximum score of 700 possible in seven subjects. Ethiopia's Ministry of Education sets the minimum standards for university entry. Consequently, high school educational performance is a continuous variable measured by the grade 12 exam with the questionnaire "How much was your grade 12 final exam result?" Family suggestion to study engineering and technology is also an independent variable measured through 1 = yes if the students were affected by their family during course selection, and 0 = if not, by asking the question "Whether your family suggested, you join the courses which are pursuing or not?" Talley and Ortiz [43] argued that early participation in STEM activities and family socializing behavior contributed the most to shaping their interest in STEM and encouraging them to continue their studies and seek careers in STEM as future professionals.

Peer pressure is an explanatory variable valued as one = yes if women students are affected by their peer pressure during course selection, and 0 = if not using the questionnaire "Do you have selected your field of study because of peer pressure?"

Expected salary is also a dummy and regressor variable valued as 1 = yes if female field selection is affected by expected future salary, and 0 = if not. The participants were asked the question, "Do you think that the salary you are expecting after graduation pushes you to join the course you are pursuing?" The family income is also a continuous independent variable measured by Ethiopian Birr obtained through the questionnaire "How much is your family's annual income?"

If there is an educated person in the respondent's family, the score is one, and if there isn't, the score is zero. Riegle-Crumb and Moore [50] divided family education into four categories: secondary school, vocational training, college-level, and advanced degree. In this analysis, the family's educational background was used as a dummy variable to determine if all family members are illiterate or educated. Other studies also argued a positive relationship between students' parental educational background and academic achievement [51]–[53]. Hu *et al.* [46] also found that higher paternal education levels possessed more positive attitudes towards science.

The duration of the program or curriculum in Ethiopia takes five years to complete engineering and technology learning. It has measured 1 = yes if students' choice of learning engineering and technology education were affected by the duration of the program or curriculum, and 0 = no if not using the questionnaire "Do the duration of the program or the curriculum bothers you at the time of course selection?" How to measure these selected factors in this study are given in Figure 1.

F. DATA ANALYSIS

Women students' choices of learning engineering and technology education is a dependent variable affected by independent factors. Expected wage, family pressure to study engineering and technology, peer pressure, the availability of engineering and technology professionals in the family, access to a role model, the family's annual income, students' high school education success, program length (curriculum), and family educational history are all factors to consider.

During primary data analysis, testing the data's reliability is essential. One of the most commonly used reliability estimators is Cronbach's Alpha [54]. This reliability test has been computed with a scale reliability coefficient of 0.6, indicating that the data is accurate. Table 5 displays Spearman's rank correlation coefficient for each independent factor and the dependent variable (women students' engineering and technology education). The correlation coefficients of program length (curriculum) ($p = 0.6377$) and family recommendation to study engineering and technology education ($p = 0.6928$) can also found in the given Table 5. Pairwise correlation of the selected independent variable is also given in Table 6, which shows a very week correlation coefficient (< 0.3) indicates no severe problem of multicollinearity.

Logit regression analysis was also conducted to analyze the most important factors affecting women student's choices of learning engineering and technology education, which are the reason for the gender imbalance in STEM education. Diagnostic tests, such as multicollinearity, constant variance, and Hosmer-Lemeshow test of the model specification were

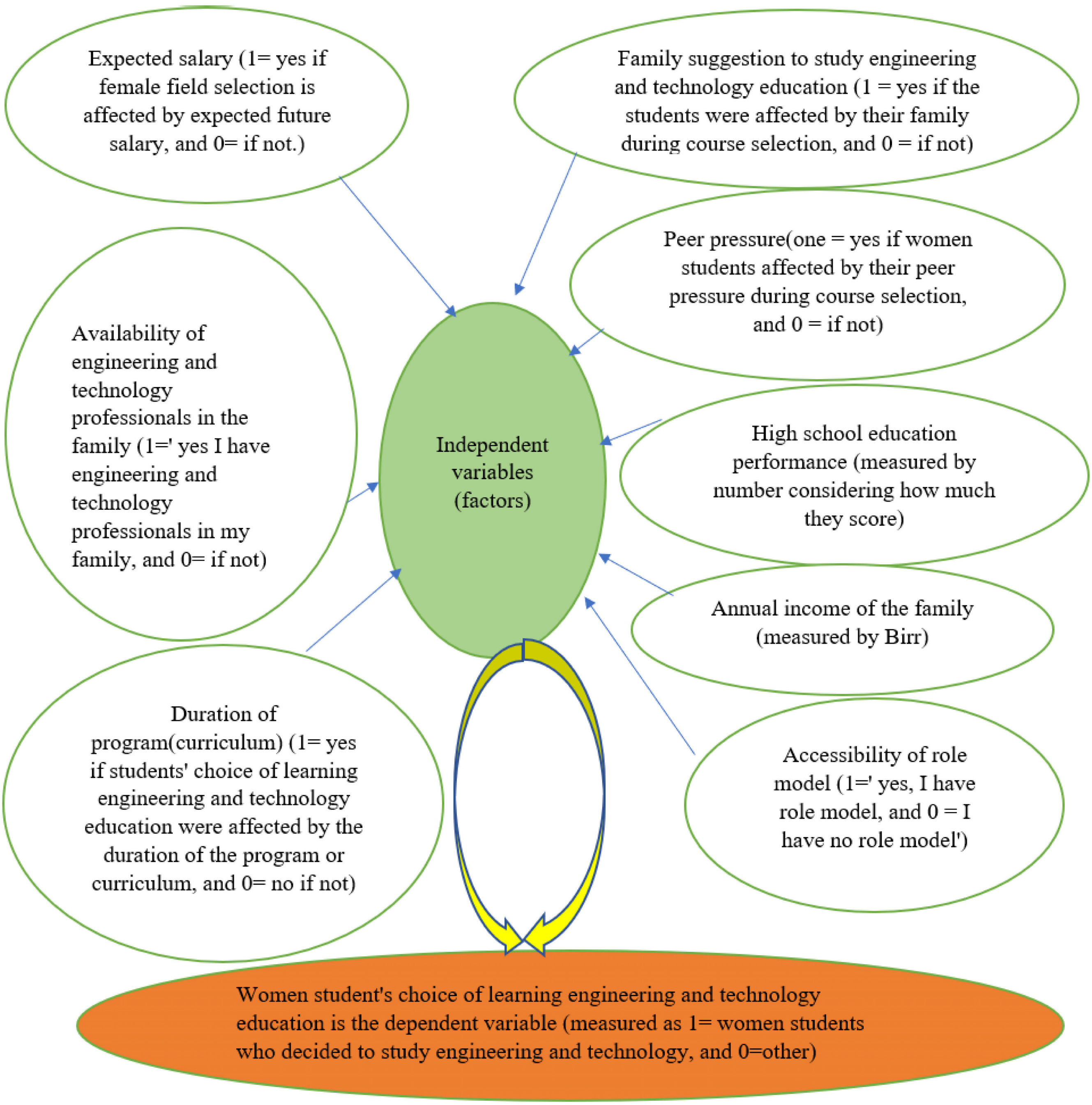

FIGURE 1. **Measurement of the selected factors affecting women's choice of learning engineering and technology.**

computed. A Pseudo R^2 and Wald chi^2 were also used to verify the estimated coefficients' unbiasedness and model fitting. Descriptive approaches have also been used to evaluate secondary data. STATA 14 was used to perform all of the tests.

G. MODEL SPECIFICATION

Factors affecting women's choice of learning engineering and technology education analyzed through binary Logit regression analysis. According to Damodar *et al.* [55], the cumulative logistic probability function is specified as follows.

$$P_i = \frac{1}{1 + e^{-(Z_i)}} \tag{2}$$

By computing some steps and taking in account of the disturbance term, the *Logit* model becomes as follows;

$$Z_i = \alpha + \sum \beta_i x_{ij} + \mu_i \tag{3}$$

TABLE 5. Results of Spearman's rank correlation coefficient test of variables.

Variables	Correlation coefficients	Sig.level	Mean
Expected salary	0.6621	0.0000	0.6666667
Availability of engineering and technology professionals in the family	0.2362	0.0000	0.4401042
Accessibility of role model	0.2613	0.0000	0.59375
Duration of program(curriculum)	0.0241	0.6377	0.359375
Family suggestion to study engineering and technology education	0.0202	0.6928	0.2578125
Peer pressure	0.1214	0.0173	0.140625
High school education performance	0.3753	0.0000	385.4714
Annual income of the family	0.1518	0.0029	69003.65

Sig.level = significant level (p-value)

TABLE 6. Results of Spearman's pairwise correlation coefficient test of independent variables.

Variables	FP	RM	PP	HEB	FINC	ES
Availability of engineering and technology professionals in the family	1.0000					
Accessibility of role model (RM)	0.1779	1.0000				
Pear preasure (PP)	0.1092	0.0753	1.0000			
High school education performance (HEB)	0.1057	0.0419	0.2401	1.0000		
Annual income of the family (FINC)	0.0493	0.0087	0.1023	0.1791	1.0000	
Expected salary (ES)	0.1039	0.1575	0.1112	0.2470	0.1389	1.0000

Z_i = dependent variable, α is the intercept (constant term), β_i is parameters associated with variables, and μ_i is a disturbance term that is not observable but can affect a dependent variable.

$$CLET = \alpha + \beta_1 ES + \beta_2 FP + \beta_3 RM + \beta_4 PP + \beta_5 HEB + \beta_6 FINC + \mu_i \quad (4)$$

where $CLET$ = women students' choice of learning engineering and technology education or other, ES = expected salary, FP = existence of engineering and technology professionals in the family, RM = accessibility of role model, PP = peer pressure, HEB = high school education background (the result of grade 12 exam), and $FINC$ = annual income of the family.

IV. RESULTS

A. DESCRIPTIVE RESULTS

As already mentioned in the second section, this study's first objective is to explain women's STEM education status with enrollment data collected from the Ethiopian Ministry of Education [56], using tables and graphical diagrams. Table 7 and Figure 2 show women students' enrollment in engineering and technology and other science departments from 2007 to 2016. The government emphasizes science and technology education by applying 70% for science and technology and 30% for higher education's social science. Even if this policy is using, there are gender gaps in Ethiopian women's share in science, technology, engineering, and mathematics. There are social and economic issues beyond students' academic interest for such a dismal proportion of women in engineering and technology educational enrollment. The social reason is that society's attitude is not encouraging women's participation in the science field since it needs physical work. There is also an economic issue in which parents cannot support their children to study engineering and technology that takes a long time training. Besides, women want to learn short-time training and get a job and establish a family. Hence, due to such conditions, the percentage share of women's enrollment in engineering and technology is below their male counterparts and other science subjects.

Academic departments in Ethiopia are categorized into six groups: Band 1(engineering and technology), Band 2 (natural and computational since that includes biology, statistic, physics, etc.), Band 3 (medicine and health sciences), Band 4 (agriculture and life science), Band 5 (business and economics), and Band 6 (social science and humanities). Figure 3 shows the percentage share of women enrollment within these faculties in all programs (i.e., regular, summer, evening or weekend and distance program). The percentage share of women from the total enrollment in engineering and technology education is 27.17% in 2016, lower than other departments.

B. LOGIT REGRESSION ANALYSIS

The researchers used logistic regression to classify the factors that influence women's decision to pursue engineering and technology education, which is the primary explanation for women's underrepresentation in STEM fields. The dependent variable is women's choice of engineering and technology education, determined by 1 = students studying engineering and technology fields and 0 = students studying other science subjects, as discussed in the second section of the article. After checking Spearman's rank correlation test, six independent variables were included in the model, and various diagnostic tests were conducted. The value of Pseudo R^2 (57%) and Hosmer-Lemeshow test with a p-value of (0.8667) show the model fit, and accepting the null hypothesis stated that the model is well specified. Furthermore, the model's overall significance was tested by the Wald chi^2, which is highly significant with a p-value of zero.

TABLE 7. Women enrollment in regular undergraduate program in engineering and technology and other science departments in Ethiopian Government Universities.

	Year	Men	Women	%of women from total
Women enrollment in engineering and technology	2007	10676	2394	18.087%
	2008	7561	2009	20.99%
	2009	25437	5647	18.1669%
	2010	43958	9679	18.045%
	2011	68276	19523	22.236%
	2012	91742	30145	24.7%
	2013	91192	29794	24.23%
	2014	118078	52881	30.93%
	2015	127837	50025	28.125%
	2016	125171	49657	28.4%
Women enrollment in natural and computational science	2007	5148	25184	20.44%
	2008	5297	22268	23.78%
	2009	8153	36147	22.55%
	2010	10089	35880	28.12%
	2011	10964	36504	30.035%
	2012	14410	42295	34.07%
	2013	14410	42295	34.07%
	2014	14393	38979	36.93%
	2015	16488	37417	44.07%
	2016	18447	41093	44.89%

Source: Ministry of education annual abstract

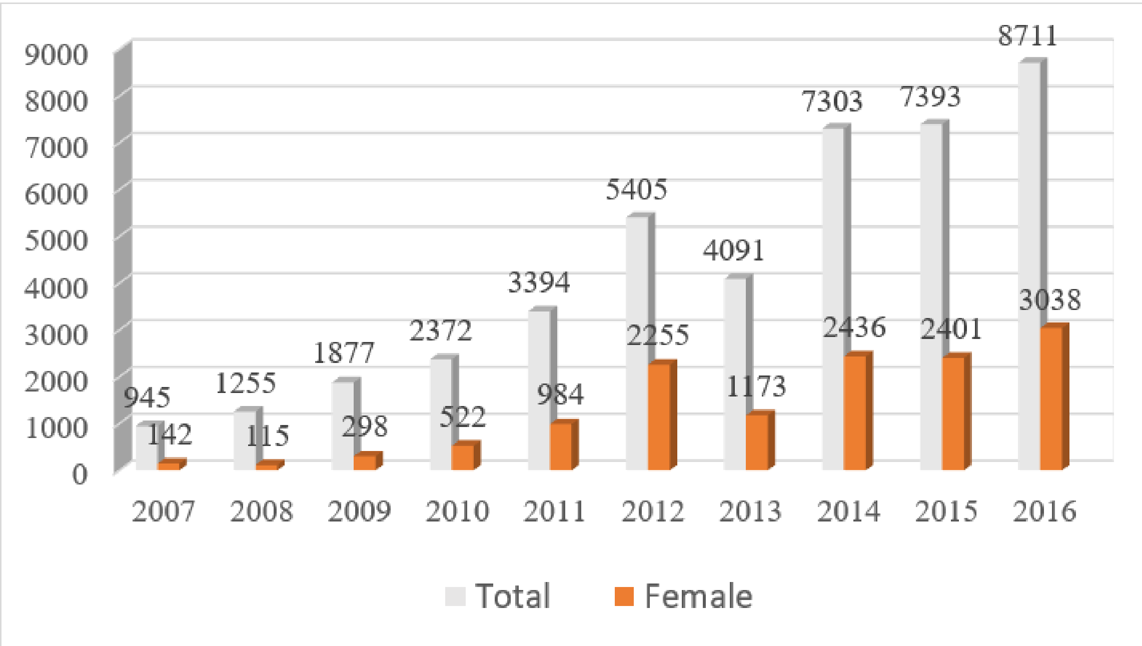

FIGURE 2. Women enrollment in regular undergraduate program in engineering and technology departments in Ethiopian private universities.

With all of these diagnostic tests, the expected salary is an essential variable with a significant and positive impact at a 1% level. The result indicates the probability of women's choice of learning engineering and technology education increases by 28.78 percent as women students expect a higher salary than students who don't have higher salary expectations, as given in Table 8.

Engineering and technology professionals' existence positively and significantly affects women students' choice of learning engineering and technology education at a 1% level. Women students who have engineering and technology professionals in the family increase their probability of studying engineering and technology by 9.3% than women students who don't have such persons in their family members.

The accessibility of role models positively and significantly affect women students' choice of learning engineering and technology education at 1%. The result shows the probability of women's selection of learning engineering and technology education increase by 9.16% if they have role models than those who don't have, keeping other things constant.

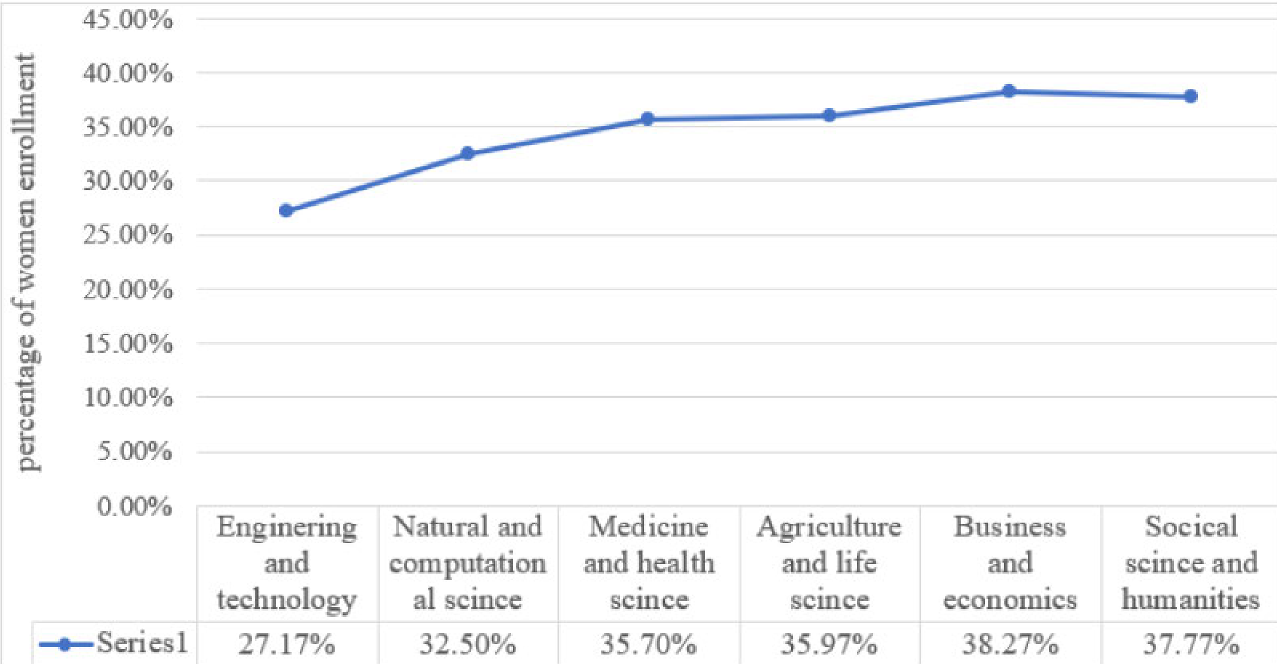

FIGURE 3. Percentage of women enrollment in an undergraduate degree in Ethiopian government-owned higher education institutions in 2016.

TABLE 8. Logistic regression results of significant variables.

Variables	Coefficient of AME	Robust Std.Err.	Z	Sig.level	[95% Confidence Interval]	
					lower	upper
Expected salary	0.2878595	0.0174039	16.54	0.000*	0.2537484	0.3219706
Family profession	0.0936166	0.0269222	3.48	0.001*	0.04085	0.1463831
Accessibility of role model	0.0916579	0.0268008	3.42	0.001*	0.0391293	0.1441866
Peer pressure	0.0237836	0.0536182	0.44	0.657	-0.0813062	0.1288734
High school education background	0.0017668	0.0004555	3.88	0.000*	0.000874	0.0026597
Income of the family	2.42e-07	1.32e-07	1.84	0.066**	-1.64e-08	5.01e-07

AME = Average marginal effect, Sig.level = Significance level, Std.Err = Standard error, * = 1% Sig.level, ** = 10% Sig.level

Similarly, high school education performance measured by grade 12 final exam positively and significantly impacts at 1% level. As the results of high school education performance increase by 1 unit, the probability of women student's choice of learning engineering and technology education increases by 0.18 percent. The family's annual income is also an essential variable with a positive influence at a 10% level, even though it has a negligible impact on the probability of women's choice of learning engineering and technology education as given in Table 8.

V. DISCUSSION

The engineering and technology profession makes essential contributions to the economy from the point of view of income generation and poverty reduction. However, the number of women in this profession is bleak. The statistical analysis of secondary data shows low-level women enrollment in these fields, accounting for 24% from 2007 to 2016. In this background, the paper under discussion investigates factors affecting women's engineering and technology education choice.

This study attempted to analyze factors associated with women students' engineering and technology education preference with all diagnostic tests. The result indicates that students' high salary expectation is the most significant variable that positively impacts women students' choice of engineering and technology education. Most students choose their area of study, which will provide a better salary after graduation. Existing studies did not study this variable in the literature as factors that affect women students' choice of learning engineering and technology. Hence, this factor's finding, which positively influences women students' choice of learning engineering and technology, will add value to the existing literature.

Additionally, the result confirms the positive relationship between engineering and technology professionals' existence in the family and women student's choice of learning engineering and technology education. It indicates most students adapt to the experience of their family. The result is in line with the finding of Talley and Ortiz [43]. According to the researchers, students described early involvement in STEM activities and family socializing training as the factors that most affected their interest in STEM and encouraged them to continue their studies and seek careers as potential STEM professionals.

The result confirms that the accessibility of a role model is another significant variable that can improve women students' engineering and technology education choices. The role model can determine student field selection, who can be a teacher or other professionals. The result confirms Webb *et al.* [46] found that teacher's practice and dialog promote students learning mathematics as a role model. This can be a base for selecting engineering and technology education since it is mainly related to mathematical computation. Other studies by [10], [12], [23] also confirmed the positive association between student's choice of field stream and role models. Hence, the accessibility of role models affected women student's choice of learning engineering and technology education positively and significantly.

High school education performance measured by grade 12 final semester exam provided countrywide is another significant variable that affects women students' choice of learning engineering and technology education. The result confirms the previous finding by Wang [42], who found that choosing a STEM major is directly influenced by 12th-grade math achievement, exposure to math and science courses, and math self-efficacy. Ünlü and Dökme [41] also found students' who have higher end-of-semester grades had a higher interest in STEM careers than those with lower achievement. So, the entrance exam results in grade 12 are the main criteria for keeping students' choice of departments regarding a country's higher education policy.

The result also indicates that the family's annual income has a positive but small impact on women student's choice of learning engineering and technology education. This might be the yearly income of Ethiopian people is found at a low level. The collected data from the respondents given in Table 4 had also confirmed that the average annual income of the family is only 62 thousand Ethiopian Birr ($US\$1,253$) in the current exchange rate. Hence, the family's yearly revenue has a small impact on women student's choice of learning engineering and technology education. The result confirms Ünlü and Dökme [41] finding stated that their family income level did not influence students' interest in STEM education. However, Großkreutz *et al.* [29] studied the influence on career choice to increase female students' participation in STEM. They noticed that the importance of family, career, and income is a crucial factor in advancing women in engineering.

Furthermore, this study indicates that peer pressure has a positive but insignificant impact even though Spearman's rank correlation coefficient shows the relation between women student's choice of learning engineering and technology education and peer pressure. Zamora-Hernández *et al.* [38] found 46% of participants answered that peer pressure is the most crucial factor affecting women's decision to study engineering. Similarly, Spearman's rank correlation coefficient of family suggestion to study engineering and technology, and duration of the program (Curriculum), with women's choice of learning engineering and technology education, become insignificant. Hence, these variables are dropped from the regression analysis. However, a study by Rankin *et al.* [35] found a positive relation. Zamora-Hernández *et al.* [37] found that 93% of women participants positively responded from their family on learning engineering education. Palincsar *et al.* [45] found that the educational curriculum is an essential determinant of students' interest in learning. Garcia Villa and Gonzalez [11] also found that the challenges faced by female students in engineering colleges due to the academic curriculum, which have an impact on the choice of learning engineering and technology.

As a consequence of these observations, the study's conclusion is: students expected salary, high school education background of students, availability of engineering and technology professionals in the family, and accessibility of role models are essential factors affecting women's choice of learning engineering and technology education based on the importance of t-statistics in the regression result shown in Table 8, rating the frequency of the variable's impacts. In comparison, the annual family income of women students has positive but minor effects. The result of post estimation of Logit regression shows the model is fitted and the coefficients are unbiased. The finding implies that women students, government, and other stakeholders should enhance women's enrollment in engineering and technology education. Such as government and employers must provide better wages for women graduates in this profession. There should also be the family's encouragement for their children in the field and increasing engineering and technology professional role models. Besides, students shall be intelligent and work hard to be ready to have better entrance exam results.

The current study has a limitation that leads us to suggest future research. First and foremost, only students who attended government universities were considered for this study. As a result, this research will need to be extended to include private institutions and male students.

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