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Inclusion of Women in the Mining Sector: Challenges and Opportunities Through Education

Selene Castañeda-Burciaga [1,2,*], Omar Alejandro Guirette-Barbosa [1,2], Martha Angélica Ramírez-Salazar [1,2], José María Celaya-Padilla [2] and Leticia Isabel García-Estrada [2,3]

[1] Department of Industrial Engineering, Universidad Politécnica de Zacatecas, Plan de Pardillo Sn, Parque Industrial, Fresnillo 99059, Zacatecas, Mexico; omarguirette@upz.edu.mx (O.A.G.-B.); juricons@hotmail.com (M.A.R.-S.)
[2] Postgraduate Department, Universidad Autónoma de Fresnillo, Carretera Federal Panamericana, Linda Vista, Ejidal 4, Fresnillo 99039, Zacatecas, Mexico; jose.celaya@uaz.edu.mx (J.M.C.-P.); letyge27@gmail.com (L.I.G.-E.)
[3] Instituto Tecnológico Loreto, Tierra Blanca, Loreto 98800, Zacatecas, Mexico
* Correspondence: scataneda@upz.edu.mx

Abstract: Labor dynamics have changed in recent years, and women have increased their participation in various activities within the production and business industries. One of these sectors is mining, which presents both challenges and opportunities to promote gender equality and decent work. In light of this, the objective of the present study is to identify the limitations faced by women in the mining sector, framed within personal, family, social, and labor aspects, in relation to their educational level. Due to the nature of the study, a cross-sectional, descriptive, and non-experimental investigation was proposed. The sample consisted of more than 50 companies distributed throughout the Mexican Republic, with a total of 316 female workers in the mining sector. The main results show greater limitations in labor and family aspects. Moreover, educational levels directly affect how women perceive the impact of working in mining on the various areas in which they operate.

Keywords: education; inclusion; women; mining; work

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1. Introduction

The economic development of any country is driven by the productive force of its economically active population. Likewise, labor dynamics have changed in recent years, with women increasing their participation in various activities within the production and business sectors. However, according to the International Labor Organization (ILO, 2023a), significant gender gaps persist in the workforce, indicating that, at the current rate of progress, it would take 300 years to achieve gender equality.

Currently, it has become more common to discuss concepts of equality, diversity, and inclusion in the workplace. Gender diversity is presented as a strategy to promote the application of equality between men and women in the work environment, recognizing the contributions of both (Caro et al., 2019). The authors argue that the concept of gender equality refers to the principle of non-discrimination in such a way that both men and women are treated according to their particularities and needs. Meanwhile, the concept of inclusion refers to an approach that positively responds to the incorporation and coexistence of diverse individuals and their differences; in other words, granting equal opportunities to benefit within a given context.

According to the ILO, gender imbalances in access to employment are highly pronounced, as for every dollar a man earns, a woman earns only 51 cents (ILO, 2023b).

Likewise, the employment gap is more severe in developing countries, where the proportion of women unable to find work is 24%, compared to 16.6% for men in the same category. Similarly, gender imbalances in the workplace are also reflected in the types of jobs available to women, as they tend to be over-represented in certain types of vulnerable employment.

Regarding the participation of women in the Mexican labor market, according to the National Institute of Women (INMUJERES, 2020), in a study conducted during the COVID-19 pandemic, it was observed that women's employment was more severely affected, with the unemployment rate rising from 3.5% to 6.3% between the first and second quarters of 2020, compared to 3.5% to 4.8% for men. Furthermore, according to the institute, women's return to work was slower than that of men during the pandemic, as a large portion of women's work is related to the provision of services, a sector heavily impacted by confinement and social distancing measures.

In this regard, it is possible to recognize how women have increasingly engaged in specific activities, which have often confined their roles as workers. Consequently, it is still difficult today to discern other areas of women's labor participation. One of these areas is mining, which, according to the ILO, represents both challenges and opportunities to promote gender equality and decent work, where the right to a safe, healthy, and harassment-free work environment is enjoyed (ILO, 2023c). It is worth noting that mining has traditionally been considered a labor-intensive activity focused on men, revealing biases against women involved in this field (Zárate, 2020).

Globally, 45% of economic activity is driven by the mining sector, and it is recognized that several critical sectors, such as construction, food production, transportation, and communications, depend on mining (Mining México, 2021). By the year 2023, the mining industry recorded a 2% growth, especially in those metals mostly related to technological and energy transition (CAMIMEX, 2024). According to ILO (2021) data, around 21.4 million people work in mines and quarries, of which 18.3 million are men and 3.1 million (14.48%) are women; the number of women has remained stable, although the proportion is still low.

The mining sector in Mexico has been an integral part of the economy since colonial times, with a rich history of extracting minerals such as silver, gold, and copper. Mexico ranks among the top 10 in the production of different minerals, standing out as the main extractor of silver worldwide (CAMIMEX, 2024). Mining contributes significantly to the country's gross domestic product (GDP), with a GDP of USD 43 million by the second quarter of 2024. During this same period, the employed population was 302,000 people, and the average age of workers in this sector was 40.5 years old, with schooling of 10.7 years. Similarly, the occupations with the highest number of workers in mining were miners and extraction workers in metallic mineral mines, drivers of mobile machinery for construction and mining, and workers in the extraction of quarry, clay, sand, stone, and gravel (SE, 2024).

According to the Mexican Chamber of Mines (CAMIMEX, 2024), the percentage of women's participation with respect to the total number of workers in the mining sector was 17.9% in 2023. Of this figure, 49% of women were in management positions, 25% were in supervisory positions, 21% were in technical positions, and 5% of women were in executive positions. These data are comparable to those presented by the ILO (2021), indicating that more than 60% of women occupy administrative positions, 14% are mining engineers, 4% are supervisors, and only 1% work as heavy equipment mechanics or extraction and preparation miners in subway mines; furthermore, the participation of women on boards of directors is only 5%, a situation that coincides with the Mexican context.

In line with the above, women in management positions face other types of challenges, considering that the mining industry has the lowest participation of women on boards of directors compared to any other sector. The obstacles they face are that women have more

responsibilities than men, they must attend to the functions assigned to them by society, there is a male corporate culture, they have a general lack of experience or little business line management, there is a lack of equality policies and programs in companies, as well as the absence of leadership training aimed at women, among others (ILO, 2021). In this regard, it is possible to recognize limitations that are reproduced not only in the mining sector but are also part of the challenges that women in management positions, in any sector, face in their professional development.

The above becomes relevant when considering that the participation of women in the mining context requires a certain level of preparation; likewise, there is a bias in the operative or manual positions that are developed inside the mine (CAMIMEX, 2024; Vaccarro & Contreras, 2022). In other words, women's occupations are conditioned by their level of professional preparation. This accentuates the dominance of men in this sector.

The mining sector is highly male-dominated, where biases and prejudices limit women's participation in the industry (Vaccarro & Contreras, 2022). Moreover, the lack of women in science, technology, engineering, and mathematics (STEM) fields, along with the inherent characteristics of mining jobs, restricts women's employment opportunities and their retention in the industry.

In Mexico, according to the National Occupation and Employment Survey (ENOE, 2023), only one out of seven university graduates in this country studied a STEM career, of which 38.4% are women enrolled in one of the 13 careers of the 56 universities that offer programs related to earth sciences in Mexico (CAMIMEX, 2024). By the second quarter of 2024, the average schooling of women working in the mining sector in Mexico was 12.8 years, which reflects that women are above the average educational level (10.7 years) of workers in the mining sector (SE, 2024).

On the other hand, the integration of women in the mining sector and its respective analysis is a relatively new topic. Despite this, a number of studies address the issue from different perspectives. One such study, conducted by Zárate (2020), in the context of mining in Mexico, aimed to identify the main challenges faced by women miners throughout their careers. This study, using a qualitative approach and focused interviews, examined three spheres of development: family, social, and work. The results suggest that the primary challenge for women is the conflict between self-fulfillment and the conventional roles they are expected to fulfill in each sphere of development.

Similarly, another study within the Mexican context, conducted by Lutz and Zaremberg (2022), employed a qualitative approach through interviews and case studies to identify the transformations in gender roles in community labor settings where extractive projects exist. This study follows a non-linear perspective, suggesting that various types of relationships between women and mining should be considered.

In the same vein, with a similar methodological approach, Cifuentes and Güiza (2021) conducted a documentary analysis to examine women's participation in mining in Colombia, considering social, economic, cultural, environmental, and legal aspects. Their findings show that women's participation in mining depends on the cultural appropriation of the territory. Furthermore, they highlighted that the human rights of women miners are negatively impacted by mechanized illegal mining.

In line with the previously mentioned studies is the research by Escalona (2021), who used interviews to identify and describe both the challenges women face and the consequences they experience in the workplace, social, and domestic spheres when they succeed in joining the mining industry. Her findings reveal that gender dynamics produced by mining highlight the marginalization women endure, exacerbating inequalities compared to men, as masculinized practices are the main cause and source of the marginalization experienced by women.

On the other hand, Stefanovic and Saavedra (2016) point out that the main obstacles to women's participation in the mining sector in Chile are primarily due to cultural barriers related to traditional roles, human resource policies of mining companies, organizational practices, and the fact that gender equality is not part of mining business policies or strategies. To a lesser extent, the following are also recognized as influencing factors: the operational conditions of the mining sector, motherhood as a barrier to access, labor regulations, differentiated infrastructure, gender equality, and unions.

According to the above, the labor context in which women work in the mining sector undoubtedly limits their ability to become leaders in science, technology, engineering and mathematics (STEM). In this regard, a study by Hernández and Hernández (2023), which focused on analyzing the perceptions of women working in STEM sectors in terms of various factors that affect their income, permanence and labor development, stands out. Its results indicate that women do not have the same opportunities as men in STEM fields; likewise, in order to enter the labor market, women had to deal with men with a high sense of superiority. Another aspect to highlight is that in the private sector, there are no clear mechanisms for women's advancement.

Similarly, in qualitative research that analyzes the interpersonal experiences of women working in STEM-associated work contexts in Chile (Gómez et al., 2024), women reported experiences such as questioning of their capabilities, gender violence, intellectual theft, and sexual harassment. Likewise, women demonstrated professional agency to deal with these scenarios, such as setting limits, validating their knowledge, setting goals, and challenging prejudices, which has allowed them to remain in and face highly masculinized environments.

On the other hand, according to the United Nations Entity for Gender Equality and the Empowerment of Women (ONU Women, 2020), there is a gender gap in STEM education, which is evident from the first educational levels and increases in the following levels. Similarly, it is detailed that the expectations held by parents, teachers, and peers have a direct influence on girls when choosing their field of interest and the studies they wish to pursue. This organization also highlights that women are subject to more prejudice during the hiring, promotion, and compensation processes compared to men.

According to The International Institute for Sustainable Development (IISD, 2023), in its global report on women and the mine of the future, which is based on data collected from a sample of 12 countries, details that, for example, in Brazil, 30% of students in STEM careers were women; while, in Chile, 20% of graduates in STEM careers related to mining programs were women. For its part, Mongolia stands out with a higher representation of women in these areas (63.7%), and, in Sweden, 49% of graduates in earth science-related programs were women. According to this report, women with STEM careers prefer other industries over mining, choosing occupations with less gender bias and fewer labor barriers.

As it is possible to recognize, the gender gap in the labor world is more noticeable in masculinized sectors, such as the mining sector. This requires transformational and cultural changes that allow the incorporation of women into the labor force, which highlights the importance of co-responsibility and flexibility in the extension of working hours (Cameron, 2023).

Now, in order to identify the differences and inequalities between men and women, with respect to the education of girls and women in science, technology, engineering, and mathematics (STEM), the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2019) developed a report through which it aims to identify the factors that contribute to the participation, achievements, and progress of women in STEM education, in addition to being able to identify the interventions that promote female interest in these disciplines. According to the aforementioned document, the factors that influence girls' and

women's participation, progression, and achievement in STEM education can be classified into factors at the individual, family, institutional, and societal levels.

As can be seen, the difficulties faced by women begin with their academic training and are consolidated when they enter the labor market. Thus, there is a gender gap in science, technology, engineering, and mathematics (STEM). In this regard, the mining sector is no exception since the masculinization of the profession hinders women's development to a greater extent.

In accordance with the above, a study conducted in the Chilean context (Salinas et al., 2023), which focused on engineering schools and technical training centers related to mining, stands out; its main findings were that there are gender stereotypes of teachers with respect to women who pursue mining careers. The results showed that teachers are more demanding and that dichotomies are reflected in the discourses that unconsciously hinder the training of women. Therefore, modifications are suggested in the hidden academic culture that sustains segregation, as well as the imperceptible resistance in the professional training of women.

This places education as a starting point since, although it is difficult to access some type of professional training related to the mining sector, those women who manage to enter this sector are limited in other areas of their lives. Therefore, it is necessary to understand whether the education of women who work in the sector is a differentiating aspect in their family, personal, and work environment.

Undoubtedly, it is possible to recognize the current status of women in the mining sector, which is influenced by aspects related to gender roles, as well as the practices of inequality between men and women. Therefore, the objective of this study is to identify the limitations faced by women miners, framed within personal, family, social, and work-related aspects, with regard to their educational level.

2. Materials and Methods

2.1. Type and Design of Research

Due to the nature of the study, a cross-sectional, descriptive, and non-experimental research design was proposed.

2.2. Data Collection Instrument

A scale entitled Women in the Mining Sector was developed ex profeso, considering four dimensions oriented to recognize the limitations faced by women in the mining sector. These dimensions correspond to personal, family, social, and labor aspects, aligned with existing theory (Zárate, 2020; Escalona, 2021; Stefanovic & Saavedra, 2016), which details the prevailing conditions in the life of women working in the mining sector. Likewise, the instrument contains a section with sociodemographic data, in which information is collected regarding age, marital status, number of children, economic dependents, maximum level of studies, position held, seniority in the company where she works, and working hours.

The instrument consists of 16 items presented on a Likert scale with a value range from 1 to 5, where 1 corresponds to "strongly disagree", 2 "somewhat disagree", 3 "somewhat agree", 4 "strongly agree", and 5 "completely agree".

Evaluation method: To evaluate the instrument, the scores obtained by the participants in each of the assessed dimensions were summed, resulting in the total score of the instrument (with a maximum score of 80 and a minimum of 25); the higher the score, the greater the perception of limitations among women working in the mining sector.

Furthermore, to validate the instrument, a sample of 25 elements was used as part of the pilot phase prior to its application. A Cronbach's Alpha of 0.912 (Table 1) was obtained, giving the instrument a high reliability value (Nunnally, 1978).

Table 1. Reliability Statistics.

Cronbach's Alpha	Number of Items
0.912	16

Note: Reliability statistics according to the Cronbach's Alpha calculation.

The piloting phase allowed the validation of the instrument in its original proposal since neither the items nor the presentation structure of the scale were modified. The items that make up the scale in its final version can be reviewed in Table 2.

Table 2. Final version of the scale: women in the mining sector.

Number	Items
1	Working in the mining sector hinders my personal self-realization
2	Working in mining complicates my relationships with my partner
3	I feel dissatisfied with the work I do in mining
4	Working in the mining sector has caused me to sacrifice personal aspects
5	My family disapproves of my work in the mining sector
6	I consider motherhood an obstacle to joining or staying in the mining sector
7	I have had to neglect my family because of work in mining
8	I am overburdened by my family duties and my job in mining
9	I feel judged for working in mining
10	I consider there is a social rejection of women working in mining
11	Working in mining prevents me from fulfilling my role as a woman in society
12	The salary I receive for my work in the mining sector is lower than that of men in the same position
13	I feel that my work is not properly recognized
14	The tools and equipment provided at work are inadequate and insufficient
15	There is inequality in working conditions between men and women
16	I feel sexually harassed by my coworkers

Note: Final items.

2.3. Descriptive Demographic Analysis

In order to determine the characteristics of the sample, a descriptive analysis was made of the sociodemographic variables included in the data collection instrument.

2.4. Factor Analysis

In order to determine the dimensions that make up the instrument, exploratory factor analysis was chosen, using a principal component extraction (PCA) method and Oblimin rotation. To assess the suitability of the data for factor analysis, the Kaiser–Meyer–Olkin (KMO) measure was used, which indicated whether the sample size and the relationships between variables were adequate to identify underlying factors.

The validation of the correlations between variables was carried out using Bartlett's test, which checks whether the correlation matrix is not an identity matrix. An identity matrix implies that the variables are uncorrelated, which is a prerequisite for the selected factor analysis.

2.5. Analysis of the Educational Variable

An analysis was developed considering the educational level of the women participants and the social, family, personal, and labor implications of working in the mining sector.

3. Results

3.1. Descriptive Analysis

The sample was represented by more than 50 companies distributed throughout the Mexican Republic, with a total of 316 women participants working in the mining sector. The sociodemographic data of the sample show that the majority of participants are in the age range of 26 to 30 years. Another noteworthy aspect is that the majority of the working women are single (56%) and without children (63%); regarding economic dependents, 37% indicated that they do not have any (Table 3).

Table 3. Descriptive statistics of the sample.

		n = 316	100%
Age (years)	18 to 20	0	0.00
	21 to 25	50	15.82
	26 to 30	101	31.96
	31 to 35	67	21.20
	36 to 40	49	15.51
	41 to 45	26	8.23
	46 to 50	9	2.85
	51 to 55	7	2.22
	56 to 60	7	2.22
Marital Status	Single	177	56.01
	Married	78	24.68
	Divorced	13	4.11
	Cohabiting	48	15.19
	Widowed	0	0.00
Children	No children	200	63.29
	One child	56	17.72
	Two children	47	14.87
	Three children	10	3.16
	Four children	3	0.95
Economic Dependents	No dependents	118	37.34
	One dependent	81	25.63
	Two dependents	70	22.15
	Three dependents	37	11.71
	Four dependents	7	2.22
	Six dependents	3	0.95
Educational Level	Middle School	6	1.90
	High School	6	1.90
	Bachelor's Degree	223	70.57
	Postgraduate	81	25.63
Job Tenure	Less than one year	15	4.75
	One year	57	18.04
	Two years	87	27.53
	Four years	56	17.72
	Five years	16	5.06
	Eight years	39	12.34
	Nine years	3	0.95
	Ten years	6	1.90
	Twelve years	14	4.43
	Thirteen years	6	1.90
	Fourteen years	3	0.95
	Eighteen years	14	4.43

Table 3. *Cont.*

		n = 316	100%
Daily Work Schedule	Eight hours	59	18.67
	Ten hours	135	42.72
	Twelve hours	82	25.95
	Fourteen hours	37	11.71
	Fifteen hours	3	0.95

Note: Own elaboration.

Similarly, information related to the educational level of the participants was gathered, revealing that the majority hold professional-level degrees (96%), either at the bachelor's (71%) or postgraduate (26%) level. Regarding job tenure, most of the workers have between one and two years of experience (46%). It is also noteworthy that the majority of work shifts are ten hours per day (43%).

Additionally, it is observed that 6.33% of the total sample holds a managerial-level position, which aligns with their professional education, either a bachelor's or postgraduate degree. Meanwhile, 51.58% hold strategic-level positions, meaning they have supervisory or departmental head roles. Operational-level positions are occupied by 26.9%, while the remaining 15.19% hold administrative roles (see Figure 1).

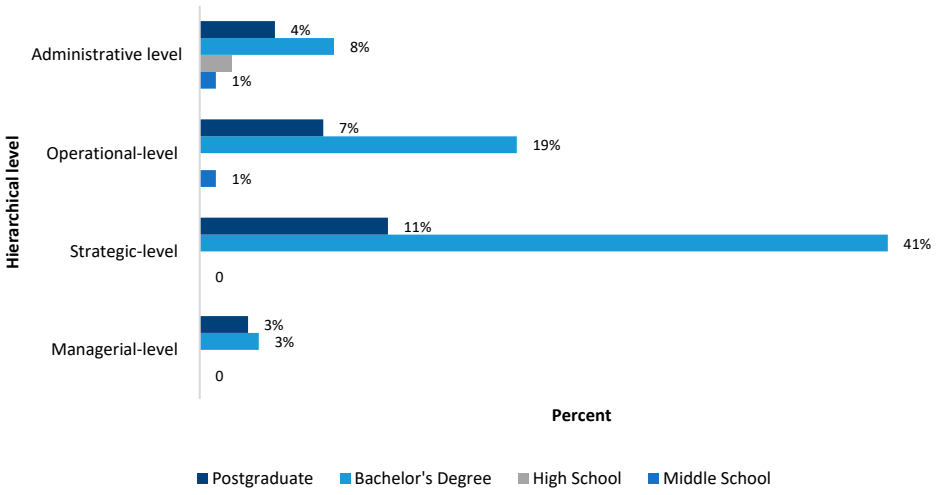

Figure 1. Hierarchical position occupation.

3.2. Exploratory Factor Analysis

Bartlett's test of sphericity and the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy (Table 4) were performed. According to the Kaiser–Meyer–Olkin measure (0.883), it indicates excellent sampling adequacy, as it exceeds the recommended threshold of 0.6. This suggests that the data are sufficiently appropriate to perform a factor analysis. Meanwhile, Bartlett's test of sphericity is significant (chi-square = 2581.686, $p < 0.001$), confirming that the correlations between variables are statistically significant and that the data do not form an identity matrix.

The results of the factor analysis adequacy tests indicate that the data are adequate for the APC. These findings support the validity of the use of factor analysis in this study and ensure that the factors extracted adequately represent the relationships between the variables analyzed.

For the factor analysis, principal component analysis was considered as the extraction method because it is ideal for identifying underlying factors that explain most of the

variance in the data. Oblimin rotation was used, as it indicates that factors may be correlated, which is appropriate for social phenomena where structures are often interrelated.

Table 4. Kaiser–Meyer–Olkin measure of sampling adequacy and Bartlett's test of sphericity.

KMO and Bartlett's Test		
Kaiser–Meyer–Olkin Measure of Sampling Adequacy		0.883
Bartlett's Test of Sphericity	Approx. Chi-Square	2581.686
	df	120
	Sig.	0.000

Note: Reliability statistics according to the Cronbach's alpha calculation.

Factor retention was by means of the Kaiser criterion factors with eigenvalues greater than 1. In this case, four main factors were identified. Likewise, according to the Scree Plot (Figure 2), the inflection point in the Scree plot confirms the retention of the first four factors since the curve begins to flatten after the fourth component; from the fifth component on, the eigenvalues gradually decrease; therefore, the inclusion of additional components is not justified, since their contribution to the variance is marginal and not significant.

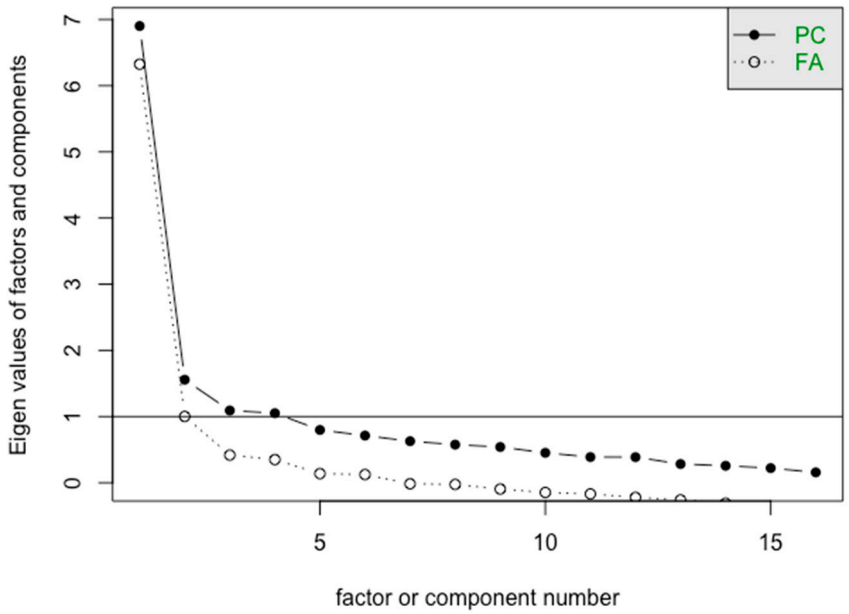

Figure 2. Factor analysis.

The four retained factors explain 66.256% of the total variance (Table 5), which is adequate for social science factor analysis standards. The initial eigenvalues indicate the variance explained by each component before extraction. Only components with eigenvalues greater than 1 were retained, which is consistent with the Kaiser criterion.

The main loadings by component can be reviewed in Table 6 (pattern matrix). Component 1 (**family**) variables such as "I have had to neglect my family because of work in mining" (0.884) and "I am overburdened by my family duties and my job in mining" (0.852) have the highest loadings, indicating that this component represents the impact of mining work on family life and personal sacrifices. Component 2 **(labor**) has variables such as "I consider that my work is not properly recognized" (−0.912) and "There is inequality in working conditions between men and women" (−0.871), which are associated with the perception of inequities and lack of recognition in the work environment.

Table 5. Total variance explained.

Component	Initial Eigenvalues	Sum of Squared Loadings (Extraction)	Sum of Squared Loadings (Rotation)
	Total	% of Variance	% Cumulative
1	6.901	43.134	43.134
2	1.557	9.729	52.863
3	1.092	6.823	59.686
4	1.051	6.570	66.256
5	0.798	4.985	71.241
6	0.713	4.453	75.695
7	0.628	3.924	79.619
8	0.576	3.599	83.218
9	0.540	3.377	86.595
10	0.452	2.826	89.421
11	0.388	2.426	91.847
12	0.387	2.418	94.264
13	0.283	1.769	96.034
14	0.257	1.603	97.637
15	0.221	1.383	99.020
16	0.157	0.980	100.000

Note: Extraction method: principal component analysis.

Table 6. Pattern matrix.

Item	Component 1	Component 2	Component 3	Component 4
1. I have had to neglect my family because of work in mining	0.884	--	−0.182	--
2. I am overburdened by my family duties and my job in mining	0.852	--	0.150	--
3. Working in the mining sector hinders my personal self-fulfillment	0.719	−0.199	0.165	−0.115
4. Working in the mining sector has caused me to sacrifice personal aspects	0.708	--	--	0.162
5. Working in mining complicates my relationships with my partner	0.602	−0.109	--	0.129
6. I consider that my work is not properly recognized	--	−0.912	--	−0.116
7. There is inequality in working conditions between men and women	--	−0.871	--	--
8. The salary I receive for my work in the mining sector is lower than that of men in the same position	--	−0.831	--	--
9. The tools and equipment provided at work are inadequate and insufficient	--	−0.595	--	0.245
10. I feel sexually harassed by my coworkers	0.137	−0.517	−0.287	0.154
11. Working in mining prevents me from fulfilling my role as a woman in society	0.291	−0.324	0.190	0.252
12. I feel dissatisfied with the work I do in mining	0.115	--	0.813	0.190
13. I consider motherhood an obstacle to joining or staying in the mining sector	0.297	−0.223	−0.444	0.345
14. My family disapproves of my work in the mining sector	0.108	0.129	--	0.789
15. I feel judged for working in mining	0.168	--	--	0.749
16. I consider there is a social rejection of women working in mining	−0.188	−0.375	--	0.637

Note: Extraction method: principal component analysis. Rotation method: Oblimin with Kaiser normalization.

Component 3 (**personal**), the variable "I feel dissatisfied with the work I do in mining" (0.813), has the highest loading, identifying this component as a reflection of personal dissatisfaction and lack of fulfillment of work expectations. Component 4 (**social**), with variables such as "I feel judged for working in mining" (0.749), highlights how working in mining can generate social tensions.

A component correlation matrix was also developed (Table 7), which shows the correlations between the components extracted after oblique rotation. Values close to 0 indicate little or no relationship, while higher positive or negative values reflect a significant correlation between components.

Table 7. Component correlation matrix.

Component	1	2	3	4
1	1.000	−0.455	0.029	0.458
2	−0.455	1.000	−0.045	−0.415
3	0.029	−0.045	1.000	0.006
4	0.458	−0.415	0.006	1.000

Note: Correlational analysis.

Accordingly, Component 1 (family) and Component 2 (labor) have a moderate negative correlation (−0.455), suggesting that the factors related to personal sacrifices and labor inequality are inversely proportional. That is, when the perception of personal sacrifices increases, concerns about job inequality decrease, or vice versa.

Components 1 (family) and 4 (social) have a moderate positive correlation (0.458), indicating that factors related to personal sacrifices are directly related to social and family tensions. Component 2 (labor) and Component 4 (social) present a moderate negative correlation (−0.415), which could imply that perceptions of job inequality tend to be in conflict with social and family tensions. Component 3 (personal), on the other hand, has very low correlations with the other components (maximum 0.029), suggesting that personal dissatisfaction is a factor relatively independent of the others.

3.3. Analysis of the Educational Variable

According to the factor analysis, the items related to the working conditions of women in the mining sector were identified, grouping the following items:

P1: There is inequality in working conditions between men and women.

P2: I believe I do not receive adequate recognition for the work I do.

P3: The salary I receive for my work in the mining sector is lower than that of men in the same position.

P4: The tools and equipment provided for my work are inadequate and insufficient.

P5: I feel sexually harassed by my coworkers.

P6: Working in the mine prevents me from fulfilling my role as a woman in society.

Using the sociodemographic variable of educational level, an analysis was conducted regarding education and the factor of working conditions. As shown in Figure 3, higher education levels (bachelor's and postgraduate degrees) share a similar perception regarding inequality of conditions, lack of recognition, and salary perception. These items were given the highest weight. It is acknowledged that the higher the level of education, the greater the general dissatisfaction with working conditions.

It is important to note that the majority of women, regardless of their level of education, do not report having experienced any form of sexual harassment by their male colleagues, nor do they feel they have difficulties fulfilling their role as women in society.

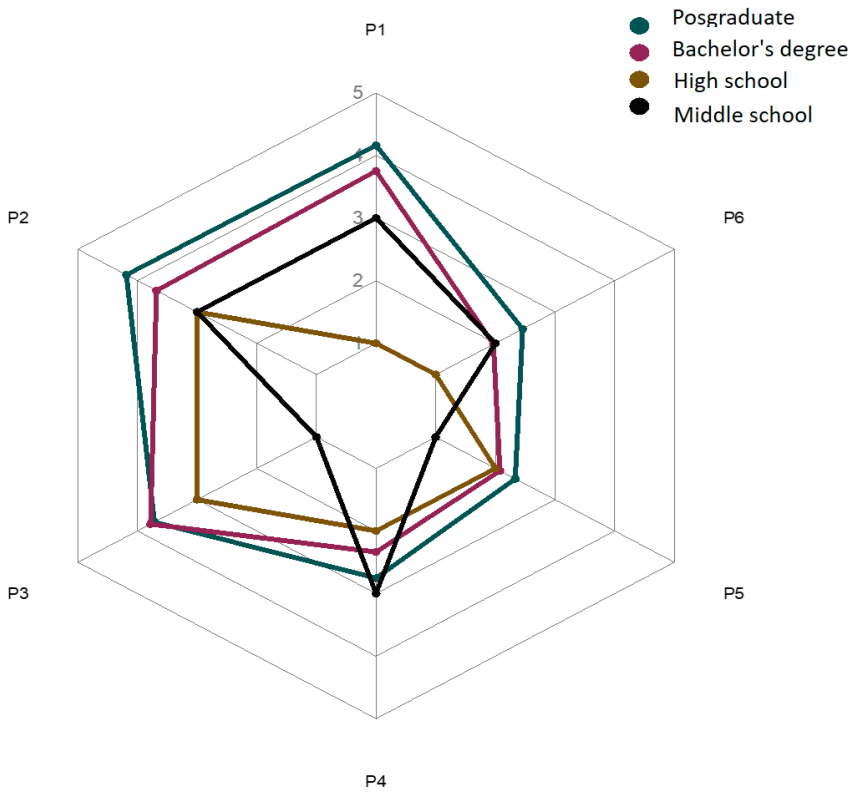

Figure 3. Radar chart for the working conditions factor.

Regarding the general perception of women about the limitations of their inclusion in the mining sector, it is possible to determine that, in the personal dimension, encompassing aspects such as personal self-fulfillment, relationships, job, and personal satisfaction, women generally perceive a low level of limitations. This is because most of their responses fall within the lower score range. Specifically, with respect to the participants' level of education, no significant differences were observed (see Figure 4). It is worth noting that the highest-scoring item in the entire data collection instrument corresponds to the personal dimension, as women feel that working in the mining sector has caused them to sacrifice personal aspects.

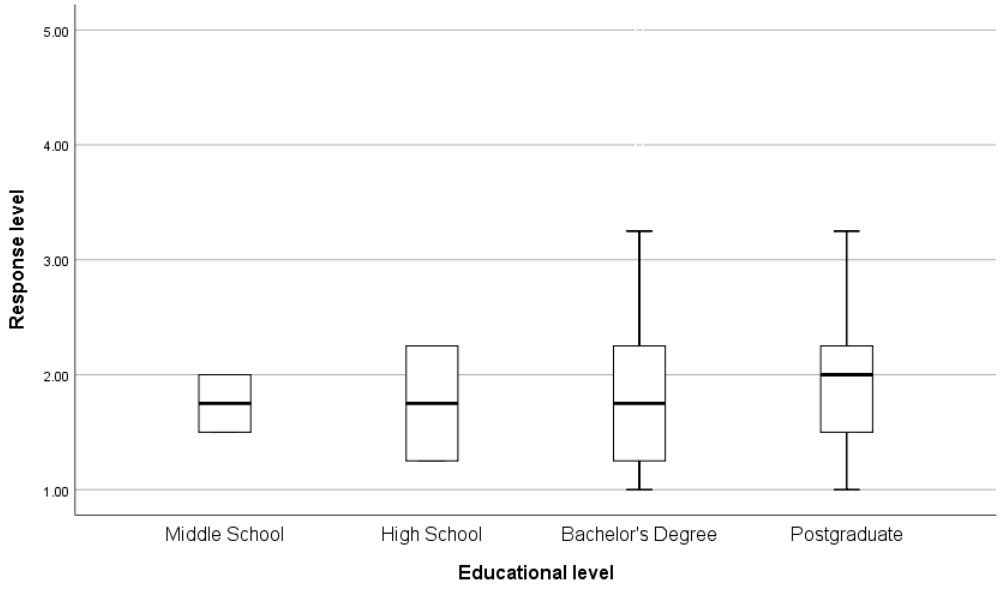

Figure 4. Analysis of the personal dimension.

Regarding the family dimension, which evaluates aspects such as family approval, motherhood, and family duties, there is no high perception of family limitations resulting from working in the mining sector. However, differences in this perception are observed based on the participant's level of education, where the higher the level of education, the greater the family challenges faced by women (see Figure 5). Specifically, within this dimension, women report greater challenges related to motherhood, as they consider that motherhood can be an obstacle to entering or remaining in work within the mining sector.

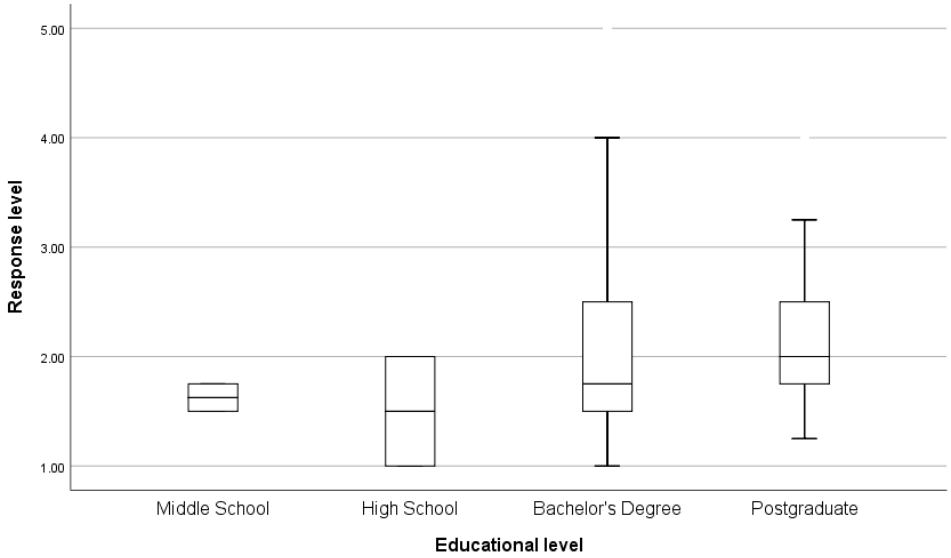

Figure 5. Analysis of the family dimension.

On the other hand, addressing the social aspect, which was evaluated considering factors such as fulfilling the role of women in society, social rejection for working in the mining sector, and the social perception of mining work, the participants expressed that this area was the least affected by working in mining. Furthermore, it was found that there is a difference in women's perceptions according to their educational level (Figure 6). Specifically, the higher the level of education, the greater the perception of the social impact on women working in the mining sector. The highest-rated factor in this dimension refers to the existence of social rejection of women's work in mining.

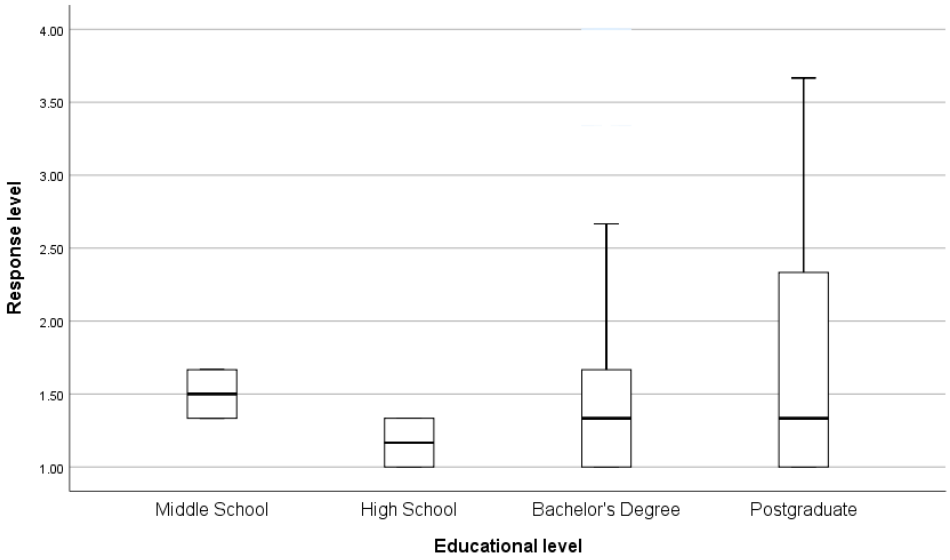

Figure 6. Analysis of the social dimension.

Now, according to a correlational analysis, it is possible to identify a moderate bilateral significant correlation (Cohen, 1992) between the daily working hours and the perception of women that working in the mining sector has caused them to sacrifice personal aspects (r = 0.304, p = 0.000), as well as the perception of having to neglect their family for mine work (r = 0.384, p = 0.000).

4. Discussion

According to the main findings of the study, there are various limitations faced by women in mining, which, to a greater or lesser extent, impact different personal, social, and professional spheres. As noted by Zárate (2020), the primary conflict women encounter relates to their self-fulfillment, a situation reflected in the present analysis since the aspect that received the highest weight was related to the sacrifice of personal aspects due to working in the mining sector. That is, there is a feeling among the women surveyed that their work in the mining sector may be limiting their ability to reach their full personal and professional potential, which coincides with Kaggwa (2020), who details that women face very significant challenges, such as career development and growth and discrimination in the management structure, as well as a marked wage gap in relation to the opposite gender. Similarly, Pactwa (2019) mentions that the mining sector remains highly masculinized, which limits or obstructs job opportunities for women who have studied in STEM mining-related fields.

Another issue to highlight is the inequality compared to men working in the same field, as the lack of recognition for the work performed and the perceived inequality in working conditions between men and women were the factors that received the highest scores. In other words, women believe that, during their professional careers, they have faced such situations, as noted by Escalona (2021). This is the case in the global mining industry, as women face gender discrimination, sexual harassment, and sexual demands during the hiring process, which hinders their professional development and job security (Kansake et al., 2021). This indicates that many women feel that their contribution to the mining sector is not adequately valued or recognized, which can affect their morale and commitment to their work. This coincides with the findings of Mueller (2021), whose study showed that women are not only a minority in high-paying positions but also face systematic barriers that limit their access to leadership roles and public recognition. In the same vein, the work of Tyshchenko et al. (2021) points out that women workers in this sector face a lack of not only salary but also professional recognition, which perpetuates their exclusion from strategic discussions and from the most highly valued positions.

Similarly, women recognize motherhood as a determining factor for entering or remaining in the mining sector, which aligns with the findings of Stefanovic and Saavedra (2016) and Caro et al. (2022). The authors mention that women working in the mining sector perceive that their maternal role is socially and entrepreneurially ignored, which generates frustration, anxiety, and guilt. This issue suggests that some women feel that motherhood may be a challenge to their continued participation in the mining sector, possibly due to the lack of work-family reconciliation policies or support for working mothers.

It is noted that "motherhood penalization or stigmatization" is a global phenomenon that affects the career progression of women in various sectors, not only in mining. Mothers face systemic barriers that limit their professional advancement, being subject to stricter standards in terms of salary and recruitment. This phenomenon is exacerbated by the lack of corporate policies that support working mothers and by a work culture that does not always value the diversity of women's experiences (Torres et al., 2024). In the mining

context, the lack of institutional support and the sexist culture intensify these challenges, making women feel that they must assume the responsibility of integrating their work and family life as a personal rather than a social problem (Caro et al., 2022).

On the other hand, the component correlation matrix provides a comprehensive view of the relationships between the factors extracted in the factor analysis. The moderate interrelationship between the factors suggests that some problems, such as personal sacrifices and social tensions, tend to coexist and reinforce each other, while others, such as labor inequality, operate on a separate level. This raises the need to address these problems from multiple perspectives: (a) family and social support to mitigate the stresses derived from mining work, (b) revision of labor policies to reduce perceptions of inequality and improve recognition in the work environment, and (c) individualized attention to address personal dissatisfaction in a targeted manner through strategies such as mentoring, training, or job redesign.

The correlations found also reflect a social and cultural context in which women's work in mining can generate conflicts with traditional social roles. This phenomenon is especially observed in the relationship between personal sacrifices and social tensions, which underlines the importance of challenging stereotypes and cultural norms to better support women in non-traditional sectors.

Regarding the analysis of the results that contemplates the educational variable, it is necessary to consider that the majority of women working in the mining sector have professional studies. Therefore, it is inferred that specialized preparation is required to join the sector, which coincides with the average schooling of 12.8 years for women working in the mining sector in Mexico (SE, 2024), a situation that is replicated in other contexts (Vaccarro & Contreras, 2022), which indicates that most women working in mining have received higher education. This becomes relevant in the STEM context since professionalization in these areas is a determining factor for their inclusion in the mining sector.

Finally, one of the most outstanding findings of this study is that the educational level of women conditions their perception of the main dimensions that make up their personal, social, family, and work lives. Therefore, a higher level of preparation in STEM areas enhances women's ability to recognize the limitations they face, which, in a way, allows them to act accordingly to close the gender and inequality gap that has been perpetuated for a long time.

5. Conclusions

Today, the gender gap between men and women, which is accentuated in the academic and work environment, is well known. For this reason, several efforts have been made at the international level to encourage girls to become leaders in science, technology, engineering, and mathematics (STEM); despite this, progress in equality, although promising, is still slow, and there are many challenges in various sectors, especially in masculinized work contexts.

A paradigm shift is required from the academic training level, where an inclusive education can be guaranteed, which promotes the active participation of women and allows them to develop professionally. Thus, a reduction in the gender gap can be achieved through education since not only are equal opportunities required for women to access careers related to the hard and exact sciences, but it is also necessary that all the actors involved during professional training provide women with the same self-perception of achievement that they give to male students since education is a differentiating factor to face the challenges in the work environment.

Specifically, the perception of women working in the mining sector can vary significantly depending on various factors, such as the organizational culture of the mining company, government policies, labor legislation, the presence of unions, and the socioeconomic and cultural conditions of the region where the mine is located.

In general, a decisive aspect of how women perceive the limitations of their inclusion in the mining sector is education. That is, the level of education directly affects how women perceive the impact of working in mining on their personal, family, social, and professional lives. It is important to note that, in the selected sample, the majority of the women hold a professional degree, which indicates that access to this sector is primarily through a bachelor's or graduate degree, representing the highest level of education.

Undoubtedly, the diversity of situations faced by women working in the mining sector is evident, and they must balance these with the roles they play in the various spheres in which they operate. The significance of this study is reflected in the description of those factors that influence the inclusion of women in the mining sector from a comprehensive perspective, highlighting education as a key aspect in the perception of the limitations women may face.

Some limitations of the study include the sample size, which, although representative of the population studied, requires greater exploration of the perspectives of women from different contexts and cultures. Additionally, for future lines of research, it is suggested to consider aspects related to occupational health and safety, career opportunities, and their impact on the community.

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