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¿CUÁLES SON LOS BENEFICIOS QUE RECIBEN LOS ESTUDIANTES DE INGENIERÍA E INGENIEROS PROFESIONALES AL PONER EN PRÁCTICA LA EDUCACIÓN AMBIENTAL?

DO ENGINEERING STUDENTS AND ACTIVE ENGINEERS RECEIVE BENEFITS IF THEY PUT ENVIRONMENTAL EDUCATION INTO PRACTICE?

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Resumen

La educación es la base del cambio social, tales como la conciencia ambiental; sin embargo, son muchos los factores que intervienen y los beneficios que se obtienen no an sido estudiados a profundidad. Por tal motivo, en este artículo se reportan los Beneficios sociales (SOB), económicos (ECB) y ambientales (ENB) de la educación ambiental (EE) en universidades mexicanas. Se utiliza un modelo de ecuaciones estructurales que integra tres relacionadas con los beneficios de la EE, tales como SOB, ECB y ENB, y una más sobre valores ambientales (Va). Las variables se relacionan mediante 5 hipótesis que son validadas con información de 573 respuestas a un cuestionario aplicado a estudiantes de ingeniería e ingenieros activos.

Este estudio asume que la EA tiene el potencial de convertirse en una herramienta que promueve la sostenibilidad al fomentar valores y prácticas que permiten una coexistencia armoniosa con el medio ambiente. La investigación destaca que, al incorporar contenidos de EE en programas de ingeniería, se potencia el desarrollo de actitudes y habilidades que mejoran el ambiente de trabajo y la comunidad, e impulsan prácticas ambientales en la industria. Este enfoque se alinea con los objetivos de instituciones educativas y empresas interesadas en reducir su impacto ambiental mediante la formación de profesionales comprometidos.

Los resultados revelan relaciones significativas entre los beneficios de la EE. En primer lugar, los SOB tienen un efecto directo y positivo sobre los ECB. Esto implica que los esfuerzos por fomentar un ambiente de trabajo seguro y saludable no solo contribuyen a una mejor calidad de vida, sino que también generan ahorros económicos mediante la reducción de costos operativos y la optimización de recursos. Además, se encontró que los SOB están positivamente relacionados con los ENB, relacionada con la reducción de residuos y el consumo de materiales peligrosos, lo cual refuerza la interdependencia entre la sostenibilidad ambiental y la eficiencia económica.

El estudio también demuestra la influencia de los Va sobre los ECB, demostrando que los estudiantes y profesionales con una mayor concienciación ambiental son más propensos a adoptar prácticas que resultan en ahorros económicos y mejor desempeño ambiental.

Con base en estos hallazgos, el artículo recomienda una mayor integración de la educación ambiental en los programas de formación en ingeniería. La inclusión de la EA no solo mejoraría la percepción de los ENB y SOB, sino que también dotaría a los futuros ingenieros de las competencias necesarias para implementar innovaciones técnicas que beneficien tanto a la sociedad como al medio ambiente. Finalmente, el artículo enfatiza que las empresas que implementan prácticas de sostenibilidad ambiental pueden acceder a incentivos financieros y

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beneficios fiscales, como los impuestos verdes aplicados en países como Finlandia, Suecia y Alemania, que reducen las cargas fiscales para las compañías comprometidas con el medio ambiente.

En conclusión, fortalecer la EE en la formación de ingenieros representa no solo una inversión hacia un futuro más sostenible, sino también una oportunidad para que la industria lidere la promoción de prácticas empresariales responsables, generando un impacto social y ambiental positivo.

Palabras clave: Beneficios ambientales; beneficios económicos; beneficios sociales; educación ambiental; valores ambientales.

Abstract

This study analyzes the social, economic, and environmental benefits of environmental education (EE) programs in educational institutions in Mexico, focusing on the relationships between environmental benefits (ENB), economic benefits (ECB), and social benefits (SOB) through a structural equation model validated with information from 573 responses to a questionnaire and using the partial least squares technique. The results mean that SOB has a direct and positive effect on ECB. In addition, it offers recommendations to effectively integrate EE into the planning, design, construction, and engineering-related project processes to maximize the realization and perception of benefits (ECB, ENB, and SOB).

Keywords: Economic benefits; Environmental benefits; Environmental education; Environmental values; Social benefits.

1. Introduction

The negative impact of human activities on the environment is a growing concern, as it negatively impacts society and living organisms. To build a sustainable society, it is crucial to maintain a balance, as humans directly benefit from and impact nature. Consequently, this theme of alarming changes is known to affect continents, societies, and governments.

Environmental education (EE) can be implemented to analyze climate change issues, which is a powerful tool to promote sustainability and address environmental deterioration. EE fosters harmony and coexistence with nature by focusing on local knowledge, experiences, values, and practices. It is a preservation strategy that fosters synergistic spaces for scientists, decision-makers, and stakeholders. Higher education institutions have recognized the importance of incorporating sustainability into education to make it more impact-oriented (Boca & Saraçlı, 2019). EE addresses environmental problems by acquiring and applying societal values, ensuring a healthy environment for future generations.

However, a need for more relationship between EE content in natural science schools and students' attitudes, skills, values, and behavior. In particular, the dangers of environmental problems have caused industries in recent years to focus on green performance and train their employees on green parameters (Darvishmotevali & Altinay, 2022).

In recent years, life has been reoriented in university education to align with new paradigms, values, and attitudes that promote harmony and meaning in scientific, technological, communication, and industrial fields (Xie & Lu, 2022). For example, the Earth Charter aims to synthesize people's values, including ecological integrity, social justice, democracy, non-violence, and peace, where sustainable development has become essential, with ethical values at the forefront (Agbedahin, 2019).

Among the tools that help analyze climate change issues is environmental ethics, which examines the moral relationship between humans and the natural environment, focusing on the value and moral standing of the environment (Mckay, 2022). Environmental ethics advocates for restrictions on the dichotomous association between humans and nature, emphasizing the responsibility of humans to live in harmony with the environment rather than dominating it (Bassey & Nwoye, 2018).

That is why the EE programs are essential for promoting positive attitudes and values toward the environment, enhancing knowledge and skills among individuals and communities, and strengthening collaboration between the public, authorities, stakeholders, decision-makers, scientists, and academic institutions (Ardoin et al., 2020). Therefore, learning spaces should be created to promote environmental values (EV) and raise awareness of the prudent use of natural resources to guarantee living conditions for future generations. Schools and companies should restructure their bases to provide learning spaces where environmental practices are strengthened, paradigm changes are achieved, and aspects that deteriorate ecological balance are modified.

In conclusion, EE is important in fostering a commitment to sustainability. It provides engineers with the necessary knowledge and competencies to tackle environmental issues and create technical innovations that influence society and the natural world favorably. There is a growing emphasis on urging engineering students and professionals to consider the ecological consequences of the systems they conceive and construct. This transition towards sustainability within engineering education is well-timed and indispensable, given the pivotal role that engineering experts play in determining resource utilization for communities.

1.1. Benefits of EE

A key aspect necessary for the success of environmental protection efforts is the existence of effective training initiatives related to environmental education and awareness, which should equip employees with the knowledge and skills required to act in an environmentally friendly manner and make environmentally responsible decisions, resulting in social, economic, business, and environmental benefits. Due to this commitment to knowledge application, EE can benefit the environment, people, and society.

For example, environmental education (EE) offers social benefits like increased physical activity, academic performance, social skill development, and a positive attitude. Additionally, some companies should respond to community needs and involve them in planning and maintaining environmental activities (Mygind et al., 2019).

Similarly, EE allows economic benefits (ECB) to be obtained from the environmental impact of rational resource use. For example, Manzoor et al. (2019) highlight the importance of EE in tourism, focusing on economic benefits. Sustainable tourism can increase livelihoods, protect cultural heritage, and foster connections between agriculture and industry. Also, green products can prevent local environmental hygiene taxes or obtain tax breaks.

Therefore, transitioning to a sustainable economy requires changes in consumer processes and behaviors (Glavič, 2021). Organizations promoting EE usually are under environmental certifications; they are favored in credit applications, leading to lower risk premiums and competitive advantages. So, fostering and developing skills, such as business skills, global outreach, and international market participation, can help companies thrive in this sustainable economy (Ferrón-Vílchez, 2016).

On the other hand, EE generates environmental benefits by reducing waste, energy consumption, and waste scarcity while promoting education in information technologies. Also, it addresses lower environmental impact by planting trees and ornamental plants, reducing solar radiation´s impact on exterior wall temperature, and reducing energy consumption (Hall & Dickson, 2011).

This study examines the social, economic, and environmental benefits of EE-implemented programs in educational institutions in Mexico. It focuses on the relationships between SOB, ECB, and ENB of environmental practices, contributing to the literature on EE and improving project efficiency and sustainability.

On the other hand, this study provides information and practical recommendations for effectively integrating EE into the planning, design, construction, and engineering-related project processes to maximize the obtainment and perception of the benefits obtained (ECB, ENB, and SOB).

2. Literature review

2.1. Literature review

EE is a fundamental addition to student development, contributing to social sectors and environmental care (Pfajfar et al., 2022). It enhances students' development of novel approaches and solutions, promoting growth and innovation (Chen et al., 2020). Companies aim to generate benefits beyond organizational boundaries, stimulating internal and external growth.

Some studies have highlighted SOB, such as the benefits of green spaces and environmental awareness in urban areas. Green tourism promotes natural preservation and benefits companies through fiscal advantages (Dolnicar, 2020). This raises awareness, improves the quality of life, and promotes the common good through sustainable alternatives, strengthening mutual benefits between companies, society, the environment, and stakeholders (Pfajfar et al., 2022). Consequently, the following hypothesis is proposed to investigate the relationship between the SOB and ECB of environmental practices:

H_1: Social benefits (SOB) generated by environmental practices are directly and positively related to the economic benefits (ECB) generated.

2.2. Relationship between SOB and ENB

EE and renewable energy are crucial for a country's development, attracting foreign investment and promoting economic activities. Environmental practices, including SOB and ENB, contribute to effective environmental policies and sustainability (Omarova & Jo, 2022). These practices, such as pollution reduction, natural asset preservation, biodiversity protection, and green product development, help reduce greenhouse gas emissions, improve air quality, and lower respiratory disease risks (Petroni et al., 2022; Zhang et al., 2022).

Budiaman et al. (2021) indicate that people who perceive SOB of their EE can implement better environmental practices focused on improving the environment through more significant commitment. This is reinforced by Abbasov et al. (2019) by pointing out the need to disseminate SOB first, and that ENB and ECB will come as a consequence of the former; that is, environmental socialization must exist first. Based on the above, the following hypothesis is proposed:

H_2: The social benefits (SOB) generated by environmental practices are directly and positively related to the environmental benefits (ENB) generated.

2.3. Relationship between ENB and ECB

A complicated and multidimensional link exists between the ENB from EE and the ECB in teaching about the environment. Methods of environmental investment and management have the potential to have an impact on the economic gains that environmentally conscious activities bring about. It is common for people to make decisions based on the highest advantages against the lowest costs, which might include money, effort, and social approbation. Resources positively correlate with social, environmental, and economic benefits, and these advantages, in turn, correlate with ECB. Resource benefits are also favorably connected with ECB (Li, 2021). Enterprises have the potential to acquire economic advantages as a result of the efforts of executives. In contrast, ENB relates to the value that executives provide to the environment while doing their duties.

Additionally, it has been discovered that EE has a favorable impact on the environmental behavior of students, which suggests that there may be a connection between it and the outcomes that are beneficial to the environment (van de Wetering et al., 2022). For example, Nurhasana (2014) indicates that waste management initiatives, such as waste banks, have been found to yield significant environmental benefits, which in turn contribute to societal well-being and potential economic gains.

In conclusion, environmental concerns are increasing pressure on governments to reduce environmental damage without affecting the economy; therefore, they have generated tools that may include regulations, information programs, innovation policies, subsidies, and taxes for environmental damage. For example, Finland, Sweden, Germany, and Switzerland are precursors to applying the so-called "green taxes" and have reduced fiscal burdens (taxes) and income taxes, among others. The following hypothesis is therefore proposed to examine the relationship between ENB and ECB:

H_3: The environmental benefits (ENB) generated by environmental practices are directly and positively related to the economic benefits (ECB) generated.

2.4. Relationship between EV and ECB

Developing sound environmental ethics focused on sustainable development at the regional level can have significant ECB because environmental ethics can help balance the relationship between population, natural resources, the environment, and economic development (Ren & Sun, 2020). Moreover, by promoting the adoption of sustainable behaviors and the transformation of the social and political system, EVs can strengthen the legal system and increase environmental awareness, which can contribute to the implementation of sustainable economic policies and practices, the efficient management of natural resources, leading to long-term ECB and the promotion of sustainable economic development (Zheng & Dai, 2012).

These values in people as customers force companies to generate eco-friendly products, which in turn force them to generate improved production processes that provide many opportunities for innovation and development, impacting them economically (Namagembe et al., 2019a). Therefore, the following hypothesis is proposed to analyze the relationship between EV and ECB.

H_4 . Environmental values (EVs) directly and positively affect economic benefits (ECB) from environmental practices.

2.5. EV moderated effect on ENB→ECB relationship

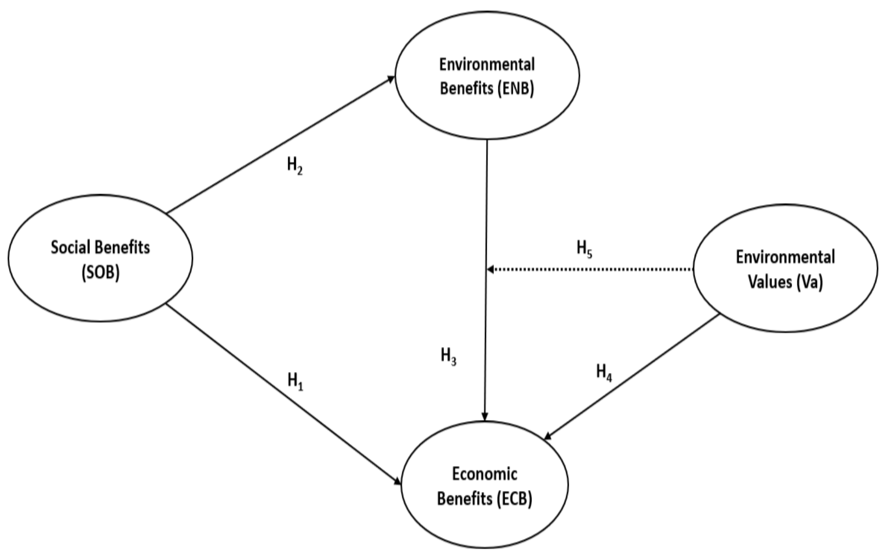
Likewise, EV reflects the perception of human relationships with nature. The EV is positively associated with environmental concern and the development of conservation behaviors, looking for a global benefit (Khan & Rundle-Thiele, 2019). Therefore, practices related to environmental management should incorporate values related to environmental care in organizations and the corporate objectives of companies and public administrations to improve environmental management continuously.

It has been shown that people with high EVs have greater environmental awareness, can identify the environmental benefits of their actions, and act accordingly. For example, Ali et al. (2021) indicate that customers with high levels of skepticism generally do not have sufficient environmental values and find it challenging to identify the ENB and ECB they can obtain. In other words, EV reinforces the relationship between ENB and ECB; a person with EV will perceive the relationship between ENB and ECB. Therefore, the following hypothesis is proposed.

H_5: Environmental values moderate the relationship between environmental benefits (ENB) and their economic benefits (ECB) generated by environmental practices. Figure 1 illustrates the proposed theoretical model.

Figure 1

Theoretical model



3. Methodology

3.1. Questionnaire design

A literature review analyzed people's intentions, attitudes, and pro-environmental behavior using databases like ScienceDirect and Scopus. The study investigated benefits from EE implementation, SOB, ENB, ECB, and ENB, based on research in other nations and industries. This literature review corresponds to a rational substantiation of the questionnaire design because it is based on research conducted in other nations and industrial sectors (García et al., 2014).

The questionnaire comprises three sections: demographic information, knowledge assessment, and social, environmental, and economic benefits for respondents fulfilling environmental intentions and applying knowledge.

The second and third sections of the questionnaire are scored on a five-point Likert scale based on the following descriptors: 1 - never (strongly disagree), 2 - rarely (disagree), 3 - sometimes (neither agree nor disagree), 4 - almost always (agree) and 5 - always (strongly agree).

It is essential to mention that in the design of the questionnaire, section one of the questionnaire will be optional; however, all questions in sections two and three will be mandatory to avoid the appearance of missing values during the analysis.

3.2. Questionnaire Validation by Judges

Since the questionnaire elements originated from studies conducted in other countries and social environments, judge validation was done to contextualize the questionnaire to the Mexican environment. Six engineering academics in regional educational institutions and five engineering managers in regional industries participated in this validation process. The academic experts had an average of 10.2 years of teaching and research experience, were affiliated with higher education institutions, and had previously participated in similar validation processes. Judges in industry had 7.9 years of experience in the industrial sector, focused on manufacturing and supply chain areas, and only four have participated in similar validation processes.

The experts evaluate aspects associated with relevance, conceptual clarity, wording and terminology, appropriate distracters, cognitive levels, and format, Pedrosa et al. (2013) as suggested. We use the index proposed by Hernández-Nieto (2002) due to its ease of use on a five-point Likert scale from 1 to 5, accepting concordance values higher than 0.8.

3.3. Operationalization of variables

The operationalization of the variables identifies the items that measure the four research variables (Bauce et al., 2018), which should identify the activities performed to collect information from the chosen population. The following list indicates the variables, the items that comprise them, and the authors from which they were selected.

Environmental values (EV) (Wiseman et al., 2012):

- I care about environmental issues, primarily for the development of the human race.

- I care about environmental issues, mainly the natural environment and the ecosystem.

Environmental benefits (ENB) (Kalyar et al., 2019) :

- To reduce the generation of urban solid waste (garbage).
- Reducing greenhouse gas emissions.
- Reduce consumption of hazardous materials.
- Improve the environmental condition of the university.

Social benefits (SOB) (García-Alcaraz et al., 2021; Kalyar et al., 2019; Sarkar et al., 2020):

- A safer environment is perceived.
- Healthier university/work community.
- Improved student and work environment.
- Decreases working pressure.

Economic Benefits (ECB) (García-Alcaraz et al., 2021; Kalyar et al., 2019; Sarkar et al., 2020):

- Income from waste disposals such as paper, cardboard, plastics, aluminum, glass, and organic waste.
- Reducing raw material costs by composting organic waste on campus
- Reduce energy costs
- Reduce inventory costs (buy only what is needed when needed)
- Reduce rework costs
- Reducing input costs through the reuse of materials

3.4. Operationalization of variables

The Research Ethics Committee at Universidad Autónoma de Ciudad Juárez (UACJ) evaluates and validates the research proposal to ensure it adheres to the Helsinki Declaration's ethical principles (Shrestha et al., 2021). The project and questionnaire are conducted online, focusing on university students and active engineers affiliated with the industry. The Maquiladora industry and higher education institutions based in Ciudad Juárez were selected since they employ active engineers.

Permission to apply for the survey was requested from the managers of the companies and rectors of the educational institutions, where it was sought that the students were studying from the seventh semester onwards, where they are already taking specialized courses. In the case of the engineers in the industry, it was sought that they had at least two years of seniority, to guarantee that they knew the company's environmental policies.

In this case, the Human Resources Department in the companies and the School Services Department in universities indicated who where the active engineers and students who met the inclusion requirements. An email invites practicing engineers and students to participate, with a link provided. A second invitation and link email are sent if no response is received after 15 days. The aim was to survey the maximum number of students and practitioner engineers. The questionnaire remained open from October 15 to December 15, 2022, and a CSV extension database was downloaded for analysis using SPSS v.25.

3.5. Debugging of information

Before analysis, information is debugged using procedures like identifying uncommitted respondents and identifying extreme values (Sonmez & Pintelon, 2020). Standard deviations are determined for each case or questionnaire response, with values greater than 0.5 included. Extreme values are replaced by medians for items greater than 4 in absolute value (García et al., 2014).

3.6. Statistical validation of variables

The statistical validity of variables refers to their ability to measure what they were designed to measure (Arnab, 2017), and in this research, we use the indices proposed by Kock (2019a):

- R^2 and adjusted R^2 have been adapted to assess the parametric predictive validity, and values greater than 0.02 are anticipated.
- Q^2 was utilized to evaluate the nonparametric predictive validity, and values comparable to R^2 and more significant than zero were anticipated.
- Internal validity is measured by Cronbach's alpha and composite validity indices and values greater than 0.7 are expected.

- The average variance extracted (AVE) was used to measure convergent validity; however, the factor loadings of the items on the various latent variables were also reported. We desire values greater than 0.5.

- The variance inflation index (VIF) assesses the collinearity of the items concerning the latent variables. Values lower than five were desired.

3.7. Structural Equation Model

The SEM technique is used to validate the hypotheses presented in Figure 1, as it allows for simultaneously finding the relationships between latent variables that occupy roles, such as independent and dependent (Shrafat & Ismail, 2019). The partial least squares (PLS) method is utilized, as it is recommended for small sample sizes; data are obtained with Likert-scale ratings or do not have a normal distribution (Kock, 2019b), and also, it is integrated into the software WarpPLS V.8.

First, it was analyzed whether the sample size obtained was adequate, for which the inverse square root and Gamma-exponential approaches were used, based on the size of the regression indices and a 95% confidence level, as suggested by Kock (2019a) and using the WarpPLS v.8 software.

Also, to ascertain the model's validity before interpretation, the following efficiency indices were analyzed with a 95% level of confidence:

- For overall model validity and predictive validity, the average path coefficient (APC), average R-square (ARS), and adjusted average R-square (AARS) were used. The corresponding p-value was lower than 0.05.

- Average block VIF (AVIF) and average full collinearity VIF (AFVIF) were used to measure multicollinearity, with values less than 5 indicating superiority.

- The Tenenhaus GoF (GoF) evaluates the fit of the data to the model, with values greater than 0.36 being preferable.

Many of these values are obtained iteratively because eliminating an item in a latent variable often increases the model's reliability.

3.7.1. Direct, indirect, and total effects

Three effects were found between the latent variables. Direct effects validate the hypotheses posed in Figure 1, where a standardized value is derived from measuring the dependence between an independent latent variable and a dependent variable using WarpPLS v.8. A test of the null hypothesis H_0: $\beta=0$ versus the alternative hypothesis H_1: $\beta\neq0$ was conducted. If it is statistically determined that $\beta=0$ with a 95% confidence level, it is concluded that there is no relationship between the variables under consideration. However, if $\beta\neq0$, regardless of the sign, it is concluded that there is a relationship between the latent variables. A p-value is assigned to each, allowing us to ascertain its significance level at 95% statistically.

In addition, indirect effects between variables, which occur through mediating variables, are estimated, and the statistical tests are the same as those applied to direct effects. This effect occurs through at least two segments mediated by variables; only the cumulative effects will be reported in this study. In conclusion, the total effects are the sum of the direct and indirect effects, which are reported using the appropriate statistical analyses.

In addition, for each of the estimated effects, an effect size (ES) is reported as a measure of the variance explained by the independent variable in the dependent variable, which two or more variables can influence. The sum of all ES equals the value of R^2, which measures the variance explained.

3.7.2. Sensitivity analysis

Probability-based sensitivity analysis was conducted for situations with low or high variable occurrence rates. This analysis allows for identifying undesirable situations' risks and generating early correction strategies. Specifically, the following probabilities are reported in this study:

1. Probability of the latent variables occurring in isolation at low and high levels.
2. Probability that the latent variables co-occur in a mix of high and low states.
3. The conditional probability that a dependent latent variable occurs, given that the independent latent variable has occurred in one of its scenarios.

4. Results

4.1. Descriptive analysis of the sample

After administering the questionnaire to university engineering students and active engineers in the maquiladora industry of Ciudad Juárez (Mexico), 1449 valid questionnaires were collected, 876 of which were responses from students and 573 from active engineers, 685 participants were female, 444 were engineering students, and 241 were active engineers in the Maquiladora industry.

Regarding the productive sector, of the 573 responses obtained by active engineers, the primary sector in which they work is the automotive sector, with 78 women and 112 men. The second place is the medical sector, with 35 women and 63 men; the third is the electrical sector, with 23 women and 27 men. Table 2 shows the industrial sectors and sex of the respondents.

4.2. Statistical validation of the survey

According to the methodology above, seven indices were calculated to validate the latent variables, as in Table 1. The R^2, adjusted R^2 and Q^2 indices indicated that the variables had sufficient predictive validity parametric and nonparametric values. In addition, Cronbach's alpha and composite reliability were above 0.7, thus concluding that all latent variables had sufficient internal validity. In addition, the AVE values indicate sufficient convergent validity by showing values greater than 0.5, and the VIF values rule out collinearity problems because the values are less than 3.3.

Table 1

Validation of the survey

Index	Variables				
	EV	ENB	SOB	ECB	EV*ENB
R-Squared		0.165		0.458	
Adj. R-Squared		0.164		0.457	
Composite Reliability	0.929	0.920	0.898	0.931	1.0
Cronbach's alpha	0.846	0.884	0.849	0.910	1.0
Avg. Var. Extract. (AVE)	0.867	0.742	0.689	0.691	1.0
Full Collin. VIF	1.351	1.997	1.361	1.829	1.342

Q-Squared	0.167	0.459

4.3. Structural Equation Model

The values of the validation indices indicate that the variables can be integrated into SEM. Table 2 lists the six model efficiency indices, where the p-values associated with APC, ARS, and AARS are less than 0.05, indicating that the model has sufficient predictive validity and can be interpreted at a 95% confidence level. Likewise, the AVIF and AFVIF values are less than 3.3, ruling out collinearity problems between the latent variables. Finally, the GoF index has a value of 0.498, indicating adequate data fit to the model. These values in the model's efficiency indices indicate that the model could be interpreted.

Table 2

Model fit and quality of fit indices

Index	**β (p-value)**	**Best if**
Average path coefficient (APC)	0.253 (p<0.001)	p<0.05
Average R-squared (ARS)	0.311 (p<0.001)	p<0.05
Average adjusted R-squared (AARS)	0.310 (p<0.001)	p<0.05
Average block VIF (AVIF)	1.497	<3.3
Average full collinearity VIF (AFVIF)	1.576	<3.3
Tenenhaus GoF (GoF)	0.498	>0.36

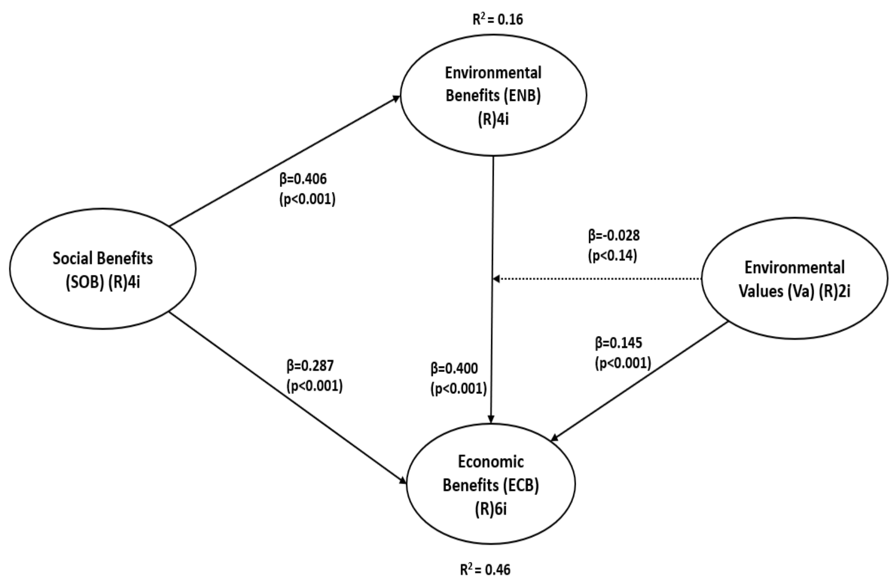
Figure 2 illustrates the evaluated model, showing the β values for each relationship, the associated p-value, and the R^2 values for the dependent variables as a measure of the variance explained. According to the β values in Figure 2, it is observed that the minimum value is 0.145 in the EV→ECB relationship, so the sample size test is performed. The calculations indicate that at least 295 responses to the questionnaire are required by the inverse square root method, while by the Gamma-exponential method, only 281 are required. Given that a sample of 573 responses was analyzed, it is concluded that the sample is sufficient and the model can be interpreted.

4.3.1. Direct Effects

The direct effects are shown in Figure 2 of the model by arrows connecting the latent variables and are represented as hypotheses. The p-values associated with the β values indicate that all are statistically significant; for example, SOB has a direct and positive effect on ECB since β=0.287 with a $p<0.001$, indicating that when SOB increases its standard deviation by one unit, ECB will increase by 0.29 units.

Figure 2

Evaluated model



Likewise, each latent variable is associated with an R^2 value, which indicates the amount of variance explained by independent latent variables; for example, SOB explains 46% of ECB since R^2=0.46. Table 3 summarizes the conclusions obtained for the hypotheses based on the p-values associated with β.

Table 3

Hypotheses test

Hypothesis	Independent variable	Dependent Variable	β	p-value	ES	Conclusion
H_1	SOB	ECB	0.287	p<0.01	0.144	Accept
H_2	SOB	ENB	0.406	p<0.01	0.165	Accept

H_3	ENB	ECB	0.400	p<0.01	0.240	Accept
H_4	EV	ECB	0.145	p<0.01	0.063	Accept
H_5	EV*ENB		-0.028	p<0.14	0.011	Reject

Note. SOB: Social benefits, ENB: Environmental benefits, ECB: Economic benefits, EV: Environmental benefits, ES: Effect size.

4.3.2. Indirect effects

There was an indirect effect between SOB and ECB through ENB as a mediator variable, where β=0.162 with p<0.001, making it statistically significant. Furthermore, SOB explains 8.1% of the variance in ECB in this relationship.

4.3.3. Total effects

Table 4 presents the total effects of the latent variables. Some total effects are equal to direct effects because the relationships of the variables have no indirect effects. According to their magnitude, the most significant total effect was on the relationship between SOB and ECB, followed by SOB→ENB.

Table 4

Total effects

	EV	ENB	SOB	ECB	EV*ENB
ENB			0.406 (p<0.001) ES=0.165		
ECB	0.145 (p<0.001) ES=0.063	0.400 (p<0.001) ES=0.240	0.287 (p<0.001) EN=0.225		-0.028 (p<0.140) ES=0.011

Note. SOB: Social benefits, ENB: Environmental benefits, ECB: Economic benefits, EV: Environmental benefits.

4.4. Sensitivity analysis

Table 5 presents a sensitivity analysis of the proposed model's assumptions. The probabilities for the high scenarios are represented by the symbol "+" for each latent variable, while the symbol representing low scenarios is "-". In addition, the symbol "&" indicates joint probabilities, whereas the symbol "if" indicates conditional probabilities. For instance, the probability of ECB+ and SOB+ co-occurring was 0.102, whereas the probability of ECB+ occurring after SOB+ has already occurred was 0.59. Similarly, the probability of ECB- occurring if SOB- has already occurred is 0.476, indicating that environmental practices do not always produce SOB. The other relationships can be interpreted similarly.

Table 5

Sensitivity analysis

Variable		SOB+	SOB-	ENB+	ENB-	EV+	EV-
	Prob.	0.173	0.130	0.339	0.146	0.267	0.101
ECB+	0.235	&=0.102	&=0.019	&=0.150	&=0.004	&=0.107	&=0.016
		if=0.590	if=0.143	if=0.442	if=0.028	if=0.401	if=0.158
ECB-	0.166	&=0.004	&=0.062	&=0.017	&=0.084	&=0.014	&=0.047
		if=0.024	if=0.476	if=0.049	if=0.578	if=0.052	if=0.466
ENB+	0.339	&=0.106	&=0.042				
		if=0.614	if=0.323				
ENB-	0.146	&=0.004	&=0.048				
		if=0.024	if=0.370				

Note. SOB: Social benefits, ENB: Environmental benefits, ECB: Economic benefits, EV: Environmental benefits, Prob.: Probability.

5. Discussion of results and conclusions

5.1. Structural Equation Model

The ENB, SOB, ECB, and EV of engineering students and active engineers in the Mexican maquiladora industry were related using a structural equation model with information from 573 responses to a survey, and findings from the analysis enable the following discussion.

There is sufficient statistical evidence to conclude that SOB has a direct and positive effect on ECB (H_1), as when the standard deviation of the first variable increases by one unit, the standard deviation of the second variable increases by 0.29 units. These results indicate that engineering students and active engineers perceive a better work environment with environmentally friendly practices, ECB, and integrated operators. Our findings agree with Moura and Tortato (2021), who mention that corporate social responsibility is linked to sustainable development, promoting economic growth and worker social respect.

In addition, the results provide sufficient statistical evidence that SOB has a direct and positive influence on ENB (H_2) since when the SOB attainment of environmental practices increases by one standard deviation, the ENB perceived by active engineers and engineering students increases by 0.406 units. Then, it can be said that the SOB from EE has a direct and positive influence on ENB. When individuals attain SOB by acquiring environmental practices, it leads to higher perceived ENB among active engineers and engineering students (Namagembe et al., 2019b).

Moreover, sufficient statistical evidence concludes that ENB directly and positively influences ECB (H_3) since when the first variable increases its standard deviation by one unit, the second goes up by 0.400 units. These findings indicate that instituting environmental practices to reduce waste production, gas emissions, and hazardous materials reduces costs associated with municipal landfills, government sanctions or fees. In addition, companies and educational institutions with environmental practices can access government institutions' support and ECB. For example, the so-called "green taxes" applied in Finland, Sweden, Germany and Switzerland represent lower tax burdens for companies committed to the environment. In addition, socially responsible companies can obtain government subsidies through their programs. Our findings are consistent with those of Jiang et al. (2020), who state that adopting new market-oriented cultures can influence managers' and employees' intentions to engage in sustainable development-oriented behaviors as a means to generate wealth.

There is sufficient statistical evidence to conclude that EV directly and positively affects the ECB (H_4) since when the first variable increases the standard deviation in one unit, the second one goes up by 0.145. These results indicate that engineering students and active engineers create EVs, reducing waste and energy use. These findings align with Hameed et al. (2020), who mention that there has been growing recognition by companies of the importance of environmental concerns and that the ecological management of human resources has acquired strategic relevance for organizations, which provides evidence of the SOB that employees can obtain, promoting their active participation in pro-environmental actions within the organization.

This study has no statistical evidence that EV moderates the relationship between ENB and ECB, as the associated p-value of 0.14 indicates that it is not statistically significant. This finding differs from Touguinha and Pato (2011) in Brazil, where favorable results were obtained for values and their relationship with ecological behavior and economic income, suggesting that institutions should emphasize the strengthening of values and thus be able to perceive personal advantages/benefits, whether economic or environmental.

5.2. Sensitivity analysis

The study suggests that active engineers should promote environmental practices that generate SOB+, as they are precursors to ECB+ with a probability of 0.590, and investments in SOB+ y have a minimal relationship with ECB-, with a probability of 0.024. Then, it can be interpreted that environmental awareness generates improvements in the social community, and the people can appreciate new business opportunities to improve their economy.

However, when SOB- occurs, it is a risk because it promotes the occurrence of ECB-, with a probability of 0.476. Therefore, managers and operating personnel should focus on generating and implementing activities favoring environmental care and SOB to generate ECB. If the company decides to produce without caring for the environment, production costs will be higher (Moura & Tortato, 2021). Furthermore, SOB- is only weakly associated with ECB+, with a conditional probability of only 0.143.

This finding indicates that SOB+ is vital, and companies should seek to obtain it because it promotes ENB+ with a probability of 0.614, the highest value in the analysis. Likewise, SOB+ is not associated with ENB-, as the conditional probability is only 0.024. However, SOB- is a precursor of ENB- because its conditional probability is 0.370, and these results can be reinforced with those of other studies which mention that Green spaces in European cities can generate ENB and SOB because they improve air quality and improve the quality of society (Mwendwa & Giliba, 2012).

In addition, the findings indicate that ENB+ obtained from environmental practices promotes the occurrence of ECB+ because they have a conditional probability of 0.442, and this indicates that ECB can be obtained if environmental practices are implemented. For example, some studies indicate that implementing green roofs in private homes or businesses reduces pollution and ambient temperature, as well as the costs associated with reducing energy consumption related to heating and cooling systems (Ren & Sun, 2020).

However, if ENB- occurs, then there is a 0.578 probability of ECB- occurring, again demonstrating that not investing in green practices can be associated with poor economic performance. Furthermore, ENB+ was only weakly associated with ECB+, as its conditional probability was only 0.028. In conclusion, investment in environmental practices generates economic performance.

It is also observed that EV+ encourages the occurrence of ECB+ with a probability of 0.401 but is associated with ECB- with a probability of only 0.052. This indicates that EV creation in active engineers and engineering students always reflects some ECB to the company, as there is greater environmental awareness. However, if EV- is present, the occurrence of ECB- is encouraged with a probability of 0.466, representing a risk, and EV- only favors ECB+ with a probability of 0.158. These findings are consistent with some case studies that mentioned that values and educational level are predictors of pro-environmental behavior, suggesting that institutions should emphasize the strengthening of self-transcendence objectives to allow staff to perceive the benefits that can be obtained from sustainable practices (Kaur & Lodhia, 2019).

In conclusion, engineering students and engineers currently working in the maquiladora industry can perceive environmental education's economic, social and environmental benefits. However, there is still an opportunity to improve the results obtained. It is essential that teaching methods in engineering programs more prominently include caring for the environment and demonstrate that tangible benefits can be gained from doing so.

Additionally, integrating environmental education more effectively into the engineering curriculum can motivate students to understand that, when the time comes to apply their knowledge in the industry, they can contribute significantly to caring for natural resources and development. This will not only benefit businesses by reducing costs and environmental risks but will also positively impact society by promoting more responsible practices and on the environment by reducing the industry's negative impact.

Ultimately, strengthening environmental education in engineering training is not only an investment in a more sustainable future but also an opportunity for the maquiladora industry and its professionals to stand out as leaders in promoting responsible business practices and respect for the environment, generating a positive impact on society and the environment in the process.

6. Limitations and future research

Practices favoring environmental care are constantly being adapted for individuals and organizations. However, in some circumstances, the environmental, social, and economic benefits they generate are not appreciated by the parties involved or are challenging to quantify. Although this study demonstrated a significant relationship between personal EVs and adopting pro-environmental practices that generate ECB, SOB, and ENB, it is important to consider some limitations.

First, the study was conducted with a sample of engineering students and active engineers; however, there may be differences between knowledge areas, daily activities, and decision-making, so the perspective of the benefits obtained may also vary. Therefore, future research should aim to compare specific engineering areas.

Second, the relationship between personal EV and environmental, social, and economic benefits may be complex and influenced by other factors such as knowledge, behavior, or motives for engaging in pro-environmental practices, which were not considered in this study and could be a starting point for future research.

Third, the relationships between the variables presented in the SEM model can be analyzed more exhaustively to verify whether better results can be obtained by redesigning the model. Considering that values are a variable associated with people, future research should analyze whether they moderate social and ENB.

Finally, institutions can implement social and environmental justice education: which increasingly addresses social and environmental justice issues, including environmental racism, inequality in access to resources, and the impacts of climate change on vulnerable communities. This approach fosters a sense of equity and responsibility among students. They can also increase green school initiatives and sustainability within their facilities, such as energy-efficient buildings, waste reduction programs, and green spaces. These initiatives provide tangible examples of sustainability in action.

7. References

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