

Perception of industrial environmental impacts among 8th-grade students at College BG 0007 Commander Dangereux, Catumbela, Angola

Percepção dos impactos ambientais industriais em alunos da 8ª classe do Colégio BG 0007 Comandante Dangereux Catumbela, Angola

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ABSTRACT

Keywords:

Perception, Environmental Impact, Industry, Students, Catumbela

This research addresses the perception of industrial environmental impacts among 8th-grade students at College 0007 BG Commander Dangereux in Catumbela, Angola. Industry is a significant factor in environmental degradation. In this context, understanding how students perceive and interpret local industrial environmental challenges and impacts is crucial, as this perception can influence their future actions to preserve the environment. The research aims to analyze the level of environmental awareness of the environmental effects among 8th-grade students at the aforementioned school. The methodology adopted in this research was descriptive, with a quantitative, cross-sectional, and non-experimental approach. Therefore, data collection used a 15-item questionnaire on an ordinal qualitative Likert scale, consisting of three dimensions: general knowledge of environmental impacts, perception of environmental risks, and actions and solutions to minimize industrial environmental impacts. The questionnaire was administered to 113 students. To test the hypothesis that students had a significant perception of industrial environmental impacts, the Wilcoxon test was applied to one sample. The results showed a statistically significant difference between the median observed in the responses and the reference value of the Likert scale ($p < 0.001$), thus refuting the hypothesis that students have a relevant environmental perception on the topic. Therefore, it can be concluded that most students do not have a satisfactory level of environmental perception regarding industrial environmental impacts, as indicated by the median being lower than the reference value.

RESUMEN

Palabras clave:

Percepção, Impacto ambiental, Indústria, Alunos, Catumbela

A pesquisa aborda a percepção dos impactos ambientais industriais em alunos da 8ª classe do Colégio 0007 BG Comandante Dangereux Catumbela, Angola. A indústria representa um fator importante na degradação do meio ambiente. Nesse contexto, compreender como os alunos percebem e interpretam os desafios e os impactos ambientais industriais locais é fundamental, uma vez que essa percepção pode influenciar suas ações futuras em favor da preservação do meio ambiente. A pesquisa visa analisar o nível de percepção ambiental sobre os impactos ambientais em alunos da 8ª classe do Colégio em referência.

A metodologia adotada nesta pesquisa foi descritiva, com enfoque quantitativo, de corte transversal e não experimental. Portanto, utilizou-se, na coleta de dados, um questionário com 15 itens em escala de Likert qualitativa ordinal, constituído por três dimensões: conhecimentos gerais sobre impactos ambientais, percepção dos riscos ambientais e ações e soluções para minimizar os impactos ambientais industriais. O questionário foi aplicado a 113 alunos. Com o intuito de testar a hipótese de que alunos apresentavam uma percepção significativa sobre impactos ambientais industriais, foi aplicado o teste de Wilcoxon para uma amostra. Os resultados mostraram diferença estatisticamente significativa entre a mediana observada nas respostas e o valor de referência da escala de Likert ($p < 0,001$), refutando, assim, a hipótese de que os alunos possuem percepção ambiental relevante sobre o tema. Conclui-se, portanto, que a maioria dos alunos não apresenta um nível de percepção ambiental satisfatório acerca dos impactos ambientais industriais, conforme indicado pela mediana inferior ao valor de referência.

Introduction

In recent years, industrial activities have caused environmental degradation as a result of the irrational use of natural resources, putting the normal functioning of the earth's spheres (atmosphere, hydrosphere, biosphere and geosphere) at risk. Against this backdrop, the deterioration of planet Earth began to take on alarming proportions. For example, with the “advent of the industrial boom, large industrial complexes were established near densely populated areas, where chemicals dangerous to both humans and the environment began to be processed and stored” (Kulman, 2021, p. 20). Similarly, Shah et al. (2021) state that accelerated economic growth in recent decades has contributed significantly to the increase in environmental pollution. The authors point out that the industrial and manufacturing sectors are considered fundamental to a country's economy, as they are responsible for approximately half of the pollution levels recorded.

Furthermore, according to Villegas et al., (2023) the planet's habitat has been profoundly impacted by factors such as technological advances, population growth, environmental pollution and global megatrends. Faced with these increasingly complex challenges, it is essential for institutions, governments and communities to establish a horizontal and authentic dialog aimed at solving social problems with an ecological approach. Industrial activity is therefore a factor in a society's economic growth, but its disorderly growth is a threat to the environment. Climate change, soil and air pollution and the degradation of ecosystems are some of the consequences of industrial activity that affect the environment and human health.

Environmental perception is a fundamental concept for understanding how individuals interact with and respond to their environment. Given this reality, environmental education is a process that enables individuals to investigate environmental problems, actively participate in the search for solutions and adopt actions that promote environmental improvement. This process contributes to the development of an in-depth understanding of environmental issues and fosters the formation of skills needed to make conscious and responsible decisions (Busi et al., 2023). In this context, environmental education is an instrument that plays an essential role in raising the awareness and commitment of future generations to adopt sustainable practices. Thus, understanding students' perceptions of industrial environmental impacts is essential for evaluating the efficiency of educational activities in the Angolan context and suggesting improvements in teaching strategies.

In the municipality of Catumbela, the industries installed in the Catumbela Industrial Development Pole (PDIC) have caused significant impacts on the local environment, which is a major social concern. Considering this scenario, this research aims to understand how students perceive the environmental impacts of industries. The way they perceive these impacts can directly influence their environmental awareness, as well as their pro-environmental attitudes and behaviors in favor of sustainability. In addition, various studies indicate that the transmission of environmental education for sustainable development has been explored mainly from the perspectives of sustainable consumption and pollution management.

The municipality of Catumbela, located in the province of Benguela (Angola), is considered the most industrialized in the region, mainly due to the presence of the PDIC, installed along the Catumbela River Delta. According to Huvi (2019) the delta has edaphic and hydrogeological characteristics favorable to the development of agriculture, as well as being the main source of drinking water for the coastal cities of Benguela province. In this context, the PDIC has driven significant industrial growth in recent decades, which has contributed significantly to its economic growth.

However, this progress has been accompanied by severe impacts, such as contamination of the air, water and soil, as well as loss of biodiversity. Furthermore, the communities living near these industries are among the most affected by these negative externalities. These include students, who, as members of these communities, are also exposed and subject to these environmental impacts.

Despite their relevance, students' perception of the environmental impacts caused by industrial activities is still limited. This lack of knowledge can significantly compromise the role these students will play as future managers and agents of transformation in building a sustainable society. Against this backdrop, the following research problem is proposed: What is the level of perception of 8th grade students at Colégio BG 0007 Comandante Dangereux Catumbela (Angola) about environmental impacts resulting from industrial activities?

The choice of topic was motivated by the need to understand how students perceive and interpret environmental challenges in their local context, given that this perception can directly influence their future actions in favor of environmental preservation and, consequently, contribute to sustainable development. The research is particularly relevant as it is set in a geographical context where there is a significant concentration of industries, located in an area of high agricultural potential and with the presence of important groundwater reservoirs. This scenario poses considerable challenges to sustainability and the balance between economic development and the preservation of natural resources. In addition, the 8th grade Geography course includes a unit on industrial activity and its relationship with economic development. This thematic unit, throughout its sub-themes, does not propose a critical analysis of the harmful effects generated by industrial activity on the environment. Therefore, the coincidence between the syllabus and the local context represents an educational opportunity to promote environmental education in the school environment, contributing to the formation of a critical awareness of local environmental problems.

From a theoretical point of view, this research is justified by the growing concern about environmental degradation and the depletion of natural resources, phenomena that have challenged humanity today. In this context, companies in the productive sector, especially industries, are among the main agents causing negative environmental impacts, due to the intense exploitation of natural resources. In this way, the theoretical references that underpin this research seek to contribute to expanding the literature on environmental education, especially in terms of its ability to foster and improve students' perception of environmental challenges, both on a local and global scale. According to Collado et al. (2020) environmental education has proven to be a significant and relevant pedagogical tool for transforming attitudes and behaviors, promoting the development of pro-environmental attitudes and thus helping to build a society guided by the principles of sustainability.

From a practical point of view, environmental education in schools is an important tool for building a critical perception of environmental problems, helping to raise students' awareness and finding solutions to understand and tackle the environmental challenges caused by industrial activities. This aspect becomes especially relevant in regions with a high level of industrialization, such as the municipality of Catumbela in Angola. Furthermore, as Araújo argues (2021) the inclusion of environmental education in the school environment is an effective strategy for transforming students' perceptions, broadening their understanding of the industrial environmental impacts caused by industrial activity. In this sense, this research has the potential to support the development of more effective educational projects, with environmental education as an essential tool in mitigating the negative effects of industrialization (Bibeiro et al., 2021).

From a methodological point of view, the purpose of this research is to provide support for the development of teaching strategies in environmental education, centered on the students' perception of the environmental impacts resulting from industries. In this sense, the

use of participatory methodologies in the teaching-learning process, such as problem-based learning, case studies and environmental studies, or visits to areas impacted by industries or school projects aimed at building sustainable alternatives, contributes significantly to building more reflective environmental thinking that is committed to sustainability. These methodological approaches, as highlighted by Souza & Santos, (2021) promote the active involvement of students in the educational process, fostering the development of a critical perception of environmental problems, while encouraging the proposal of contextualized solutions.

Therefore, this analysis aims not only to enrich the academic debate on environmental perception in schools, but also to contribute to the development of public policies aimed at sustainability, with a focus on education as an instrument of social transformation. The general objective of this research is to analyze the level of perception of industrial environmental impacts among 8th grade students at Colégio BG 0007 Comandante Dangereux Catumbela, Angola.

Method

This research was carried out using a quantitative methodological approach. The level of research adopted is descriptive, as it aims to describe the characteristics of a specific phenomenon or situation. The design of this research is non-experimental, because the study variable was not manipulated. According to Hinojosa Mamani et al. (2024) cross-sectional research designs collect data at a single point in time, with the main aim of describing and analyzing the current state of the variables of interest in a population. This research was carried out at Colégio BG 0007 Comandante Dangereux, located in the municipality of Catumbela, a suburban town with the same name, in the province of Benguela, Angola, with a sample made up of 113 8th graders, randomly selected from a population of 160 students, with a 95% confidence level and a maximum admissible error of 5%.

To collect the data, a political questionnaire consisting of 15 items was used, divided into three dimensions. The instrument was structured on a five-point Likert scale (1 - Strongly disagree, 2 - Disagree, 3 - Neither disagree nor agree, 4 - Agree, 5 - Strongly agree) in order to measure students' attitudes and opinions.

In this research, data processing followed a descriptive statistical approach, in accordance with Espinoza Casco et al. (2023) "Descriptive statistics consists of the graphical and numerical methods used to summarize and process data and transform them into information" (p. 104). Thus, descriptive statistics is a statistical procedure that aims to represent and describe the data of a problem and represent it graphically.

Microsoft Office Excel was used to organize the data. For statistical analysis, two software packages were used: the statistical analysis software Program for Statistical Processing (PSPP) version 1.4.1-g79ad47 for Windows, used for descriptive statistics (frequencies, mode and median), the results of which were presented in table form, and Jeffrey's Amazing Statistics Program (JASP) software version 0.19.3 for Windows, used to apply the Wilcoxon test to a sample in order to check for significant differences in relation to the neutral point of the Likert scale.

As far as descriptive analysis is concerned, the answers on the Likert scale were grouped into three categories in order to facilitate the interpretation of the data and identify the general trends in the participants' opinions: The options "1 - Strongly disagree" and "2 - Disagree" were grouped together in the (Disagree) category, the option "3- Neither disagree nor agree" was kept alone, under the designation (Neutral) and the options "4 - Agree" and "5 - Strongly agree" were grouped together in the (Agree) category.

In addition, the reliability of the Likert scale used in the research was assessed using the Cronbach's alpha coefficient, which was 0.83, indicating a good internal consistency of the instrument. Second Tarakçı Eren & Düzenli (2021) this result represents a reliable level for assessing students' environmental perception. To Popa (2020) also highlights values of around 0.83, whose instruments contain 15 items and a sample of 113 participants, which are considered very good, especially in educational and social surveys.

Results

Table 1
General knowledge of industrial environmental impacts

Items	f (1)	f (2)	f (3)	f (4)	f (5)	% (1)	% (2)	% (3)	% (4)	% (5)	Median	Fashion
Item 1. Industrial activities are one of the main causes of environmental pollution.	19	58	8	15	13	16,8	51,3	7,1	13,3	11,5	2	2
Item 2. Industrial gas emissions contribute to global warming and climate change.	10	36	16	32	19	8,8	31,9	14,2	28,3	16,8	2	2
Item 3. Industries are responsible for much of the contamination of water resources.	17	42	14	24	16	15,0	37,2	12,4	21,2	14,2	2	2
Item 4. Industrial activities contribute significantly to air pollution.	20	28	4	28	33	17,7	24,8	3,5	24,8	29,2	2	5
Item 5. Soil contamination caused by industries is detrimental to the practice of agriculture.	32	36	9	31	5	28,3	31,9	8,0	27,4	4,4	2	2

Note. 5-point Likert scale: 1 = Strongly disagree; 5 = Strongly agree. The data reflects the distribution of the participants' responses (N=113). The absolute frequencies (f) represent the number of responses for each category. Mode and median refer to the central tendency of the answers for each item. The values have been rounded to one decimal place.

According to the data presented in Table 1, the majority of participants, 52.8%, disagreed with the statement, selecting "Strongly disagree and Disagree". Only 38.2% of the participants expressed some degree of agreement, indicating "I totally agree" and "I agree", and 9.0% remained neutral. The median was 2 (Disagree), showing a central tendency towards disagreement among the participants. The results showed that, in general, there was a strong tendency to disagree among the participants, suggesting a negative perception of the statement evaluated. In the context of this research, we tested the hypothesis that students have a general knowledge of industrial environmental impacts. To do this, the Wilcoxon one-sample test was applied to check whether the median of the answers differed from the neutral value of the Likert scale (reference value = 3), which indicates an average level of knowledge.

An alternative directional hypothesis was considered, according to which the answers would tend towards values greater than 3 ($\mu > 3$), which would indicate that the students demonstrate general knowledge about industrial environmental impacts. However, this

hypothesis was refuted, since the test revealed a median equal to 2 in the five items evaluated, with values ($V = 64441.000$ and $p < 0.001$) indicating a statistically significant difference below the reference value. In this way, the results suggest that, in general, students showed a lower-than-expected level of knowledge about the environmental impacts caused by industrial activities.

Table 2
Perception of the environmental risks generated by industrial activities

Items	f (1)	f (2)	f (3)	f (4)	f (5)	% (1)	% (2)	% (3)	% (4)	% (5)	Median	Fashion
Item 6. Industrial activities pose a great risk to human health due to pollution.	33	41	9	17	13	29,2	36,3	8,0	15,0	11,5	2	2
Item 7. Pollution caused by industries negatively affects biodiversity and ecosystems.	14	38	17	29	15	12,4	33,6	15,0	25,7	13,3	2	2
Item 8. Pollution caused by industries directly affects global climatic conditions.	29	51	11	9	13	25,7	45,1	9,7	8,0	11,5	2	2
Item 9. Poorly managed industrial waste can cause serious public health problems.	12	38	2	24	37	10,6	33,6	1,8	21,2	32,8	2	2
Item 10. Industrial activities cause environmental problems, even in regions far from urban centers.	28	43	9	19	14	24,8	38,0	8,0	16,8	12,4	2	2

Note. 5-point Likert scale: 1 = Strongly disagree; 5 = Strongly agree. The data reflects the distribution of the participants' answers ($N=113$). The absolute frequencies (f) represent the number of answers for each category. Mode and median refer to the central tendency of the answers for each item. The values have been rounded to one decimal place.

According to the data presented in Table 2, the majority of participants agreed with the statement, with 57.9% of participants selecting “Strongly disagree” and “Disagree”. On the other hand, 33.6% of participants indicated “I agree” and “I totally agree”. Only 8.5% remained neutral. The median was 2 (Disagree), indicating a tendency to disagree among the participants. The results revealed that there was a strong inclination to disagree among the participants, suggesting a negative perception of the statement evaluated.

In the context of this research, we tested the hypothesis that students perceive the environmental risks generated by industrial activities. To do this, the Wilcoxon test was applied to a sample in order to check whether the median of the answers differed from the neutral value of the Likert scale (reference value = 3), which represents an average level of perception. An alternative directional hypothesis was considered, according to which the answers would tend towards values greater than 3 ($\mu > 3$), indicating that the students perceive environmental risks generated by industrial activities at a higher level than the reference value. However, this hypothesis was refuted, since the test revealed a median equal to 2 in the five items evaluated, with values ($V = 64441.000$ and $p < 0.001$) indicating a statistically significant difference below the reference value. Thus, the results showed that the participants tended to have a lower-than-

expected level of knowledge regarding the perception of environmental risks resulting from industrial activities.

Table 3

Actions and solutions to minimize industrial impacts

Items	f (1)	f (2)	f (3)	f (4)	f (5)	% (1)	% (2)	% (3)	% (4)	% (5)	Median	Fashion
Item 11. Companies in the industrial sector have a social responsibility to mitigate the environmental impacts they cause.	19	58	8	15	13	16,8	51,3	7,1	13,3	11,5	2	2
Item 12. The development of green industries is the solution to minimizing environmental impacts.	10	36	16	32	19	8,8	31,9	14,2	28,3	16,8	2	2
Item 13. Individual actions can help minimize the negative effects of industries on the environment.	17	42	14	24	16	15,0	37,2	12,4	21,2	14,2	2	2
Item 14. Consumers have the power to put pressure on industries to be more sustainable.	20	31	3	25	34	17,7	27,4	2,7	22,1	30,1	2	5
Item 15. Industries must invest more in sustainable practices and technologies to reduce pollution.	33	32	9	32	7	29,2	28,3	8,0	28,3	6,2	2	1

Note. 5-point Likert scale: 1 = Strongly disagree; 5 = Strongly agree. The data reflects the distribution of the participants' responses (N=113). The absolute frequencies (f) represent the number of responses for each category. Mode and median refer to the central tendency of the answers for each item. The values have been rounded to one decimal place.

According to the data presented in Table 3, the majority of participants, 52.7%, disagreed with the statement evaluated, indicating "Disagree" and "Strongly disagree". On the other hand, 38.4 of the participants showed some level of agreement, selecting "I agree" and "I totally agree". While 8.9% remained neutral. The median was 2 (Disagree), suggesting a central tendency towards disagreement among the participants. These data show a strong trend of disagreement among the participants, suggesting a negative perception of the statement evaluated.

In the context of this research, we tested the hypothesis that the majority of students believe that the adoption of certain actions and solutions by industries can minimize the environmental impacts generated by industrial activities. To do this, the Wilcoxon one-sample test was applied to check whether the median of the answers differed from the neutral value of the Likert scale (reference value = 3), which represents the average level of knowledge or agreement. An alternative directional hypothesis was considered, according to which the answers would tend towards values higher than 3 ($\mu > 3$), indicating that the students would believe that the adoption of certain actions and solutions by industries can minimize the environmental impacts generated by industrial activities. However, this hypothesis was refuted, since the test revealed a median equal to 2 in the five items evaluated, with values (V =

64441.000 and $p < 0.001$) indicating a statistically significant difference below the reference value. Thus, the results showed that the participants tended to have a lower level of knowledge than expected in relation to actions and solutions to minimize industrial environmental impacts.

Discussion and Conclusions

With regard to the students' perception of the main environmental impacts generated by industrial activities, the results reveal a very worrying environmental perception. Most of the students disagreed that industrial activities are responsible for environmental impacts such as environmental pollution, global warming and climate change, loss of biodiversity, air pollution, water and soil contamination. Only a minority of students showed any degree of agreement with these statements recognized by science. The hypothesis that the students have a general knowledge of industrial environmental impacts that is higher than the reference median was refuted. These findings are in line with the results of Dopelt & Radon (2020) who identified limited knowledge among students about the environmental impacts of industry. However, they observed that their pro-environmental attitudes and behaviors are significantly influenced by their level of environmental knowledge. Similarly, Maurer & Bogner (2019) found that individuals with a higher level of education tend to have more contact with ecological ideas than those with less schooling. Thus, a possible explanation for the lower level of knowledge may be related to the lack of environmental education content in the curricula. Thus, the integration of environmental education into curricula with a view to maximizing students' perception of the current environmental problems facing humanity, in order to form critical citizens who are prepared to face current challenges.

Previous studies suggest that environmental education plays a key role in promoting sustainable development. According to Taboada-González & Aguilar-Virgen (2024) it is capable of fostering a mindset towards sustainability, empowering individuals to become agents of change. It also helps to raise awareness of the importance of environmental preservation. On the other hand, there was a worrying tendency to be unaware of or undervalue the impacts caused by industrial activities, which contrasts with various findings in the literature. (Bose, 2024) points out that industries are among the main emitters of greenhouse gases, especially carbon dioxide, which is a crucial factor in aggravating global warming and climate change. Along the same lines, Zhang et al. (2020) point out that industrial activities are responsible for significant forms of environmental pollution, affecting water resources, soil and biodiversity, especially in regions with a strong industrial presence. Shah et al. (2021) reinforce this perspective by stating that industrial pollution represents a significant threat to the environment, causing the degradation of ecosystems and generating high social costs, including for human health and safety.

Thus, the results suggest that this dissatisfaction may be influenced by various factors, such as the absence or poor presence of content on industrial environmental impacts in curricula, low exposure to themes on industrial environmental problems. The level of disagreement shown by the students in relation to their general knowledge of industrial environmental impacts means that they have a limited perception of the environmental impacts produced by industries. Environmental knowledge is therefore a key factor in identifying and assessing environmental risks and, consequently, in taking pro-environmental measures in favor of the environment.

Regarding the perception of environmental risks generated by industrial activities. The results showed that the majority of students disagreed with the statements directly associating industrial activities with environmental risks. Only a minority indicated some level of

agreement with the statements evaluated, such as: industrial activities directly affect climatic conditions and public health. The level of disagreement presented by the students in relation to the environmental risks resulting from industrial activity demonstrates an existing gap in terms of perception in the general knowledge of the environmental impacts produced by industries. The hypothesis that students perceive the environmental risks generated by industrial activities to be higher than the reference median was refuted. These results reveal a lack of awareness of the negative effects caused by industries, which can be attributed to the low level of environmental knowledge observed in the items assessed. Similar findings were identified by Dopelt & Radon (2020) whose research shows that students with higher levels of environmental knowledge have significantly more pro-environmental attitudes and behaviors. Along the same lines, Janmaimool & Khajohnmanee (2019) observed that students who took part in a course on environmental issues had more positive environmental attitudes than those who did not. This suggests that the higher the level of environmental knowledge, the greater the ability to understand environmental risks, which favors sustainable behavioral changes.

On the other hand, these results contrast with the scientific literature that shows the risks and impacts of industrial activities on the environment and human health. According to Ramadani et al. (2025) industrial activities are responsible for significant emissions of pollutants, contributing to the contamination of soil and water, with serious implications for ecological balance and public health. Ruba et al. (2021) also point out that industrial growth, when dissociated from sustainable principles, causes degradation of natural resources, generating air, water and soil contamination, as well as affecting entire ecosystems. Corroborating these findings, Pabón Guerrero et al. (2020), argue that industrial activities represent the main source of heavy metals released into the environment, negatively affecting human health, animals, plants, water sources and soils, thus compromising the entire food chain. According to Ogwu et al. (2024) the causes of these problems are diverse, including the excessive use of agrochemicals, inadequate disposal of industrial waste and poor solid waste management. In addition, industrial activities contribute significantly to global climate change, especially due to the emission of greenhouse gases. According to Mikhaylov et al. (2020) these emissions have led to a gradual increase in the planet's average annual temperature, exacerbating the effects of climate change.

Therefore, the results show that the majority of students had a negative level of perception. Thus, these findings suggest the need to integrate thematic units on environmental risks into curricula in order to raise students' level of environmental awareness. However, understanding how students assess these risks represents an opportunity to understand how students are aware of the damage produced by industries, and from there to adopt environmental practices and actions that contribute to the preservation of the environment.

Regarding the perception of actions and solutions to minimize the environmental impacts generated by industrial activities. In general, the results indicated that the majority of students showed a strong degree of disagreement with the statements evaluated. Although a small number of students agreed with the statement that consumers have the power to put pressure on industries to be more sustainable, this reveals a perception in line with scientific literature that recognizes these factors as the main environmental management tools for controlling and minimizing industrial environmental impacts. The hypothesis that students believe that the adoption of certain actions and solutions by industries can minimize the environmental impacts resulting from industrial activities, which was higher than the reference median, was refuted. These results are in line with the findings of Chakraborty et al. (2024), which show that although students are becoming increasingly aware of sustainable practices and environmental impacts, their perceptions of solutions to mitigate the effects of industrial activity are still heterogeneous. While some show engagement and understanding, others

remain critical or indifferent, which highlights the importance of a more practical and engaging educational approach to sustainability.

These results showed that, despite the majority of students having no general knowledge of industrial environmental impacts and a poor perception of industrial environmental risks, some students believe that adopting certain actions and solutions can help mitigate the negative effects of industries on the environment. According to Montefalcone et al. (2025) emphasize that the search for sustainable solutions in the industrial sector must consider the balance between economic growth, social justice and environmental preservation, since genuine sustainability depends on the harmonious interaction of these three elements.

The environment represents capital that supports industrial activities, and the goods and services produced are used by man for his survival. It is therefore imperative to adopt actions aimed at mitigating the impacts caused by the extraction and production of natural resources. As highlighted by Gabriela de Oliveira et al. (2021) the implementation of sustainable practices is an essential condition for the continuity of organizations. This need can arise both from the pressure exerted by stakeholders and from the search for strategies that improve organizational performance, promote competitive advantage, protect the environment, meet social demands and ensure compliance with the standards established by environmental policy instruments.

Therefore, the results show that the majority of students had a limited level of perception in relation to the statements assessed. Thus, these findings suggest the importance of reinforcing the presence of thematic units in curricula; in order to consolidate students' perception of the actions and solutions that industries must adopt to guarantee the sustainability of resources. Thus, the degree of disagreement shown by the students represents an opportunity to design educational policies aimed at contributing to the preservation of the environment, towards sustainable development.

In conclusion, with regard to the perception of general knowledge about the environmental impacts resulting from industrial activities, the statistical results indicated that the alternative hypothesis proposing a level of knowledge higher than the midpoint of the scale (reference value = 3) was refuted. The median observed was equal to 2 in all five items evaluated, with statistical significance ($V=64441.000$; $p < 0.001$), showing that the students demonstrate a low level of knowledge than expected. This finding points to an important gap in students' environmental education, especially when it comes to understanding the negative effects of industrial activities on the environment, such as environmental pollution, warming and climate change, contamination of water resources and soil contamination.

With regard to the perception of environmental risks associated with industrial activities, the results followed a similar trend. The alternative hypothesis, that students would perceive such risks at a higher level than the neutral point on the scale, was also refuted. Again, the median was 2. With statistical significance ($V = 64441.000$; $p < 0.001$), showing that students have a limited perception of the risks to human health and the ecological balance caused by these activities. This result reveals a weakness in students' environmental awareness, indicating that the impacts on health and well-being resulting from pollutant emissions and environmental degradation are still poorly understood in the educational context analyzed.

Finally, with regard to the hypothesis that students believe in the effectiveness of actions and solutions to minimize the environmental impacts generated by industrial activities, the alternative hypothesis was also rejected. The analysis again revealed a median of 2 in the five items evaluated ($V = 64441.000$; $p < 0.001$), showing a negative or underdeveloped perception of statements such as the use of sustainable technology and practices, corporate social responsibility, adoption of green industries and individual actions to minimize environmental impacts. These results suggest that students are not only unaware of the environmental

problems caused by industrial activities, but also show disbelief or ignorance of the viable means of mitigation.

It can therefore be concluded that, in the context of the sample investigated, students show a low level of environmental knowledge and awareness in relation to the impacts, risks and possible solutions associated with industrial activities. These conclusions reinforce the need to rethink the pedagogical and curricular practices adopted by educational institutions, with a view to the systematic and critical inclusion of environmental education, in a transversal, participatory and contextualized way. In addition, the data obtained reinforces the urgency of educational actions that favor the development of environmental literacy as a fundamental tool for building ecologically and socially responsible citizenship towards sustainable development.

One of the limitations is related to the scope of the sample, which was restricted to students from a single educational institution. This factor limits the generalization of the results to other educational, social and geographical realities. The lack of a qualitative assessment to further explore the reasons behind the answers is also a major limitation, as it prevented subjective aspects of the students' perceptions from being better understood. In addition, the research focused solely on environmental impacts related to industrial activities, disregarding the interrelationship with other pollutants, such as different types of transportation, agricultural activity, etc. This thematic delimitation, although necessary for the study, limits the general and systemic view of the environmental problem.

Finally, given the limitations mentioned above, future research should expand the sample to include students from different levels of education (secondary and higher education), urban and rural areas and varied social contexts. Comparative studies between regions or between public and private schools can also provide relevant information on the effectiveness of environmental education policies.

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