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Scientific articles

**Educación ambiental participativa en estudiantes de instituciones
educativas en Tlacoachistlahuaca, Guerrero**

***Participatory environmental education for students in educational
institutions in Tlacoachistlahuaca, Guerrero***

***Educação ambiental participativa em estudantes de instituições de ensino
em Tlacoachistlahuaca, Guerrero***

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Resumen

El presente estudio se desarrolló en un contexto rural, el cual enmarca un caso con enfoque cualitativo. El trabajo inició con la identificación de las prácticas de manejo de residuos sólidos municipales y su impacto ambiental en la cabecera de Tlacoachistlahuaca, Guerrero. Se implementó un taller de educación ambiental sobre manejo integral de residuos en tres instituciones educativas del municipio, incluyó contenidos teóricos relacionados con la clasificación de residuos, el impacto ambiental de los desechos mal gestionados, los principios de las 3R's (reducir, reutilizar, reciclar), la normatividad ambiental básica aplicable y la situación actual de la localidad. Se desarrollaron dos dinámicas participativas: *“Mapa de identificación”* y *“Ordena tu residuo”*, orientadas a fomentar la comprensión del tema y promover hábitos de separación y reciclaje en los jóvenes estudiantes.

Para evaluar el nivel de aprendizaje, se aplicó un cuestionario cerrado de opción múltiple antes y después de la intervención, lo que permitió contrastar el conocimiento previo y el aprendizaje significativo. Los resultados de los talleres y del cuestionario aplicado evidencian que el residuo de mayor presencia en la localidad es el tereftalato de polietileno (PET), con mayor concentración en la colonia Las Brisas, así como el limitado conocimiento que tienen los estudiantes del tema. Estos hallazgos se correlacionan con el diagnóstico preliminar y las entrevistas previas realizadas a los actores clave. Se concluye que la incorporación de metodologías participativas en la educación ambiental contribuye de manera significativa a despertar el interés de los estudiantes del municipio, promoviendo cambios favorables en sus hábitos de reciclaje y en la valoración de los recursos ambientales de su entorno.

Palabras clave: educación ambiental, manejo integral de residuos sólidos, hábitos de reciclaje, método participativo.

Abstract

This study was conducted in a rural setting and takes a qualitative approach. The research began by identifying municipal solid waste management practices and their environmental impact in the town of Tlacoachistlahuaca, Guerrero. An environmental education workshop on integrated waste management was implemented in three educational institutions in the municipality. It included theoretical content related to waste sorting, the environmental impact of poorly managed waste, the principles of the 3Rs (reduce, reuse, recycle), applicable basic environmental regulations, and the current situation in the locality. Two participatory

activities were conducted: “Identification Map” and “Sort Your Waste,” aimed at fostering understanding of the topic and promoting waste separation and recycling habits among young students.

To assess the level of learning, a closed-ended multiple-choice questionnaire was administered before and after the intervention, allowing for a comparison of prior knowledge and meaningful learning. The results of the workshops and the questionnaire show that the most prevalent waste in the town is polyethylene terephthalate (PET), with the highest concentration in the Las Brisas neighborhood, as well as the students’ limited knowledge of the subject. These findings correlate with the preliminary assessment and the prior interviews conducted with key stakeholders. It is concluded that the incorporation of participatory methodologies in environmental education contributes significantly to sparking the interest of students in the municipality, promoting favorable changes in their recycling habits and in their appreciation of the environmental resources in their surroundings.

Keywords: environmental education, comprehensive solid waste management, recycling habits, participatory method.

Resumo

Este estudo foi conduzido em um contexto rural, enquadrando-se em um estudo de caso com abordagem qualitativa. O trabalho iniciou-se com a identificação das práticas de gestão de resíduos sólidos urbanos e seu impacto ambiental na cidade de Tlacoachistlahuaca, Guerrero. Uma oficina de educação ambiental sobre gestão integrada de resíduos foi implementada em três instituições de ensino do município. A oficina incluiu conteúdo teórico relacionado à classificação de resíduos, o impacto ambiental do descarte inadequado de resíduos, os princípios dos 3Rs (reduzir, reutilizar, reciclar), as normas ambientais básicas aplicáveis e a situação atual na comunidade. Duas atividades participativas foram desenvolvidas: "Mapa de Identificação" e "Organize Seu Resíduo", com o objetivo de fomentar a compreensão do tema e promover hábitos de separação e reciclagem entre os jovens estudantes.

Para avaliar o nível de aprendizado, um questionário de múltipla escolha com questões fechadas foi aplicado antes e depois da intervenção, permitindo a comparação do conhecimento prévio e da aprendizagem significativa. Os resultados das oficinas e do questionário aplicado mostram que o tereftalato de polietileno (PET) é o resíduo mais prevalente na área, com a maior concentração no bairro Las Brisas, e também revelam o

conhecimento limitado dos estudantes sobre o tema. Esses resultados corroboram a avaliação preliminar e as entrevistas anteriores realizadas com as principais partes interessadas. Conclui-se que a incorporação de metodologias participativas na educação ambiental contribui significativamente para despertar o interesse dos alunos pelo município, promovendo mudanças positivas em seus hábitos de reciclagem e na valorização dos recursos ambientais em seu entorno.

Palavras-chave: educação ambiental, gestão integrada de resíduos sólidos, hábitos de reciclagem, método participativo.

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Introduction

Environmental education is geared towards practical training for understanding environmental problems. From a social perspective, it is the most important mechanism, consisting of designing and implementing educational experiences (formal, non-formal, and informal) that facilitate reflection, knowledge, and conscious action by individuals and communities (Secretariat of the Environment, 2023).

The study is framed within non-formal environmental education, which “comprises organized and systematic educational proposals that are developed outside the official education system, aimed at addressing specific learning needs through activities such as workshops, courses or training” (Soto Kiewit et al., 2023).

In Mexico, the development of environmental education still faces significant gaps. Although institutional and community efforts have been made in recent decades, weaknesses persist in specialized teacher training and the availability of teaching resources. This situation is particularly relevant in regions with social inequalities and in marginalized urban contexts.

(Lara Arzate, 2021) points out that “the great challenge [is] to serve the most vulnerable populations, not only as beneficiaries, but also as agents of social change.”

Integrated waste management is a priority on the agenda of municipalities in Mexico, as the environmental and public health consequences have increased in recent decades, such as a) water and soil pollution, b) the generation of greenhouse gases, c) the proliferation of harmful fauna and transmission of diseases (CENAPRED, 2024).

In recent decades, the generation and inadequate management of solid waste have increased environmental impacts, as these can end up in landfills or in natural ecosystems of

the localities, causing pollution of the soil, water and air, as well as affecting health and the environment (León-Cabrera & Hoogesteyn Reul, 2025) .

The Ministry of Environment and Natural Resources (2017a) reported that 102,895 tons of waste are generated daily in Mexico, of which 83.93% are collected and 78.54% are placed in final disposal sites, with only 9.63% of the waste generated being recycled.

According to a new report by the United Nations Environment Programme (UNEP), only a drastic reduction in waste generation will guarantee a habitable and affordable future, as municipal solid waste generation is projected to increase from 2.3 billion tons in 2023 to 3.8 billion tons in 2050 (United Nations, 2024) .

Based on the above, environmental education is recognized as a relevant strategy to improve the quality of degraded ecosystems, since "to begin with the changes, the necessary information must first be given to the population, as well as the appropriate channels to form a sustainable population" (Cervantes Castro et al., 2019, p. 4) .

Environmental education is a powerful tool for achieving and maintaining the balance and health of the planet. The main objective of environmental education is to develop a global population that has the knowledge, skills, attitude, motivation, and commitment to work individually and collectively toward solving existing problems and preventing new environmental conflicts (Ministry of the Environment and Natural Resources, 2024) .

“In the rural context there is a direct connection of people with the natural environment (landscapes, ecosystems, agricultural communities), which favors that environmental education is more experiential, contextualized and meaningful” (Sousa et al., 2020) .

Environmental education highlights the root causes of problems based on various social, cultural, and economic factors. Many organizations, such as the UN and UNESCO, have warned of the environmental problems generated in the ecosystem by the advance of economic development, which would lead to deterioration and negative consequences for the environment in which we live. Likewise, two major problems must be taken into account : the global environmental crisis and the educational context that must contribute to overcoming these problems (Visa, 2022, p. 3) .

“Studies agree that environmental problems in rural communities are related to limitations in infrastructure, climate change and everyday resource management practices,

which makes it necessary to implement participatory and contextualized strategies for their attention” (Del Carmen-Niño, 2025) .

Implementing environmental education strategies in rural communities helps mitigate the environmental problems caused by the inadequate management of municipal solid waste (MSW). These strategies enable people to acquire new knowledge, attitudes, and practices related to this issue and, consequently, develop a new environmental awareness (Viesca Arrache, 2009) .

Báez Corona (2024) mentions that policies in Mexico in recent decades on environmental education are mainly developed in two general laws: The General Law of Education (LGE) contemplates environmental education as one of the contents that must be considered in the plans and programs of study in official education; and the General Law of Ecological Balance and Environmental Protection (LGEEPA) is the regulation that provides the definition of environmental education in the Mexican legal system, in both normative instruments there is concrete reference to environmental education (p. 53).

The Ministry of Environment and Natural Resources (2017b) establishes the quality standard the Mexican standard NMX-AA-61-1985 entitled “Generation of Urban Solid Waste (USW)”, classifying them into: a) domestic waste, referring to those generated in homes, b) non-domestic waste, indicated as those generated outside of homes, such as streets, offices, stores, schools, temples, among others, with the purpose of facilitating their identification and proper management.

A study conducted by Bedolla Solano et al. (2024) aimed to analyze the problem of urban solid waste in the community of Las Vigas, in La Costa Chica Guerrero, Mexico, thereby identifying problems in the management of MSW, including inadequate practices such as lack of separation, incorrect disposal of MSW and citizen attitudes that demonstrate their lack of environmental awareness (p.17).

A study by Pérez and Rodríguez (2022) in a town whose main activity is agriculture shows that the recycling potential is expressed in four categories. One of these is the organic fraction, which accounts for 59.2% and can be transformed into compost. By selling part of the inorganic fraction and recycling the organic fraction, it is possible to remove more than 90% of the waste from the flow and use it for other purposes . To this end, a proposal for the participatory management of municipal solid waste (MSW) in San Pedro Benito Juárez is presented. This proposal is based on the premise of local participation, and training in waste

classification and recycling provides input for decision-making regarding the specific conditions of the waste (p. 2).

In Mexico, applied studies have also been conducted at the secondary level to analyze solid waste management from an environmental perspective. A relevant case is the study carried out in a secondary school in Guerrero, where an environmental audit was used to evaluate the conditions of the school environment and practices related to waste management. The results revealed a low level of compliance with sustainability standards, highlighting the limited implementation of actions for the proper management of solid waste, as well as deficiencies in infrastructure and sanitary conditions (Gutiérrez Villalobos et al., 2022).

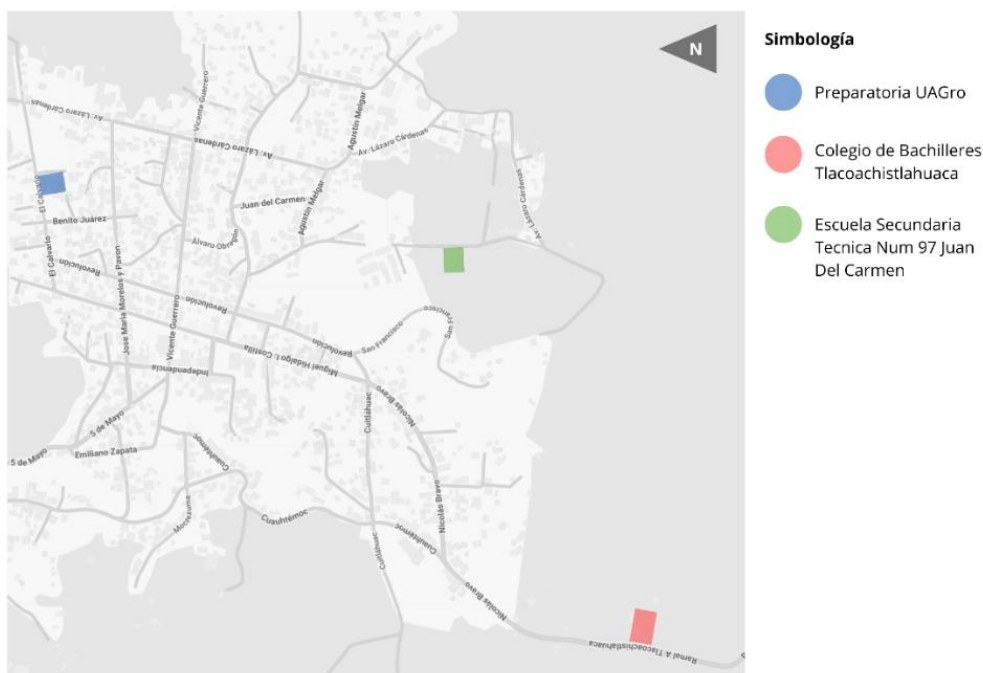
The implementation of structured environmental education programs is fundamental, as it fosters the development of knowledge, values, and responsible actions among residents, as well as their participation in solving environmental problems and building sustainable communities. Similarly, the United Nations Educational, Scientific and Cultural Organization (2020) highlights the importance of education in its communication, dissemination, and promotion efforts related to sustainable development and the Sustainable Development Goals (SDGs), including public campaigns (p. 43).

Materials and methods

This paper presents a descriptive case study based on a participatory method with a qualitative approach, conducted in three public institutions (a high school, a preparatory school, and a middle school) in the municipal seat of Tlacoachistlahuaca, Guerrero. The objective was to identify students' perceptions of solid waste concentration in the community, as well as to analyze their interest in activities related to recycling habits and the appreciation of environmental resources. To this end, a workshop on integrated waste management was implemented, incorporating participatory activities called "*Identification Map*" and "*Organize Your Waste*," based on the work of Rojas Sandoval et al. (2020) and adapted for in-person delivery to the rural context.

Figure 1 represents a map with the location of the schools where the workshop was held, which were: the Colegio de Bachilleres, the Preparatoria UAGro and the Secundaria Técnica 97.

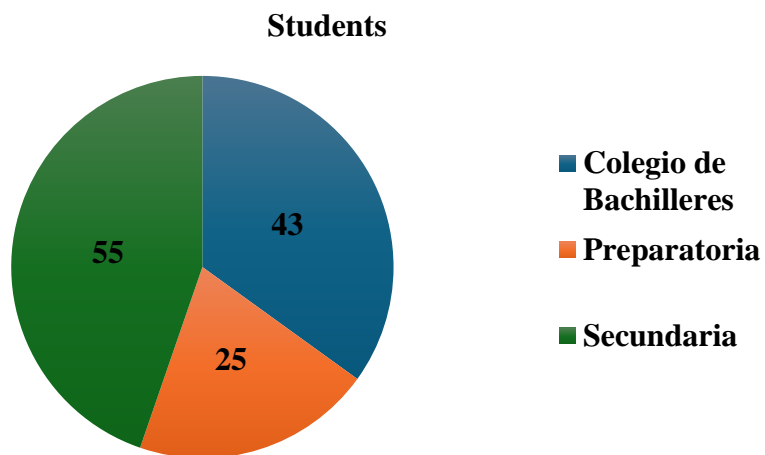
Figure 1. Location of schools in Tlacoachistlahuaca



Source: Own elaboration

The average age of the students participating in the workshop was 16 years (range 15-17 years), corresponding to the second and third years of each institution. Figure 2 shows that the highest participation was recorded at Technical Secondary School 97, with 55 students; followed by the College of Baccalaureate Studies, with 43; and finally, the UAGro Preparatory School with 25 students.

Figure 2. *Student* participation in the workshops



Source: Own elaboration

By carrying out activities and dynamics in institutions, “social perceptions of the environment” are identified, understood as the interpretations, beliefs, and values that individuals construct around the environment. These perceptions are reflected in actions in favor of the environment, such as the practice of recycling, reusing products, reducing the consumption of polluting products, saving energy and water, caring for green areas, and monitoring political actions for environmental conservation and preservation (Yangali Vicente et al., 2021) .

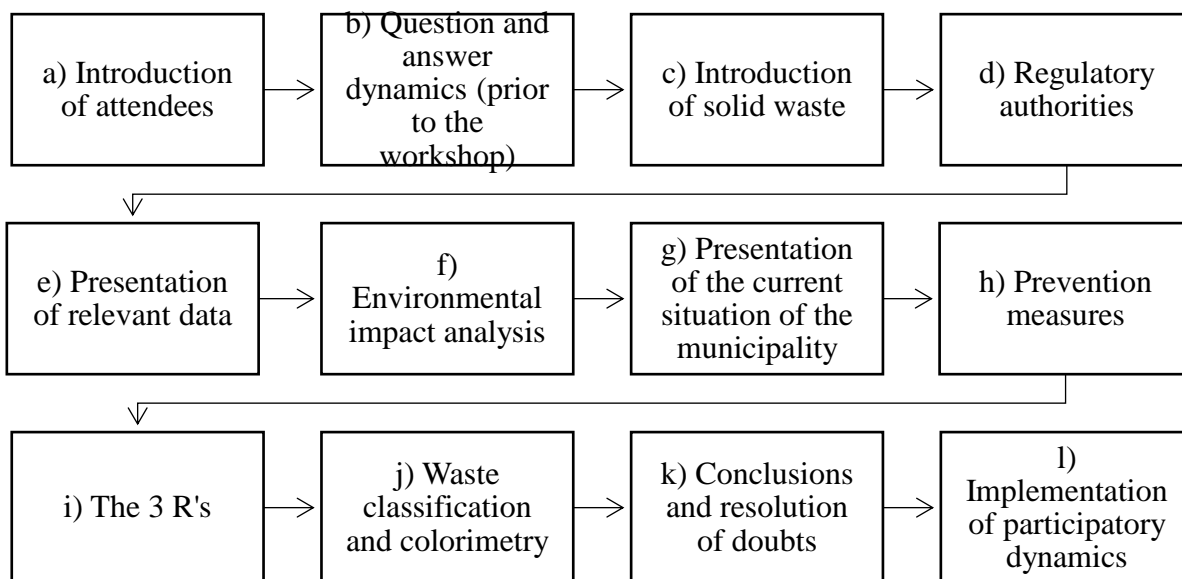
The participatory method is a collaborative process in which social actors, communities and organizations are involved in the generation of knowledge and in decision-making for environmental management, integrating different values, knowledge and contexts to improve socio-environmental outcomes (Reed et al., 2018) .

On March 24 and 25, 2025, a workshop on integrated waste management was held in the classrooms. The workshop included theoretical content related to: waste classification, the environmental impact of poorly managed waste, and the principles of the 3Rs (reduce, reuse, and recycle).

Preventive measures were shared, such as source reduction, proper waste separation, home composting, and civic education. Emphasis was placed on the iconography and colorimetry of waste, using the Design Guide for the Graphic Identification of Integrated Waste Management from the Ministry of the Environment and Natural Resources as a reference, in order to clearly identify solid waste. The workshop concluded with oral questions directed at the students, clarifying doubts and listening to their contributions.

The workshop was developed with a logistics designed in collaboration with the Secretariat of the Environment of the H. Municipal Council, which is shown in figure 3.

Figure 3. Phases in the development of the workshop



Source: Own elaboration

- a) Presentation of the attendees: the welcome and presentation of the workshop attendees was carried out by authorities of the H. Municipal Council.
- b) Question and answer dynamics (prior to the workshop): diagnostic questionnaire of thirteen multiple-choice questions, in order to identify the level of prior knowledge of the students.
- c) Introduction to solid waste: presentation of the concept, production in Mexico and the generating locations.
- d) Regulatory authorities: review of the General Law for the Prevention and Comprehensive Management of Waste (LGPGIR) and what it establishes as those responsible for the management and handling of waste.
- e) Presentation of relevant data: information on daily household waste production and examples of their equivalencies.
- f) Environmental impact analysis: pollution, greenhouse gas emissions, public health and damage to ecosystems.
- g) Presentation of the current situation of the municipality: presentation of photographs of the final disposal site of the waste, where the large quantities generated can be observed.
- h) Prevention measures : reduction at the source, proper separation, home composting and citizen education.
- i) The 3 R's: the meaning of reduce, reuse, and recycle

- j) Waste classification and colorimetry: based on article 18 of the LGPGIR and on the design guide and graphic identification of the comprehensive waste management.
- k) Conclusions and resolution of doubts: clarification of doubts, feedback and application of learning assessment.
- l) Implementation of participatory dynamics: development of the dynamics “Order your waste” and “Identification map”, considering the characteristics of each institution.

The workshop lasted approximately two hours at each school (middle school, high school, and preparatory school), including theoretical topics and participatory activities. The breakdown of times is shown in Table 1.

Table 1. Workshop logistics

Workshop: Integrated Solid Waste Management			
Activity	Duration		
	College of Baccalaureate 43 attendees	Preparatory 25 attendees	Secondary 55 attendees
Introduction of attendees	9 minutes	5 minutes	6 minutes
Question and answer dynamics	9 minutes	8 minutes	10 minutes
Introduction to solid waste	5 minutes	5 minutes	6 minutes
Regulatory authorities	5 minutes	5 minutes	5 minutes
Important data	7 minutes	6 minutes	8 minutes
Environmental impact	6 minutes	6 minutes	7 minutes
Images of the current situation in the municipality	8 minutes	8 minutes	10 minutes
Preventive measures	10 minutes	8 minutes	8 minutes
The 3 R's	10 minutes	6 minutes	6 minutes
Iconography and colorimetry	15 minutes	13 minutes	13 minutes
Conclusions and answers to questions	10 minutes	8 minutes	5 minutes
Participatory dynamics	20 minutes	20 minutes	18 minutes
Total time	1 hr 54 min	1 hour 38 minutes	1 hr 42 min

Source: Own elaboration

As part of the activities , photographs were shown of the environmental impacts in the town caused by solid waste pollution, taken from a previous visit to the final disposal site, with information provided by the director of the Municipal Environment Secretariat.

Two participatory activities were developed aimed at inducing separation and recycling habits in young people:



In the case of the students from the Colegio de Bachilleres (High School), the activity took place on the first day, with a different number of participants and a different format than that used in the Preparatory School. The activity was called *"Identification Map."*

Students were presented with a printed map of the municipal seat, which included landmarks to help them locate areas they perceived as having the highest concentration of waste. For this activity, the students organized themselves into teams of ten. Each team brainstormed and then selected two representatives, who identified the neighborhoods, districts, or sites where the most waste accumulated.

For middle and high school students, the *"Organize Your Waste" activity* involved dividing them into teams of eight and assigning each team an icon of the corresponding color, according to the Design Guide for the Graphic Identification of Integrated Waste Management. A slide with images of different types of waste in random arrangements was also projected on the board, and the students then arranged the waste according to the slide.

To evaluate the learning level of the workshop in each of the educational institutions, a non-probability convenience sampling method was used. The sample consisted of 40 elementary school students (out of a total of 55 attendees) and 42 high school students (out of 68 attendees).

The instrument used was a questionnaire consisting of four multiple-choice questions and two open-ended questions, with a total of 13 items related to solid waste, the 3Rs (Reduce, Reuse, Recycle), environmental regulations, and the identification of icons and colors corresponding to each type of waste. The instrument was validated through expert review and developed in conjunction with municipal authorities.

Its application was carried out before and after the workshop, which allowed for a comparison of prior knowledge and learning.

Results

The workshop held at the Colegio de Bachilleres featured the "Identification Map" activity. This involved providing students with a scale map of the municipality, highlighting the most well-known landmarks in the municipal seat.

Based on this activity, the participants located the sites with the highest concentration of waste, as shown in Figure 4.

Figure 4. Team participating in the identification map activity at the Colegio de Bachilleres



Source: Own elaboration

Table 2 presents the results of the “Identification Map” activity, which records the neighborhoods and the classification of the waste identified by the students of the College of High School Graduates, based on the categorization criteria addressed during the workshop.

Table 2 “ Identification Map” activity

Cologne	Waste sorting
Tank neighborhood	Organic and inorganic
Chimeco neighborhood	Inorganic
Las Flores neighborhood	Inorganic
Trout	Organic and inorganic
San Pedro Colony	Inorganic
Guapinoles	Inorganic
Heel	Inorganic
The ejido house	Inorganic
The revolution	Inorganic
Chinatown	Inorganic
The breezes (mentioned 3 times)	Inorganic

Source: Own elaboration

Based on the information presented in Table 2, the neighborhood most frequently mentioned by the working groups was Las Brisas, where inorganic waste predominated. These results corroborate the information obtained during the workshop and previous visits, in which municipal authorities noted a high generation of this type of waste, associated with the high consumption of bottled beverages. Based on the above information, Figure 5 presents a map of the neighborhoods recorded by the students, along with the icons corresponding to the identified waste.

Figure 5. Places identified with waste



Source: Own elaboration

In high school and middle school, the "Sort Your Waste" activity was implemented. In this activity, students classified waste according to the corresponding icon and color. Student participation in the activity is shown in Figure 6.

The activity was carried out in short periods, during which the students were able to organize themselves both inside and outside the classroom. Afterwards, they presented the results of their classification.

Figure 6. Dynamics: Sort your waste



Source: Own elaboration

To identify the learning acquired during the workshop, a diagnostic assessment and a final assessment were administered to secondary school and high school students. The instrument consisted of a questionnaire with four multiple-choice questions and two open-ended questions, for a total of 13 response options.

The results show an increase in the average score obtained by the students: in the Colegio de Bachilleres, the average went from 2.3 to 6.0, while in Secundaria it increased from 1.7 to 6.2.

Table 3 Evaluation results

School	Evaluation moment	Average number of correct answers	Overall average
College of Baccalaureate	Before the workshop	3.0	2.3
	After the workshop	7.4	6.0
Technical Secondary School 97	Before the workshop	2.2	1.7
	After the workshop	8.1	6.2

Source: Own elaboration

Note: The *average score* corresponds to the average number of correct answers obtained by the students. The *overall average* represents the average grade obtained on a standardized evaluation scale of 1 to 10.

Based on the results obtained, an increase in the average number of correct answers and in the overall average was identified in the evaluated institutions, compared to the values recorded before the workshop. This increase is observed mainly in the average number of correct answers, indicating an improvement in the level of knowledge related to solid waste management.

Furthermore, the increase in the overall average suggests a positive effect of the strategies implemented in the learning process, particularly in the identification and classification of waste. These results demonstrate that incorporating participatory activities promotes learning among high school and secondary school students.

In this sense, the diagnosis and the applied intervention made it possible to identify areas of opportunity and generate improvements in the observed learning, which supports the use of this type of strategy in the educational field.

Discussion

The results obtained in the environmental education workshop show that, when participatory methodologies adapted to the rural context are used, students increase their level of knowledge and improve their ability to identify environmental problems in their immediate surroundings. This finding reinforces the argument made by Reed et al. (2018), who maintain that participatory methods allow for the integration of local and scientific knowledge to build more legitimate and contextualized solutions, especially in territories where waste management has historically been weak.

In the case of Tlacoachistlahuaca, the repeated identification of plastic –particularly PET– as the main waste coincides with previous diagnoses of an institutional and academic nature, indicated both by municipal authorities and by regional studies that document inadequate practices of separation and final disposal of waste in rural communities of Guerrero (Bedolla Solano et al., 2024) .

This agreement validates the students' perception and shows that the problem is widely recognized by different actors, which facilitates the construction of more comprehensive community interventions.

A relevant element derived from the pretest-posttest evaluation is the increase in knowledge scores, which went from 2.3 to 6.0 points in the Colegio de Bachilleres and from 1.7 to 6.2 points in the Secundaria Técnica 97.

More than a quantitative improvement, this progress reflects the workshops' ability to translate technical information—regulations, colorimetry, waste classification, and the 3Rs principles—into learning processes. This aligns with the findings of Sousa et al. (2020), who argue that in rural contexts, environmental education takes on an experiential and situated character, which can promote knowledge retention and the adoption of sustainable practices.

Furthermore, the applied activities (“Identification Map” and “Sort Your Waste”) proved to be effective tools for motivating young people and linking theoretical learning with their everyday environment. The students' response supports the findings of Yangali Vicente et al. (2021) , who emphasize that the social perception of the environment is strengthened when activities promote reflection on individual and collective habits related to consumption, separation, and recycling.

The recurring identification of the Las Brisas neighborhood as a critical point of waste accumulation also coincides with what was observed during visits to the final disposal site and with the information provided by the municipal authorities, who attribute this

concentration –from their perception– to the high consumption of bottled beverages in the area.

These types of findings, as mentioned by León-Cabrera & Hoogesteyn Reul (2025), allow us to recognize that in Mexico the generation and inadequate management of solid waste continue to intensify environmental impacts, by promoting its disposal in landfills or in natural ecosystems, which results in contamination of the soil, water and air, as well as affecting health and the environment.

Finally, the results reinforce the idea that teaching techniques confirm that environmental education is a key tool for transforming community practices, as noted by Cervantes Castro et al. (2019), who emphasize that environmental culture is strengthened when educational processes involve dynamic strategies, horizontal dialogues, and participation.

In this study, the enthusiasm shown by the students, along with the improvement in the scores obtained, suggests that these activities can be a starting point for driving deeper changes in the community.

Taken together, the findings show that combining participatory approaches, contextualized content, and active learning has the potential to foster a strong environmental awareness among young people. However, for this effort to have a lasting impact, it will be necessary to continue the workshops, involve families and local authorities, and strengthen institutional capacities for waste management. Environmental education alone will not solve the problem, but it does lay the groundwork for a cultural transformation that will allow us to address it more effectively.

Conclusions

The work carried out with students from the three schools in the municipal seat of Tlacoachistlahuaca shows that environmental education, when linked to the participants' everyday context, fosters understanding of the content and its application in actions related to waste management. During the workshop, the students acquired technical and regulatory knowledge and recognized the problem of solid waste as part of their immediate environment.

The identification of plastic as the most frequent type of waste and the repeated mention of neighborhoods like Las Brisas indicate that the students recognize the areas where

waste accumulation is most visible. This recognition is related to their daily experiences in the local environment, based on observations in streets, homes, and school spaces.

Furthermore, the incorporation of accessible information and dynamic activities is associated with an increase in scores obtained after the workshop, suggesting a positive effect on learning.

The quantitative results are complemented by observations made during the workshop, which documented the students' active participation in the proposed activities. During these activities, the students exchanged ideas about waste accumulation and classification, demonstrating the potential for fostering dialogue and collective learning in environmental education, even in contexts with limited resources.

The results of this study demonstrate the importance of environmental education in strengthening knowledge and raising awareness about waste management in school settings. They also show that implementing participatory strategies fosters an understanding of the relationship between individual actions and their impact on the environment. These findings provide evidence of the potential of environmental education to promote changes in learning and in the perception of environmental problems at the community level.

In conclusion, the workshop represents a first step in implementing environmental education strategies in the municipality. The results obtained suggest that continuing these actions, along with family participation and strengthened institutional support, can contribute to developing a more informed and sustainability-oriented environmental culture. Therefore, it is recommended that these types of interventions be monitored to consolidate and expand their impact on the community.

Future lines of research

Based on the results obtained, several opportunities were identified to further analyze environmental education in Tlacoachistlahuaca within the framework of sustainable regional development. First, it will be beneficial to study in greater detail the relationship between the population's consumption habits and waste generation, considering that daily practices and local purchasing patterns directly influence waste accumulation, especially plastics. This line of inquiry will allow us to understand how cultural, economic, and commercial factors shape environmental behaviors in rural communities.

Furthermore, longitudinal research is recommended to evaluate the lasting impact of environmental education workshops on students and their families. Analyzing the learning

acquired can help determine whether it is maintained over time and translates into observable changes within the family. These studies can provide relevant evidence to strengthen future educational programs and improve their pedagogical strategies.

Another area of interest is examining local governance of waste management to identify institutional capacities, levels of coordination among stakeholders, and sociopolitical barriers that hinder effective overall management. This exploration may offer opportunities for collaborative models that integrate schools, municipal authorities, and the general public, promoting more responsible and sustainable management.

Furthermore, it is important to investigate community-based proposals based on the circular economy, such as collection centers, composting projects, or student recycling initiatives. Evaluating their technical, social, and economic viability contributes to improving the design of replicable strategies in other rural municipalities with similar characteristics.

It is also recommended to analyze environmental perceptions from an intergenerational perspective, since understanding how different age groups interpret the problem of waste would allow for the design of more culturally relevant interventions.

Finally, it is suggested that detailed environmental studies be developed to assess the impact of inadequate waste management on soil, water, and public health, with the aim of generating regional indicators to guide the formulation of public policies and evidence-based municipal decision-making.

Taken together, the lines of research mentioned above can contribute to strengthening environmental education, informed decision-making, and progress towards a sustainable regional development model for Tlacoachistlahuaca and its rural surroundings.

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Appendix

DIAGNOSTIC ASSESSMENT PRIOR TO THE TALK ON INTEGRATED SOLID WASTE MANAGEMENT

Date: _____

School: _____ Grade and Group: _____ Age: _____

Gender: ____

Answer the following based on your prior knowledge before the discussion:

1. How is solid waste defined?

- a) Materials, objects, substances or elements that are discarded or abandoned as a result of human activities.
- b) These are the ones generated in homes, resulting from the disposal of materials used in domestic activities, products consumed, and their containers, packaging, or wrapping.
- c) All those materials that can be biologically degraded, that is, by the action of microorganisms.

2. Select the 3 magic R's designated by the National Commission of Natural Protected Areas

- a) Refuse, Reuse, Recycle
- b) Reject, Reduce, Recover
- c) Reduce, Reuse, Recycle

3. My commitment to the environment is:

- a) Take care of it and protect it.
- b) Classify, store and properly dispose of all waste generated in projects and at home.
- c) Being indifferent to any event that affects the environment
- d) A and B is my commitment.

4. Which article of the General Law for the Prevention and Comprehensive Management of Waste (LGPGIR) establishes the classification of solid waste?

- a) Article 15
- b) Article 18
- c) Article 4

5. According to the General Law for the Prevention and Comprehensive Management of Waste (LGPGIR), how are urban solid wastes classified?

6. Mention the colorimetry and classification corresponding to the following iconographies:



