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Scientific article

Conciencia y acción ambiental en estudiantes de nivel medio superior: Un caso de estudio en México

Environmental awareness and action in high school students: A case study in Mexico

Conscientização e ação ambiental em estudantes do ensino médio: um estudo de caso no México

Griselda Andrade-Cruz
Instituto Politécnico Nacional, México
gandradec2200@alumno.ipn.mx
https://orcid.org/0009-0000-1969-6907

Rosalba Zepeda-Bautista
Instituto Politécnico Nacional, México
rzepedab@ipn.mx
https://orcid.org/0000-0003-0988-8619

Martha Elena Domínguez-Hernández
Universidad Nacional Autónoma de México
marthadominguez@comunidad.unam.mx
https://orcid.org/0000-0001-7924-5171

Norma Esmeralda Rodríguez-Ramírez
Instituto Politécnico Nacional
nerrodriguez@gmail.com
https://orcid.org/0000-0002-8793-8602

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Resumen

El sistema de educación ambiental en las instituciones educativas es complejo y dinámico. En esta investigación se exploró la relación entre conciencia y acción ambiental entre estudiantes de nivel medio superior en dos instituciones educativas ubicadas en Zumpango de Ocampo, Estado de México. El estudio se realizó con 148 estudiantes de entre 15 y 18 años mediante la aplicación de una encuesta para recopilar datos sobre su rendimiento académico en asignaturas relacionadas con el ambiente, su conocimiento ambiental y su participación en actividades proambientales. El análisis estadístico de datos se hizo a través de componentes principales y conglomerados para clasificar a los estudiantes en cuatro grupos según su rendimiento académico en muy bueno (RAMB), bueno (RAB), regular (RAR) y suficiente (RAS). Los resultados revelaron que los estudiantes con mayor conocimiento académico (RAMB) muestran una mayor conciencia ambiental (23.7); sin embargo, su participación en acciones proambientales no fue significativamente diferente en comparación con la de los grupos con menor conocimiento (RAR y RAS). Es crucial destacar que el conocimiento del entorno escolar también se relaciona con la conciencia ambiental. Se identificó una brecha entre la conciencia y la acción ambiental, lo que indica que el conocimiento sobre los problemas ambientales no se traduce automáticamente en acciones concretas. Asimismo, se observó una tendencia de los estudiantes a autoevaluarse positivamente (entre 49% y 64%), incluso cuando los datos objetivos sobre su participación en acciones concretas fueron bajos (entre 0% y 16%). Se definió la línea base del sistema y se propusieron estrategias de mejora, entre ellas el enriquecimiento del mapa curricular, la impartición de talleres, la organización de concursos sobre problemas ambientales, carreras ecológicas y campañas locales de recolección de basura. Es indispensable la participación de estudiantes, padres de familia, sociedad, instituciones de enseñanza e investigación e instituciones gubernamentales en las actividades proambiental. Es necesario contar con una educación ambiental integral que vaya más allá de la simple transmisión de la información y que se adapte al contexto del estudiante.

Palabras clave: Educación ambiental, conciencia ambiental, consumo sustentable, mapa curricular, rendimiento académico.

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Abstract

The environmental education system in educational institutions is complex and dynamic. This research explored the relationship between environmental awareness and action among high school students in two educational institutions located in Zumpango de Ocampo, State of Mexico. The study was conducted with 148 students between 15 and 18 years old by applying a survey to collect data on their academic performance in subjects related to the environment, their environmental knowledge and their participation in pro-environmental activities. Statistical data analysis was conducted using principal component analysis and cluster analysis to classify students into four groups based on their academic performance: Very Good (RAMB), Good (RAB), Regular (RAR), and Sufficient (RAS). The results revealed that students with higher academic knowledge (RAMB) showed a higher environmental awareness (23.7); however, their participation in pro-environmental actions was not significantly different compared to that of groups with lower knowledge (RAR and RAS). It is important to highlight that familiarity with the school environment is also linked to environmental awareness. A gap between environmental awareness and action was identified, indicating that knowledge about environmental issues does not automatically translate into concrete actions. Furthermore, students tended to evaluate themselves positively (between 49% and 64%), even when objective data on their participation in concrete actions was low (between 0% and 16%). The baseline of the system was defined, and improvement strategies were proposed, such as enriching the curriculum, organizing environmental issue competitions, workshops, eco-friendly races, and local garbage collection campaigns. An integral environmental education is needed, one that goes beyond the mere transmission of information and is adapted to the student's context.

Keywords: Environmental education, environmental awareness, sustainable consumption patterns, curriculum framework, academic performance.

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Resumo

O sistema de educação ambiental em instituições de ensino é complexo e dinâmico. Esta pesquisa explorou a relação entre consciência ambiental e ação entre estudantes do ensino médio em duas instituições educacionais localizadas em Zumpango de Ocampo, Estado do México. O estudo foi realizado com 148 estudantes entre 15 e 18 anos por meio da aplicação de uma pesquisa para coletar dados sobre seu desempenho acadêmico em disciplinas relacionadas ao meio ambiente, seus conhecimentos ambientais e sua participação em atividades pró-ambientais. A análise estatística dos dados foi feita por meio de componentes principais e clusters para classificar os alunos em quatro grupos de acordo com seu desempenho acadêmico: muito bom (RAMB), bom (RAB), regular (RAR) e suficiente (RAS). Os resultados revelaram que os alunos com maior conhecimento acadêmico (RAMB) apresentam maior consciência ambiental (23,7); Entretanto, sua participação em ações pró-ambientais não foi significativamente diferente quando comparada aos grupos com menor conhecimento (RAR e RAS). É fundamental destacar que o conhecimento do ambiente escolar também está relacionado à consciência ambiental. Foi identificada uma lacuna entre a conscientização ambiental e a ação, indicando que o conhecimento sobre questões ambientais não se traduz automaticamente em ações concretas. Houve também uma tendência dos estudantes se autoavaliarem positivamente (entre 49% e 64%), mesmo quando os dados objetivos sobre sua participação em ações concretas eram baixos (entre 0% e 16%). A linha de base do sistema foi definida e estratégias de melhoria foram propostas, incluindo enriquecimento do currículo, realização de workshops, organização de competições sobre problemas ambientais, corridas ecológicas e campanhas locais de coleta de lixo. A participação de alunos, pais, sociedade, instituições de ensino e pesquisa e instituições governamentais em atividades pró-ambientais é essencial. É necessária uma educação ambiental integral que vá além da simples transmissão de informações e que se adapte ao contexto do aluno.

Palavras-chave: Educação ambiental, conscientização ambiental, consumo sustentável, mapa curricular, desempenho acadêmico.

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Introduction

Education is a continuous learning and development process that can be formal or informal. It focuses on the acquisition of knowledge, skills, values, attitudes and aptitudes to improve the quality of life of individuals and the society in which they live (UNESCO, 2020; UNESCO, 2018). The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines environmental education (EE) as an awareness-raising strategy so that the population is aware of the problems and the different ways of caring for the environment (UN, 1972). Its objectives include: acquiring knowledge about environmental problems at local, national and global levels; developing individual and collective values and attitudes to interact in a harmonious, positive and permanent way with the environment; and obtaining scientific, social and technical capacities and skills to participate in the solution of environmental problems (UNESCO, 1977).

This concept has been developed over the last five decades by incorporating theoretical and practical knowledge, values and attitudes aimed at caring for the environment. Due to its positive on protecting the environment and improving the quality of life at both individual and collective levels, environmental education should be included in the school system and in the economic, social and cultural activities of the population. (UNESCO, 1987; UNEP, 1975; UN, 1972). In addition to environmental education terminology, Education for Sustainable Development (ESD) is used nowadays. In addition to the knowledge, skills, values and attitudes necessary for the development of a productive life, informed decision-making is sought to assume an active and ethical role in solving socio-environmental problems at the local and global level (UNESCO, 2020; Nurhayati *et al*., 2020). At the same time, it is necessary that environmental education or sustainability education programs consider, in addition to the environment, the social, economic and political dimensions of sustainability (Arias, 2004; Becker *et al*., 1999).

Currently, Environmental Education (EE) or Education for Sustainable Development (ESD) plays a relevant role in the development of environmental awareness and in changing the consumption habits of students (Zsóka *et al*., 2013). However, for this type of teaching to have a significant effect on the environment, it is necessary for students to have tools and knowledge that, when applied, allow them to demonstrate positive attitudes towards the environment and increase their motivation to propose solutions to environmental problems (Altin *et al*., 2014; García, 2013; UNESCO, 1978; UNESCO, 1977).

Although the importance of EE or ESD is important for sustainable development and socio-environmental problems, not all countries have incorporated this type of content into their curricula and programs. In a report published by UNESCO (2022) on environmental education in 46 countries, it was determined that more than 80% of educational policies and curricula address at least one topic related to the environment, while only 69% mention sustainability and more than 50% do not address climate change.

Although environmental education is essential for the sustainable development of humanity (UN, 1987), at a global level, environmental content is included in subjects such as Biology, Science, and Geography. However, activities in favor of the environment are carried out to a greater extent in the first and second cycle of secondary school (UNESCO, 2022). In Mexico there are 33.1 million students, 72.3% at the basic level, 15.4% at the middle level, and 12.3% at the higher level (INEGI, 2021). However, the basic level curricular maps do not have specific subjects on environmental education, although related topics are included in the formative fields of Knowledge, Technology, and Environment (SEP, 2022). At the upper secondary level, EE is included in subjects from different study programs such as Matter and its Transformations, Science Workshop I, Geography and Ecology, and Environment (SEP, 2022).

On the other hand, research related to environmental education at different educational levels includes the role in the formation of attitudes and behaviors, as well as its effect on environmental awareness and other characteristics that lead to sustainable behaviors and actions in favor of the environment. In the period between 1980 and 2024, according to the results obtained in a literature search carried out in scientific databases, there are 12,868 articles related to this topic, however, only a few address environmental education in educational institutions.

At the basic level, research addresses issues related to the cognitive area and the development of programs to improve environmental development in early childhood (Vodopivec, 2010; Lee y Ma, 2006). For example, in countries such as Germany, programs such as the Public Climate School are being implemented to raise awareness about climate change and promote action among students (Keller *et al*., 2024). Published results also highlight that science learning is more likely to be integrated with environmental education (Sukma *et al*., 2020; Winanti *et al*., 2019), however, it should not be limited to this type of subjects (Bilavych *et al*., 2022; Zsóka *et al*., 2013).

Research has found that when rapid environmental assessment protocols are applied in environments close to the student, it is possible to instill values, knowledge, skills, actions and social competencies that promote environmental conservation (Guimarães *et al*., 2017). There is a positive correlation between environmental education and sustainable consumption practices. Students with greater environmental education tend to be more aware of their consumption choices (Zsoka *et al*., 2013).

In the same sense, when students are older, this type of education should be addressed in the natural, social and cultural environment of the student (Yusa and Hamada, 2023), using environmental facts that promote the development of process-oriented capacities, awareness, participation and action (Hyseni *et al*., 2014; Gurel, 2011). Thus, experiential learning becomes relevant to give meaning to the concepts and knowledge addressed in the curriculum.

It is important to understand how environmental education can influence students' awareness and actions regarding the environment in order to find appropriate ways to improve their behavior and attitude towards it. There is a consensus that environmental education positively influences the environmental practices carried out by students (Cruz *et al*., 2023; Ergen *et al*., 2015; Rogayan and Nebrida, 2019; Vilca-Cáceres, 2022). However, it is important to consider that environmental knowledge does not always translate into a change in behavior, therefore, it is necessary to promote pro-environmental attitudes that drive action (Ergen *et al*., 2015; Kousar *et al*., 2022). In this sense, participation in environmental projects and practical experiences, such as composting or school gardens, can improve students' understanding and motivation (Rogayan and Nebrida, 2019; Vilca-Cásares, 2022). However, for environmental education programs to be successful, they must be adapted to the local context to address specific problems and involve the community (Rogayan and Nebrida, 2019; Vilca-Cásares, 2022).

In general, studies several a moderate to high level of environmental awareness in students (Cruz *et al*., 2023; Ergen *et al*., 2015; Gul, 2024; Rogayan and Nebrida, 2019). This means that students are familiar with environmental problems such as pollution, but may have limited knowledge about more complex issues such as desertification, climate change or the importance of water resources (Rogayan and Nebrida, 2019). Likewise, they are aware of environmental practices such as recycling, reusing products and participating in clean-up campaigns, but there are areas for improvement to reduce plastic consumption and manage organic waste (Rogayan and Nebrida, 2019; Vilca-Cásares, 2022).

Studies show that gender and educational level can influence environmental awareness and practices (Kousar *et al*., 2022; Ergen *et al*., 2015). In this context, Ergen *et al*. (2015) found that female students had a higher level of environmental knowledge and awareness. Formal inclusion of environmental education at different educational levels is crucial to foster a deep understanding of environmental issues and such understanding will increase along with the acquisition of knowledge (Al-Naqbi and Alshannag, 2018).

It is possible to see that the development of environmental awareness is multifactorial. Altin *et al*. (2014) determined that media, socioeconomic status, and gender play a crucial role in shaping students' environmental awareness. Materialism can be an obstacle to environmental awareness as it is associated with excessive consumption (Ergen *et al*., 2015).

On the other hand, there is a close relationship between the level of awareness and the participation of students in environmental activities. Although students generally demonstrate a high awareness regarding environmental problems, their participation in environmental activities is often limited (Altin *et al*., 2014). For example, the negative impact of plastic waste is a well-known environmental problem among the population. However, addressing it from school is complex because there are misconceptions that persist in the student's extracurricular environment (Anokye *et al*., 2024) and that can limit the positive and decisive effect of actions proposed in educational institutions.

Environmental education has been evaluated from various points of view to demonstrate its importance in the development of environmental awareness and sustainable behaviors. Torroba *et al*. (2023) focus their evaluation on environmental intelligence as a key factor for environmental behavior. In this sense, a positive correlation is confirmed between environmental knowledge and attitude towards the environment, as well as between the latter and environmental behavior. On the other hand, Carmi and Alkaher (2019) focus their evaluation on risk perception and systemic thinking. Students with training in the area perceive the risks of socio-environmental problems as more severe, closer and personally relevant, and they also show a greater capacity to understand the interrelations between problems, focusing on global impacts in the medium and long term. The results of these evaluations suggest that environmental education increases the perception of the relevance of environmental problems and favors pro-environmental actions.

The evaluation of environmental education is subject to the adequate selection of the method to be used and the approach to the analysis (Berzosa *et al*., 2017). In the same sense, Brito *et al*. (2018) based on an evaluation with indicators, highlight differences in how

sustainability is perceived within the substantive functions of a University, detecting the need to integrate sustainability in all areas to achieve real progress on the subject.

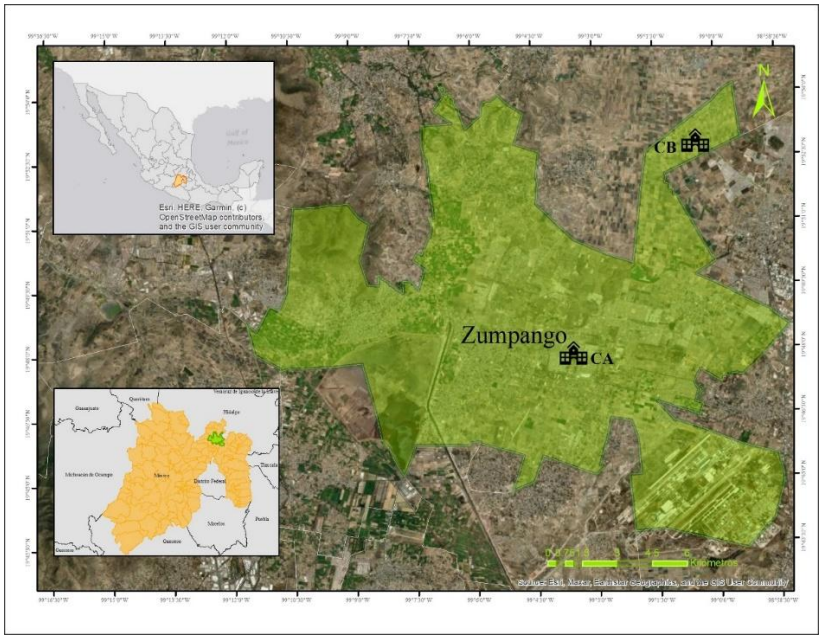
For the accomplishment of environmental education, implementation within institutions is required as well as a tool for solving environmental problems, an interdisciplinary approach, experiential learning and efforts from schools, as well as a change in the attitudes of the student or person who receives it. Therefore, the objective of this research was to classify high school students according to their environmental awareness and action, analyzing the relationship between their academic performance in environmental subjects and their participation in pro-environmental activities. It is hypothesized that students with greater environmental awareness and greater participation in sustainable initiatives tend to obtain better academic performance, since these activities foster skills such as responsibility, organization and critical thinking, which can positively influence their academic performance.

Methodology

Description of the study area

The research was carried out in two secondary education institutions located in the municipality of Zumpango de Ocampo, State of Mexico (Figure 1). This municipality has an area of 244.08 km² and is located at an altitude of 2,281 meters above sea level, with coordinates 19° 47' 50" N and 99° 06' 02" W (Government of Mexico, 2023). Its climate is dry with summer rains, the average temperature ranges between 14 ºC and 18 ºC and it has an average annual rainfall between 500 and 700 mm. The predominant soils are durisols and cambisols, with grassland vegetation. In addition, the municipality has a body of water called Laguna de Zumpango (INEGI, 2020).

Figure 1. Location of the schools in Zumpango de Ocampo, State of Mexico



Source: Own elaboration (2024)

Zumpango has 280,455 inhabitants, with an economic activity centered on the tertiary (65.9%), secondary (29.4%) and primary (2.3%) sectors. In the agricultural sector, 306,689 tons of crops are produced, as well as meat, eggs and milk (IGECEM, 2021). 47.7% of the population has access to the internet and 91.3% to a cell phone. Likewise, there are 286 schools with 68,185 students, of which 31 belong to the upper secondary level (INEGI, 2021; IGECEM, 2021). The municipality has health services from the Mexican Social Security Institute (IMSS), the Institute of Social Security and Services for State Workers (ISSSTE), it has a health sector hospital, as well as pharmacy offices (Government of Mexico, 2023).

Design and application of a survey to students

A structured survey was designed with six sections: a) general data, b) participation in caring for the environment, c) knowledge of the environment, d) curricular map, e) institutional infrastructure, and f) student behavior towards caring for the environment. The survey was applied with a non-probabilistic convenience sampling between April 22 and 28, 2023 within the facilities of CA and CB schools. The average response time was 20 minutes per student. 148 students from the selected schools participated in the study.

Information management and statistical analysis

The surveys were processed to extract the data. The variables were sorted and grouped into an Excel database to enable management of information. The data obtained were analyzed with the Statistical Analysis System software (SAS, 2014). A principal component analysis was applied to reduce the dimensionality of the variables and a cluster analysis to classify the students into different typologies (Hahs-Vaughn, 2016). To analyze environmental awareness and action in high school students, 15 indicators were considered as described in Table 1. Once the typologies were obtained, a descriptive statistical analysis was applied to obtain the characteristics of each cluster.

Table 1. Indicators of awareness and action in high school students in Zumpango de Ocampo, State of Mexico

Indicator	Description	Measurement
Academic performance (RA) (5 to 10 grade).	Average grade obtained by students in subjects related to the environment.	$RA = \frac{Q1 + Q2 + B1 + B2 + G + EyM}{6}$ $Q1 = Chemistry\ 1, \quad Q2 = Chemistry\ 2, \quad B1 = Biology\ 1, B2 = Biology\ 2, G = Geography, EyM = Ecology\ and\ environment$
Number of subjects (ARCMA) and topics related to the environment (TRCMA).	Quantifies the subjects and topics related to the environment.	$ARCMA = \sum_{i=1}^{n=6} Subjects$ $TRCMA = \sum_{i=1}^{n=24} Topics$
Knowledge of the 3Rs.	Proportion of students who know the 3Rs.	$\frac{\text{Number of students who know the 3Rs}}{Total\ number\ of\ students\ surveyed} * 100$
Number of elements that the student knows about the school (CES) and the infrastructure (COINFES).	Level of knowledge of the school environment and infrastructure.	$CES = \sum_{i=1}^{n=12} elements$ $COINFES = \sum_{i=1}^{n=82} elements$
School and infrastructure rating.	Rating provided to the school environment and infrastructure.	Rating from 0 to 10, where 0 is bad and 10 is excellent.
Level of environmental awareness.	Quantifies the student's level of environmental awareness.	Level of environmental awareness = Number of subjects related to the environment + Topics related to the environment.
Participation in garbage collection campaigns per year (NPCREBA).	Quantifies the proportion of students who participate in garbage collection campaigns during the year.	NPCREBA = (Number of students who participated in garbage collection campaigns in the year/Total number of students surveyed)*100
Satisfaction with participation in garbage collection campaigns.	Quantifies the degree of satisfaction of students who participated in garbage collection campaigns.	% Satisfaction = {[(Number of students who liked participating in the campaign) – (Number of students who were indifferent)]/Number of students surveyed}*100
Carrying out 3R actions per year (HRRR).	Quantifies the number of students who have reduced, reused and recycled.	HRRR = Number of students who have reduced, reused and recycled at least one product in the year
Percentage (PPRR) and number of products that the student has reduced (NPRED), reused (NPREU) and recycled (NPREC) in the year.	Quantify the percentage and number of products that the student has reduced, reused and recycled during the year.	$PPRR = \sum_{i=1}^{n=38} Products$ $NPRED = \sum_{i=1}^{n=21} Reduced\ Products$ $NPREU = \sum_{i=1}^{n=10} Reused\ \ Products$ $NPREC = \sum_{i=1}^{n=7} Recicled\ Products$

Source: Own elaboration (2024)

Results

The students who participated in this study range in age from 15 to 18 years. 80.3% of them are 15 or 16 years old. 47.5% are women and 52.5% are men. 91.8% live at home with their parents or guardians in areas close to the school. The schools included in the study have, on average, 82 elements of infrastructure, equipment and personnel. These are distributed as follows: two spaces for laboratories, courts, flowerbeds and cisterns; a space for stationery, a warehouse, a multipurpose room, a library and a cafeteria, as well as a water intake. They also have nine administrative and classroom areas, four sanitary areas with five divisions each, 28 computers and three trash cans. In addition, they have 15 teachers.

Student typology

Principal component analysis was used to reduce the dimensionality of the variables. The first two principal components have eigenvalues of 2.97 and 2.11, respectively. These components explain 63.6% of the variability in the data. The first component, called Consciousness, explains 37.2% of the variability and shows a positive correlation with the number of subjects in the curriculum that are related to the environment, as well as with related topics and environmental awareness, these variables with weights of 0.45, 0.48 and 0.49, respectively (Table 2). The second component, called Action, explains 26.4% of the variability and shows a positive correlation with the number of products reduced, reused or recycled per student each year, these variables with weights of 0.46, 0.48 and 0.47, respectively.

Table 2. Principal components in high school students

Variable	Awareness	Action
Academic performance	0.11	0.20
Subjects related to the environment in the curriculum map	0.45	0.28
Participation in garbage collection campaigns per year	0.01	0.15
Products reduced annually per student	0.32	0.46
Products reused annually per student	0.32	0.48
Products recycled annually per student	0.31	0.47
Environmental related topics	0.48	0.30
Level of environmental awareness	0.49	0.32

Source: Own elaboration (2024)

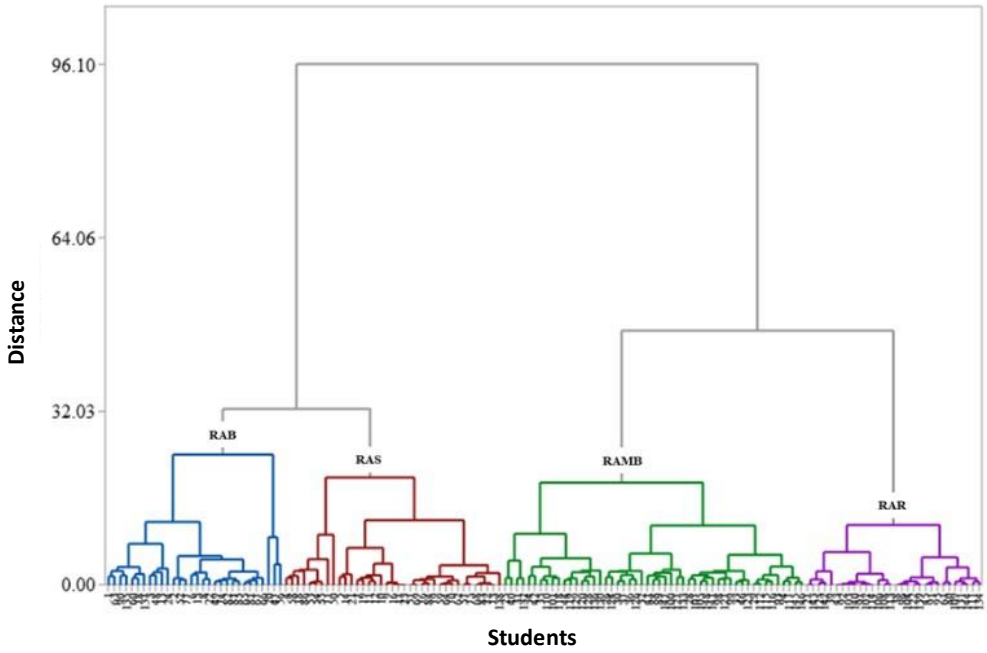
The cluster analysis classified students into four groups (Figure 2), defined according to the survey results. The clusters were named RAMB (Very good academic performance),

RAB (Good academic performance), RAR (Average academic performance) and RAS (Sufficient academic performance) (Figure 2). The characteristics of each group are described in the following sections.

Very good academic performance (RAMB)

34.4% of students belong to this group. Of these, 59.6% are men, with an average age of 17 years. In the subjects related to the environment: Chemistry I, Chemistry II, Biology I, Biology II, Geography and Ecology and Environment (DGB, 2018), their average academic performance was 9.5 (Table 3).

Figure 2. Dendrogram of the classification of high school students in Zumpango de Ocampo, State of Mexico.



Source: Own elaboration (2024)

On the other hand, 98% of the students in this group know the meaning of the 3Rs (Reduce, Reuse and Recycle), and they also mentioned that they know where the natural areas and trash cans are located in their neighborhoods and homes (Table 3). 100% of these students are familiar with the school's infrastructure, equipment and staff. In addition, they consider that the number of these elements is sufficient and give a score of 7.6 to the infrastructure and 8.4 to the school in general, on a scale of 0 to 10 (Table 3). The students

in this group have a calculated value of the level of environmental awareness of 23.7 (Table 3).

Table 3. Indicators related to the level of environmental awareness of students in Upper Secondary Education. Zumpango de Ocampo, State of Mexico, Mexico.

Indicator	Academic Performance[1]			
	Very good	Well	Regular	Enough
Academic performance (5 to 10)	9.5	8.6	8.1	6.2
Subjects related to the environment (Number)	6.0	3.8	5.8	3.4
Environmental issues (Number)	17.7	5.2	17.7	4.7
Knowledge of the 3Rs (%)	98.0	96.7	71.4	70.2
Elements you know from school[2] (Number)	7.1	7.7	8.1	8.1
School rating given by students (0 to 10)	8.4	8.9	7.7	7.9
Infrastructure available at school[3] (Number)	56.8	48.4	49.5	43.8
Student rating of school infrastructure (0 to 10)	7.6	8.1	7.1	7.6
Calculated environmental awareness level values	23.7	9.1	23.6	8.1

[1]Average of subjects related to the environment, [2]of a total of 12 elements considered, [3]out of a total of 82 elements considered

Source: Own elaboration (2024)

Regarding actions to protect the environment, in the RAMB group only 5.8% of students participated in a garbage collection campaign per year (Table 4). All students in this group have reduced, reused or recycled between 5 and 38 products annually. The action they perform the most is reduction (Table 4).

Good Academic Performance (GAP)

This cluster represents 20.2% of the students, of which 64.6% are women with an average age of 16 years. The average academic performance in subjects related to the environment was 8.6 (Table 3). These students have taken between 2 and 4 subjects related to the environment during the semester they are enrolled in (Table 3).

Table 4. Indicators related to environmental action in high school students. Zumpango de Ocampo, State of Mexico, Mexico

Indicator	Academic Performance[1]			
	Very good	Well	Regular	Enough
Participation in garbage collection campaigns per year (Number)	0.05	1.7	0.06	0.1
Have you reduced, reused and/or recycled any product in the year (% Yes)	100.0	96.7	3.3	24.3
Products that the student has reduced, reused and recycled per year (Number)	15.1	15.2	0.1	2
Number of products that the student has reduced per year[1]	8.7	9.0	0.1	1.2
Number of products that the student has reused per year[2]	4.1	3.7	0	0.6
Number of products that the student has recycled per year[3]	23	2.5	0	0.1

[1]Total elements considered 21, [2]Total elements considered 0, [3]Total elements considered 7

Source: Own elaboration (2024)

96.7% of the students in this group know the meaning of the 3Rs (Reduce, Reuse, and Recycle). Most of them mentioned that they know where the natural areas and trash cans are

located in their neighborhoods, homes, or schools. All the students in the RAB group are familiar with the infrastructure, equipment, and staff that the school has and consider that the number of these elements is sufficient, giving a score on a scale of 0 to 10 for the condition of the infrastructure, 8.1, and the school in general, 8.9 (Table 3). The students in this group have a calculated environmental awareness score of 9.1 (Table 3).

Regarding actions in favor of the environment, in the RAB group 20% of the students participated in garbage collection campaigns. It is important to mention that the students participated between 1 and 24 times in this type of events (Table 4). 97% of the students have reduced, reused or recycled between 4 and 33 products annually (Table 4). The majority reduces between 4 and 20 products annually (Table 4).

Regular Academic Performance (RAR)

This cluster accounts for 20.2% of the students, of which 56.3% are women with an average age of 16 years. The average academic performance in subjects related to the environment was 8.1 (Table 3). The majority of these students (94%) have taken between 6 subjects related to the environment (Table 3).

Only 71.4% of the students in this group know the meaning of the 3Rs. In this group, students know on average 8 items of equipment and personnel that the school has, in addition to almost 50 infrastructure elements (Table 3). The rating given to the school and the infrastructure is 7.7 and 7.1, respectively (Table 3), these values are the lowest of all the groups. The environmental awareness of the RAR group is 23.6, similar to that of the RAMB group (Table 3).

Regarding actions in favor of the environment, in the RAR cluster only 6.7% of the students participated in a garbage collection campaign in the year and almost 97% of the students mention that they have not reduced, reused or recycled any product in the year (Table 4), this result is the lowest reported in this study.

Sufficient Academic Performance (RAS)

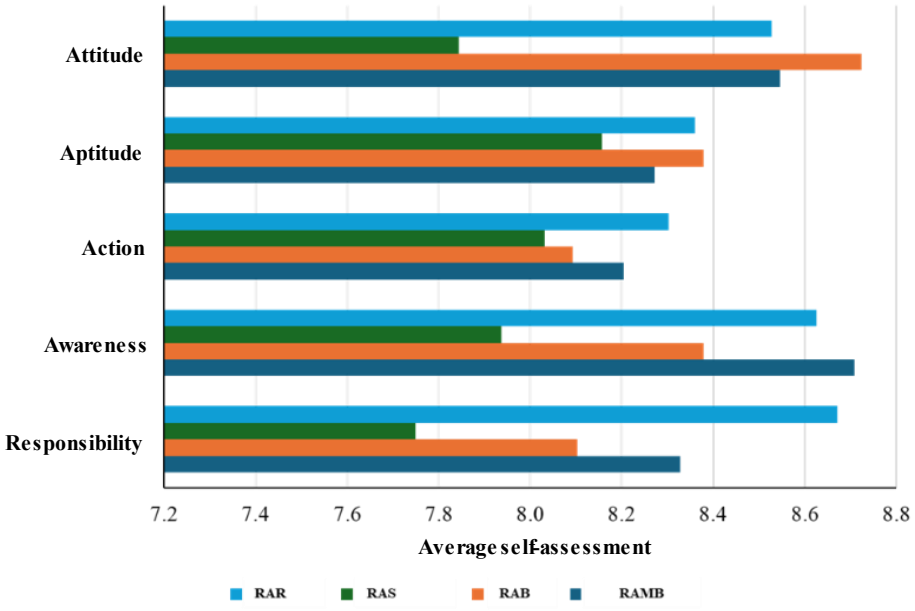
This cluster includes 25% of the students, 62.5% of whom are women with an average age of 16 years. The average academic performance in subjects related to the environment was 6.2 (Table 3). 60.2% of the students in this cluster have taken 4 subjects related to the environment and 35.1% only 2 (Table 3). The environmental awareness of the group was 8.1, the lowest of all the clusters (Table 3). Only 70.2% of the students in this group know the

meaning of the 3Rs and only 24.3% have applied them (Tables 3 and 4). Regarding actions in favor of the environment, in the RAR group only 10.8% of the students participated in a garbage collection campaign (Table 4).

Students' perception of their environmental awareness and action

In general, students in the RAMB, RAB, and RAR groups perceive that their responsibility, awareness, action, aptitude, and attitude toward the environment is good, for this reason they self-evaluate with values greater than 8 (Figure 3). In contrast, students with sufficient academic performance (RAS) tend to self-evaluate with values less than 8 in the attitude, awareness, and responsibility they have toward the environment. It is important to mention that all groups rate themselves with lower values in the actions they carry out in favor of the environment and in the aptitude they have to develop them (Figure 3).

Figure 3. Perception of high school students about their responsibility, awareness, action, aptitude and attitude towards the environment. Zumpango de Ocampo, State of Mexico



Source: Own elaboration (2024)

These results suggest that greater environmental knowledge does not always translate into greater participation in pro-environmental actions, highlighting the need for more effective educational strategies to encourage environmental action.

Discussion

The academic performance of the students allowed to generate a typology with four groups. However, the effect it has on the development of environmental awareness and action is not clear. In this research, it was found that the students who belong to the RAMB and RAR clusters have the highest environmental awareness values of the group, 23.7 and 23.6, respectively (Table 3). These groups have received the greatest environmental training of the group, implying greater environmental intelligence, which, according to Torroba *et al*. (2023), should be reflected in greater knowledge and better environmental attitude. Additionally, more than 58% are women, which coincides with Altin *et al*. (2014) who mention that female students tend to have a greater environmental awareness.

However, RAMB and RAR groups differ in the action they take to develop individual or collective activities in favor of the environment. These results indicate a close relationship between the level of awareness and environmental action, and the findings coincide with those reported by Altin *et al*. (2014) who determined that, although students demonstrate a high environmental awareness regarding environmental issues, this will not necessarily be reflected in greater participation in environmental activities. This may explain why students with very good academic performance (RAMB) carried out 96.7% more actions to reduce, reuse and recycle products compared to students with average performance (Table 4).

On the other hand, it is clear that the environmental attitude is not only influenced by the level of knowledge that the student has, but also by values, beliefs, social norms and personal experiences. Therefore, the approach to environmental action from school can be complex since there are concepts that persist in the student's extracurricular environment (Anokye *et al*., 2024) and that may limit their participation. In this sense, it is possible to see that students with the highest academic performance (RAMB) carry out fewer collective actions in favor of the environment compared to students with good (RAB) or sufficient (RAS) performance (Tables 3 and 4), which suggests differences in the students' attitudes and environment.

For this reason, it is essential that educational institutions play a key role in developing and implementing activities that improve knowledge and raise awareness among students about environmental issues (Magela y Mesquita, 2021; Kousar *et al*., 2022; Rogayan y Nebrida, 2019). These activities should be developed in diverse environments, ensuring that they are adapted to the local context of the students and focus on the acquisition of knowledge, the rational and conscious use of natural resources and the reduction of waste

(Junichiro, 2005; Nieto *et al*., 2013; SEMARNAT, 2017; Berchin *et al*., 2017; Vicente *et al*., 2021; Fiestas, 2024; Miranda *et al*., 2024).

Knowledge of the environment is another determining factor in the level of environmental awareness and action of students. In this research, it was found that such knowledge is similar among the four groups, being lower in students with sufficient academic performance (RAS) who identify 12 fewer elements of infrastructure, equipment and personnel in the institution than the students of the RAMB group and also have the lowest value of environmental awareness. This can be explained because ignorance of the environment can lead to negative and less sensitive attitudes regarding the care and protection of the environment (Yazici and Babalik, 2016) and can affect in the same way the development of environmental awareness (Cruz *et al*., 2023).

It is important to mention that, although the groups identified in this study are environmentally conscious, no significant effect was found, in real terms, on the environmental actions that each student performs. Therefore, to improve the scarce environmental action resulting from the lack of values, attitudes and interest in the environment, it is necessary to promote a comprehensive education in which both families and schools participate. In this way, students will be able to get involved in environmental projects and activities that foster their awareness and reinforce a positive attitude towards the environment (Ergen *et al*., 2015; Vilca-Cáceres, 2022).

The perception that students have regarding their responsibility, awareness, action, aptitude and attitude towards the environment is affected by both their environment and the stage of life they are in (Rodrigo *et al*., 2004; Altin *et al*., 2014). In this research, it was found that age and knowledge positively affect the student's self-assessment of the mentioned variables (Table 4 and Figure 3), which possibly indicates that as people increase their environmental knowledge and mature, their capacity for critical analysis and their understanding expand, positively affecting their responsibility, awareness, action, aptitude and attitude towards the environment (Ergen *et al*., 2015; Bilavych *et al*., 2022; Rogayan y Nebrida, 2019; Torroba *et al*., 2023; Zsoka *et al*., 2013).

The academic performance obtained by the student is another factor that affects their perception of their environmental awareness and action. Students in the RAS group gave themselves the lowest scores in attitude and responsibility, which indicates that they consider that they do not have the habits and knowledge required by the institution and therefore

perceive a lower development of their elevated environmental awareness (Escudero *et al*., 2018; Brito *et al*., 2018; SEP, 2022).

Various investigations indicate that there is a connection between students' perception of the environment and their actions to protect it. That is, if the student does not perceive a problem as something real, close and important, it is unlikely that he or she will act to solve it (Cruz *et al*., 2023). However, an interesting finding in this research is that, although the results of the surveys indicate that students carry out few actions in favor of the environment, they perceive that their action in caring for the environment is good, self-evaluating themselves with grades greater than or equal to 8 (Figure 3). These results can be explained because students are carrying out other actions in favor of the environment that were not considered in this study.

On the other hand, this study identified positive critical points of the education system at the high school level. It was observed that, in general, students complete their assignments, projects, exams, attendance and participation in class, which allows them to obtain an academic performance between 8.9 and 9.5 in subjects related to the environment. In addition, 84.5% of students know the meaning of the 3Rs (Table 3). This performance and knowledge can be used to implement academic activities such as garbage collection and separation campaigns, field visits (parks, ponds, planting and caring for a tree, a day with a farmer or rancher, among others) and the preparation of a report, which they would be willing to do because it is part of their classroom activities.

Likewise, if students adopt the habit of reducing water consumption in the toilet by placing two plastic bottles with sand or stones inside the toilet tank, they could save up to 25% of water (Robles *et al*., 2015). Likewise, the reuse of notebooks, clothing, footwear, cell phones and computers would reduce pollution and production costs. Finally, if they recycle PET, paper, aluminum and cardboard, and deposit them in containers classified by color, they would contribute to a more effective collection that reduces the environmental impact (SEMARNAT, 2017).

In this context, critical negative points of the upper secondary education system were observed; for example, there is no environmental education subject in the curriculum (SEP, 2018a), and of the 61 subjects in the curriculum map, only 1.6% of them teach topics such as environmental education, basic principles of sustainable development and their implications, impact and legislation, and environmental energies (SEP, 2018b). This could limit students from becoming more aware and taking pro-environmental actions (Hyseni *et*

al., 2014; Gurel, 2011) because they are not provided with the necessary information on the importance of caring for the environment, which could prevent them from developing practical skills to effectively contribute to environmental conservation, such as reducing waste and adopting sustainable habits in their daily lives (Mendoza *et al*., 2019).

Based on the results obtained in this research and the analysis carried out on the environmental education system at the upper secondary level, it is considered pertinent to propose improvement strategies such as:

1) Enrich the curriculum (SEP, 2018a) in the preparatory and job training components by 30%, which corresponds to incorporating as options in said components, two subjects in each one, which could be: Environmental education, Production, management and processing of garbage, Water and its efficient use, and Education for sustainable consumption where the parameters of 30% theory and 70% practice are applied because in this area it is essential to know how to do and know how to be (Gul, 2024).
2) Incorporate the topics: Eco-techniques , Organic waste management, Sustainable water management, Savings and efficient use of electrical energy consumption, Determination of the water and carbon footprint, Community environmental action practices to the 6 subjects (Chemistry I and II, Biology I and II, Geography and Ecology and Environment) that are currently being taught in the study plan (DGB, 2018).
3) Conduct diagnostics and design interventions on the environmental education system with a multifactorial, systemic and transdisciplinary approach (Domínguez and Zepeda, 2024).
4) Link and work together between students, parents, society, teaching and research institutions and government institutions such as the Ministry of Environment and Sustainable Development (2024).
5) Plan, organize and execute at least two workshops per year on the efficient use of water, reforestation and green corridors; as well as photography and/or video contests on environmental issues, local races for the environment and garbage collection campaigns (SEMARNAT, 2017).

These results showed that there is a dissociation between the level of environmental knowledge acquired in subjects and topics related to the environment, and participation in pro-environmental actions. This shows the lack of environmental education in the curricula

(SEP, 2018a) of projects and activities adapted to the local context of students and focused on the acquisition of knowledge and the rational and conscious use of natural resources, knowledge of their ecosystem, values, attitudes and interest in the environment, among others. Therefore, there is a need to reinforce training in environmental awareness and action.

Conclusions

Although academic training influences environmental knowledge, research reveals a dissociation between environmental awareness and action. This means that knowledge about environmental problems does not necessarily translate into participation in activities aimed at caring for the environment. Although students with higher academic performance (RAMB and RAR) demonstrated greater environmental awareness, their participation in concrete actions such as reducing, reusing and recycling in garbage collection campaigns was not significantly different from that of the groups with lower performance.

This finding highlights that environmental action does not depend exclusively on knowledge, but also on values, beliefs, social norms and personal experiences. The research suggests that environmental education should go beyond the transmission of information, incorporating the formation of values, the development of pro-environmental attitudes and active community participation. On the other hand, knowledge of the school environment was lower in the group with lower environmental awareness (RAS), suggesting that a greater understanding of the environment can foster more sensitive and pro-environmental attitudes.

The results highlight the importance of student perceptions of their environmental responsibility. It was observed that older students with better academic performance evaluated themselves more positively in this regard, suggesting that maturity and knowledge may influence self-perception of environmental responsibility. Overall, despite low participation in concrete actions, students tend to evaluate themselves positively in terms of their action towards the environment. This contrast could be due to a discrepancy between the actions considered in the study and the pro-environmental practices that students carry out in their daily lives.

To strengthen environmental action and awareness in high school students, collaboration between families and educational institutions is essential, promoting the formation of values, habits and positive attitudes towards the environment.

It is essential to integrate environmental education into various subjects at all educational levels. It is recommended to combine traditional teaching methods with

experiential learning strategies, using technology and multimedia resources. It is also necessary to encourage collaboration between schools, communities, and non-governmental and governmental organizations to design comprehensive environmental education programs. Finally, it is suggested to conduct research to evaluate the effectiveness of these programs and identify areas for improvement.

Future lines of research

The results obtained show a correlation between academic performance and environmental awareness. However, this relationship does not always translate into concrete environmental actions. The findings suggest the need for further research to understand the additional factors that motivate students to actively participate in pro-environmental activities. It is essential to include a more in-depth evaluation of educational strategies, the influence of the social and family environment, as well as the impact of the perception of environmental responsibility on the adoption of concrete actions in the real world.

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Contribution Role	Author(s)
Conceptualization	Griselda and Rosalba (same)
Methodology	Rosalba and Martha Elena (same)
Validation	Griselda and Rosalba (same)
Formal Analysis	Griselda, Rosalba and Martha Elena (same)
Investigation	Griselda and Rosalba (same)
Resources	Griselda, Rosalba, Martha Elena and Norma Esmeralda (same)
Data curation	Griselda and Rosalba (same) and Martha Elena (supports)
Writing - Preparing the original draft	Griselda, Rosalba, Martha Elena and Norma Esmeralda (same)
Writing - Review and editing	Griselda, Rosalba, Martha Elena and Norma Esmeralda (same)
Display	Rosalba and Norma Esmeralda (same)
Supervision	Rosalba
Project Management	Griselda and Rosalba (same)
Acquisition of funds	Griselda, Rosalba, Martha Elena and Norma Esmeralda (same)