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Abstract

This article examines the impact of implementing a didactic strategy rooted in inquiry-based learning on the development of pro-environmental behaviors. The study considers the Learning Approaches and Performance Levels achieved by 108 students aged 13 to 16 from a public rural educational institution in the Department of Meta, Colombia. This research follows the principles of the mixed methodological paradigm, employing a Simple Integrated Empirical Case Study with a descriptive approach. The characteristics of inquiry-based learning contribute to the improvement of environmental education processes. This approach enables half of the participating students to reach the higher levels of the SOLO taxonomy, while a third achieve the multi-structural level. These outcomes are not influenced by the student's preferred Learning Approach or associated factors such as their academic ease in environmental sciences or the socioeconomic conditions of their families. Instead, the strategy enhances pro-environmental behaviors by encouraging students to analyze the impact of human actions on their environmental reality, particularly those actions that benefit the environment and improve the well-being of social groups. The study concludes that actions perceived as difficult by young people are often linked to negative socio-affective aspects, such as low self-esteem or feelings of shame.

Introduction

Faced with a panorama of socio-environmental imbalances and inequalities, exacerbated by the impact of global challenges such as climate change (IPCC, 2022), it is imperative to recognize the decisive role of schools in fostering environmental citizenship. This approach enables addressing these global risks through evidence-based decision-making. Some studies show that pro-environmental behaviors aimed at mitigating socio-environmental problems are mediated by the environmental attitudes of individuals (Perez, Porras & Tuay, 2025; Kesenheimer & Greitemeyer, 2021; Markowitz et al., 2012), their environmental identity (Porras & Perez, 2019), and their eco-citizen training (Tuay, Perez & Porras, 2023), recognizing that educational research and inquiry are effective processes for the configuration of critical and resilient subjects.

This article analyzes the effect of implementing a didactic strategy developed from inquiry-based learning on pro-environmental behaviors, the learning approach, and the level of performance of 108 students between 13 and 16 years of age from an official rural educational institution located in the Department of Meta (Colombia). The structuring of the teaching strategy based on inquiry allowed for the recognition of observable learning results, delimited by the SOLO Taxonomy, promoting critical and reflective thinking. From this perspective, the role of evaluation as a process that reconciles the students' potential for informed decision-making regarding environmental problems is highlighted, in addition to constituting the axis on which the proposed activities are structured based on the designed learning outcomes.

In Latin America, and especially in Colombia, few studies empirically relate the Learning Approach followed by the student and the type of knowledge achieved (Vrioni et al., 2021), which is defined based on assessment processes under the authentic or meaningful modality (Biggs et al., 2019; Soler-Contreras, 2015). It is worth noting that most of the studies found are oriented toward higher education, with very few findings in basic education (Kirchherr & Piscicelli, 2019; Pather et al., 2020; Skulmowski & Xu, 2022). The importance of investigating the effect of implementing an inquiry-based strategy on the learning approach and the type of knowledge achieved by students transcends the traditional meaning of assessment, turning the learning experience into a useful and meaningful process for people's lives, particularly in the face of their commitment to transforming their environmental reality through the adoption of pro-environmental behaviors.

The importance of this type of research focuses on improving educational processes in the context of environmental training, based on the development of skills and abilities related to more complex cognitive processes (Biggs et al., 2019). To fulfill these purposes, this research advances toward the characterization of the learning approach followed by 108 secondary school students, between 13 and 16 years old, through the Learning Approaches Questionnaire instrument validated for Colombia by Soler (2015), in addition to analyzing the effects of implementing the didactic strategy based on inquiry on the evidenced learning approach and the type of knowledge achieved by the students. The results presented in this document are part of a doctoral research that has been developed in the National Pedagogic University (Colombia), by the Science, Environment and Diversity Education research group.

In the following sections, we first define the key terms that guide this research. It is important to recognize the theoretical bases related to pro-environmental behaviors, learning approaches, and performance levels that guide a teaching and learning strategy based on inquiry that seeks to promote decision-making in the field of environmental education of a group of young Colombians from a territory characterized by mining extractivism and commercial practices based on extensive cattle ranching.

Pro-environmental Behaviors

Pro-environmental behavior can be defined as actions by people that have a significant impact on environmental reality, materialized in protective actions toward the environment, aiming to achieve well-being conditions (Krajhanzl, 2010). Some researchers argue that when analyzing behavior as an event of people in the natural world

that can be studied through observable quantitative properties such as frequency, intensity, duration, and latency, it is necessary to consider two trends in the definition of pro-environmental behaviors: the first includes behaviors that provide benefits to the environment and are therefore governed by the impact of human actions on the natural environment. The second trend, oriented by intention, relates pro-environmental behavior to the environmental benefits that such actions can bring to the individual (Gatersleben, 2023; Lange, 2023; Lange, 2024).

When methodologically examining pro-environmental behaviors, Lange (2024) clarifies that it is necessary to distinguish behavioral properties such as frequency and duration of action, versus personal properties such as pro-environmental preference, where pro-environmental behavior is assumed to be a psychological construct. This author emphasizes the need to avoid biases in the study of pro-environmental behavior, particularly when it is related to psychometric aspects that consider such behaviors as constructs or psychological properties of people. In this sense, the author warns that it is necessary to analyze the propensity and impact of pro-environmental behaviors through strategies that involve the tendencies and preferences of individuals, which is why he calls for responses to the items on measurement scales to accurately reflect how people engage in pro-environmental behavior in daily life.

The Inquiry

The first references to inquiry are connected to the emerging proposals in science education at the beginning of the twentieth century, particularly with the work of Dewey, who promoted the development of practical activities with students as a means of formalizing scientific concepts. Some of the postulates formulated by Dewey, which are condensed in his popular article "Method in Science Teaching" (Dewey, 1916), have to do with the importance of considering children's experiences in the early stages of scientific training, which become opportunities to integrate "the life sciences and the physical sciences" (Dewey, 1916, p. 7). Similarly, the experiential work of students must connect with the posing of problem questions, promote the study of phenomena by differentiating the available data, and formulate possible solutions through hypotheses that, beyond conjectures, become dynamizers of the processes of the construction of scientific knowledge.

In the second half of the twentieth century, Schwab (1960) warned of the need to transform traditional science teaching, giving inquiry a preponderant role in promoting higher-order skills to face the political, economic, and educational challenges seen during the Cold War. Proof of these reflections is the marked importance given by the governments of different countries around the world to the results of studies that evaluate cognitive achievement around science, specifically the use of inquiry in standardized tests such as TIMSS and PISA (Teig, 2021). In 2000, the National Research Council established that the essential characteristics of inquiry in the classroom are:

> "1) Students ask scientifically oriented questions;
>
> 2) Students prioritize evidence, which allows them to develop and evaluate explanations that address scientifically oriented issues;
>
> 3) Students provide explanations from tests to answer scientifically oriented questions;
>
> 4) Students evaluate their explanations in light of alternative explanations, especially those that reflect

the scientific view;

5) Students communicate and justify the explanations they propose" (National Research Council, 2000, p. 25).

Conceptualizing inquiry requires epistemological, ontological, and methodological precisions, from which to promote discussions about its impact in the scientific, sociological, and educational fields. Authors such as Lederman (2004) consider that there are two levels of interpretation for inquiry: the first is related to processes used by scientists to answer research questions in an academic community. The second, recognized as inquiry-based learning, is associated with educational processes from which scientific knowledge is constructed as a response to central questions that are potentiated as research problems. However, at this last level, it is necessary to understand that inquiry is not only associated with aspects of science learning; it also allows students to recognize central aspects of the functioning of science itself. Inquiry is a scientific practice since it is consolidated as a process that allows the construction of scientific knowledge, encourages the development of models, and promotes the communication of such knowledge through evidence-based arguments (Jiménez-Liso et al., 2019).

Learning Approaches and Performance Levels

Learning is a relatively enduring process of behavioral change that occurs as a result of direct or indirect experiences (Beyaztaş & Senemoğlu, 2015). Learning Approaches (LeAp) can be understood as how a student's intentions, behaviors, and study habits evolve in response to their perceptions of a learning task. Within this framework, learning approaches have been classified into two main categories: deep and superficial, each reflecting distinct ways in which students engage with and tackle a given task. For example, when students perceive an academic activity as an imposition (extrinsic motivation), they usually use a learning path that requires minimal effort, therefore, they can use lower-order cognitive strategies of the SOLO taxonomy (Table 1) to fulfill the assigned task, without, in most cases, achieving significant learning (Kember et al., 2004). In this approach, called superficial learning (Marton & Säljö, 1976), the student assumes a minimum assimilation of the concepts, achieving, in most cases, declarative or procedural knowledge of them.

When student has intrinsic motivation, they use a learning strategy that requires higher-order cognitive activities (levels 3 and 4 of the SOLO taxonomy), allowing them to relate their learning to daily life (Kember et al., 2004). In this approach, called deep learning (Marton & Säljö, 1976), the student achieves functional and conditional knowledge, which is appropriate for the development of useful skills in their everyday context (Soler-Contreras, 2015). Students may have a preferred learning approach to engage in teaching and learning activities, which in the 3P (Presage, Process, and Product) model constitutes the first stage of the experience (Biggs et al., 2001).

It is important to note that the context, prior knowledge, understanding of what it means to learn, and the characteristics of the subject define how people relate to their learning process. When the teacher structures an Intended Learning Outcome using verbs that imply the development of more complex cognitive operations, the student's engagement increases, raising the probability of following the deep learning route, thus achieving better results (Biggs & Tang, 2011; Treleaven, 2008; Wang et al., 2013). In this way, students are encouraged to use

more complex mental operations during the execution of teaching and learning activities (Biggs et al., 2019; Biggs & Tang, 2011; Treleaven, 2008; Wang et al., 2013).

Table 1. SOLO Taxonomy (Structure of the Observed Learning Outcomes).

SOLO Levels	**0 Pre-structural**	**1 Uni-structural**	**2 Multi-structural**	**3 Relational**	**4 Extended Abstract**
	No relevant aspects	A relevant aspect	Several independent relevant aspects	Several relevant aspects integrated into one structure	Generalize to a new domain
Verbs used in the definition of intended learning outcomes (ILOs) and in the evaluation of the learning level achieved.	*Misses the point*	Memorizes Identifies Recite Account Unites Orders	Describe Classify Calculate Illustrates	Compare Contrast Explain causes Argues Analyzes Applies Builds Solve problems Relates	Generate theories Generate hypotheses Generalizes Reflects Improve Invent / Create Solve new problems

Method

An empirical Integrated Simple Case Study (Yin, 1994) is carried out, with a descriptive scope, a mixed methodological design, and intra-subjects (Gifford, 2015). This research focuses on the observation of student changes during the following times: baseline (t_0), intervention (t_1, t_2, t_3, and t_4), and post-implementation (t_f), to evaluate the impact of the intervention carried out. The didactic proposal includes a Sequence of Teaching and Learning Activities (STLA) based on inquiry (Figure 1), formulated from least to highest cognitive complexity, that is, from the lowest to the highest level in the SOLO taxonomy, contemplating the contents requested by Colombian regulations (ICFES, 2015; Mineducación, 2006, 2016). For the sequence, three Intended Learning Outcomes for the development of critical, systemic, and scientific thinking skills are established. Each Learning Outcome has its own assessment rubric, which corresponds to the level achieved by the student in the SOLO taxonomy (Biggs et al., 2019; Rembach & Dison, 2016). Regarding the instruments implemented to evaluate the impact of the strategy, the Learning Approaches Questionnaire (Soler-Contreras, 2015) is used, a quantitative instrument filled out at the beginning and end of the process (Kember et al., 2004). The initial moment (t_0) corresponds to the student's preferred Learning Approach, which is relatively stable and determined by their individual characteristics, while the final moment (t_f) indicates how young people modify their preferred Learning Approach to adapt to the requirements of the teaching context (Wang et al., 2013).

The Multiple Item Classification (MIC) Interview (Pacheco, 1996; Páramo, 2017a) is used to assess the Pro-Environmental Behavior of students, which aims to describe the mental structure of students for 33 pro-environmental actions listed, using the MSA software (Multidimensional Scalogram Analysis) of the HUDAP® statistical package (Amar and Toledano, 2001), and a word cloud obtained from the NubeDePalabras.es website. The directed classifications are used as a self-report of Pro-Environmental Behavior, where each student defines on a Likert-type scale (1 to 5) the ease, frequency, and favorability of the proposed actions. The higher the value, the improvement in Pro-Environmental Behavior is assumed. These numerical values are analyzed with the POSAC software (Partial Order Scalogram Analysis) and SSA software (Smallest Space Analysis). Likewise, an analysis of average values is carried out to define certain characteristics of the group's Pro-Environmental Behavior. Finally, direct observation is carried out to triangulate the information.

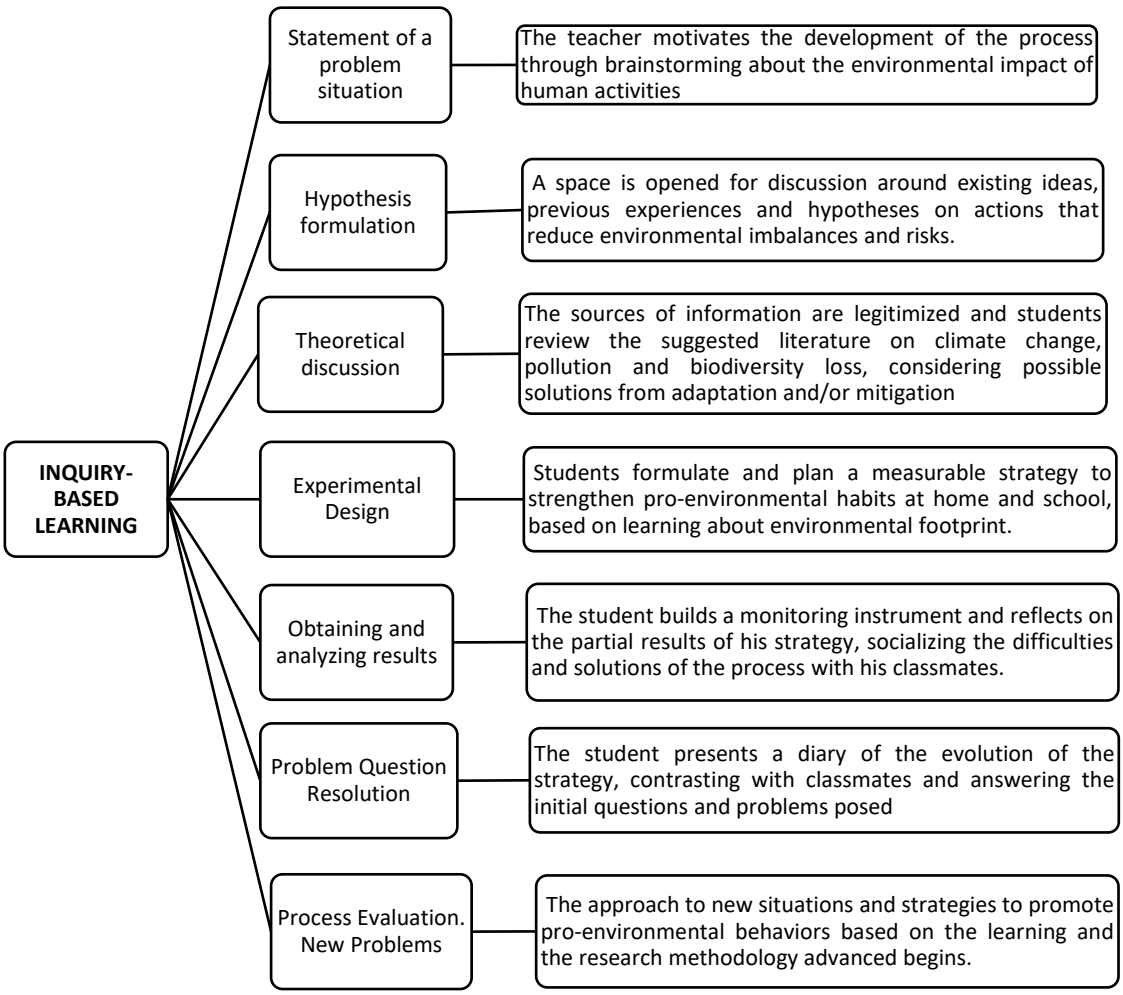

Figure 1. Basic Structure of STLA from Inquiry-Based Learning

The Learning Approaches Questionnaire score can vary from -44 to 44, so those students who are in a range of -44 to -1 would have a superficial learning approach (LeApS); students in a range of 1 to 44 would have a Deep Learning Approach (LeApD); students with a score of 0 would have an Indefinite Learning Approach (LeApI) (Soler-Contreras, 2015). To quantitatively review the effect of the Didactic Strategy on students, an analysis of variance by blocks (Steel & Torrie, 1985) is carried out, which corresponds to the student's Learning Approach

(initial and final), together with qualitative factors such as academic ease (qualitative classification according to students' performance in environmental sciences) and structural aspects, such as the SISBEN (Potential Identification System for Beneficiaries of Social Programs) which constitutes a population classification made by the Colombian State of household conditions, which include: A. Extreme poverty, B. Moderate poverty, C. Vulnerability, and D. No poverty.

On the other hand, the type of knowledge achieved is established qualitatively, based on the rubric of each Intended Learning Outcome, taking into account the level of complexity of the cognitive operation achieved by the student. To this end, participant observation and the teacher's field diary were taken into account, with the description of the process of each student, in addition to the Observable Learning Outcome and the learning diary developed by the young people. It is important to mention that the principal investigator has been working for three years with the students, advancing an active learning processes based on inquiry, which has promoted higher-level cognitive operations on them. By way of conclusion, the theoretical propositions that are established from this research are: 1) to get students who follow the superficial learning approach (LeApS) as a preference (t_0) to use a deep approach at the end (t_f); 2) to ensure that the type of knowledge achieved by students is, for the most part, of greater complexity in the SOLO taxonomy.

Results

Pro-environmental Behaviors of Students

The analysis of pro-environmental behaviors is based on the model developed by Steg et al. (2014), which encompasses most of the advances to predict the actions of the subjects. The model describes three essential elements that allow or prevent pro-environmental actions: values, goals, and situational cues. The latter generate actions according to the weight that the person gives to them at a specific time. In this sense, three types of goals are described:

a. Hedonic goals: endorsed by the hedonic values (emotional dimension) of the Pro-environmental behaviors. It's what makes you feel good.
b. Gain goals: This is based on selfish values (cognitive dimension) and developed by the Theory of Planned Behavior (TPB). In this case, the subject rationally analyzes the costs and benefits of acting.
c. Normative goals: based on altruistic and biospheric values (social dimension), developed by the Norm Activation Model (NAM) and the Value-Belief-Norm (VBN) theory, which uses the New Ecological Paradigm questionnaire to define the subject's values. In these models, the norm is understood as acting appropriately. The norm can be inductive, when others expect positive attitudes from the subject, that is, they are considered correct by society. The descriptive norm is defined as what the majority does and involves a social representation.

Based on the model of Steg et al. (2014), and the broad theoretical and empirical development of Pro-Environmental Behavior, the results of the implementation of the Didactic Strategy based on inquiry can be interpreted, which, being focused on actions, generates visible results on such behavior (Farrukh et al., 2023; Kollmuss & Agyeman, 2002; Medina & Páramo, 2014; Páramo, 2017b; Sánchez Flores et al., 2024; Steg & Vlek,

2009). To begin with, a significant difference was found between the 33 pro-environmental actions the students classified based on ease, frequency, and favorability (Figure 2). It is worth mentioning that the didactic strategy generated significant differences in ease, while frequency had significant changes only in the easiest actions to do (above average), and favorability did not present significant modifications once the strategy was implemented.

#	SENTENCES
15	Turn off the water while I brush my teeth.
1	I unplug my cell phone charger and unused appliances.
2	I throw the garbage in the trash cans.
10	I reuse the plastic bags I get from the supermarket.
11	I turn off the tap while I soap up.
6	I turn off the lights in empty rooms.
22	I usually print or write on both sides of a sheet of paper.
21	I walk to nearby places.
5	I reuse containers for storage or other purposes.
29	I wash the windows and floors using water from buckets.
31	I pick up trash that other people throw on the floor.
4	Classify and separate the waste produced in my house.
26	I consume local products.
25	I avoid using glasses, plates, and cutlery made from single-use plastics.
16	I buy products with returnable packaging.
30	I classify and separate waste in my school.
17	I only buy the needed products, even if I find them on sale.
18	I wash dairy and dairy product containers to facilitate recycling.
14	I use a bicycle
7	I reduce the time in the shower.
33	I defend the environmental rights of my community.
19	I deposit batteries and electronic devices in the appropriate containers.
12	I watch TV shows or videos on social media related to environmental protection.
32	I compost with organic waste.
8	I reuse the washing water.
9	I buy products that do not pollute.
23	When buying products I check that their materials are natural or ecological.
24	I wash and iron clothes once a week.
29	I talk about environmental issues with my family and friends.
13	I buy products that are not packaged.
3	I avoid the use of private vehicles.
27	I am actively involved in an environmental group.
28	I avoid eating meat frequently.

Figure 2. Comparison of the Average Value of the Initial and Final Pro-environmental Behavior (ease, frequency, and favorability)

The four actions that decreased their ease and frequency are strongly related to the socio-affective dimension of young people (actions 29, 13, 27, 28), because the lack of confidence in mastering the subject can increase their emotion of shame when trying to perform them. Another reason for not considering certain pro-environmental behaviors relates to sacrificing comfort (actions 2 and 31). Likewise, the decrease in the favorability of nine actions implies fewer articulations between the daily life of the students and what they worked on at school. On the other hand, the actions that strongly increased their ease, frequency, or favorability are related to the reading of labeling and avoiding the use of packaging. On the other hand, the POSAC analysis reveals that action 28 (avoiding meat consumption) is considered by all students as the most difficult to perform, since in this geographical region the diet is based on the consumption of beef. Similarly, action 27 (participating in an ecological group) is considered difficult to carry out, probably because of the socio-emotional burden involved in relating to people who are not part of their close social group.

The easiest actions are associated with those promoted by the media, while the least carried out are the most difficult to do, as is the case with composting. Regarding favorability, the least favorable would be those that students do not initially relate to their positive effect on the environment, such as buying products without

packaging. After the strategy is implemented, the favorability of these actions does not improve as expected, but their ease and frequency does improve (with the exception of item 28), which implies that not cognitively relating the actions to the environment does not imply that they do not relate them to positive effects in their daily lives. This could be due to the difficulty that young people with a LeApS have in relating the effects of their behaviors over time. The possible disadvantage of not relating the action to cognitive and socio-environmental aspects has to do with the difficulty of maintaining pro-environmental behavior in the future.

Analysis of the Initial and Final Learning Approach (LeAp) of the Students

The results of the Learning Approaches Questionnaire show that the Deep Approach is preferential for the 108 secondary school students surveyed (51.9%), which is maintained after the strategy is implemented (48.1%). It is worth mentioning that this research analyzes the use of didactic strategies based on inquiry, with which the development of higher-level cognitive operations is promoted, being consistent with theoretical development and empirical research that support the use of active pedagogy. The normal distribution curve in the students' LeAp (Figure 3) denotes its variation among the subjects, that is, it highlights the natural difference that exists between young people both in their way of understanding and in the way they approach the learning process (Wang et al., 2013).

The didactic strategy encourages subjects to carry out collective actions in their own context, which allow the development of critical and systemic thinking, as well as participation, collaboration, and the development of values (Biggs et al., 2019; Biggs & Tang, 2011; Guimarães-Sobrinho & Andrade-dos-Reis, 2022; Hattie et al., 1996; Lopera-Pérez et al., 2021; Medina & Páramo, 2014; Monroe et al., 2019; Onopriienko et al., 2021; Prosser-Bravo & Romo-Medina, 2019; Ripollés and Blesa, 2024; Tian et al., 2024; Wang et al., 2013).

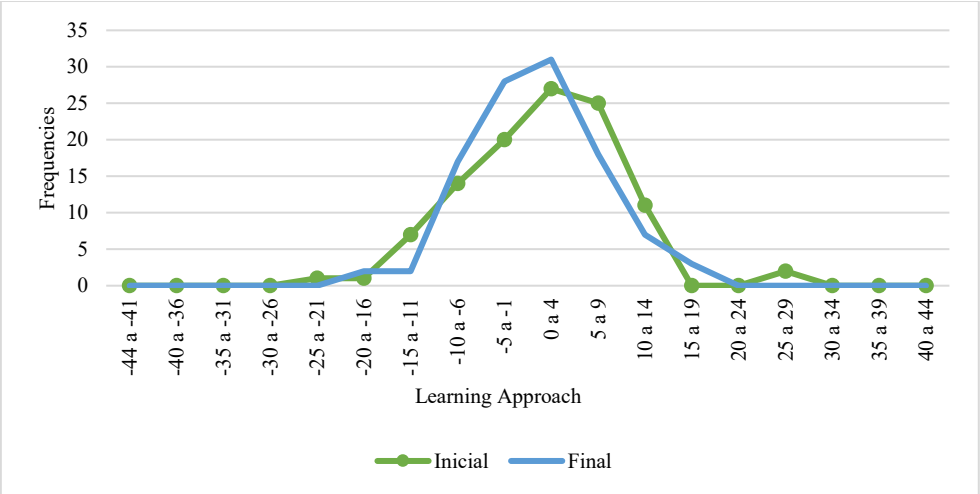

Figure 3. Initial and Final Distribution of the Students' Learning Approach

In general terms, the change in the Learning Approach of the students is positive, once the strategy was implemented, with 18.6% of the population that improved and 56.4% that remained in the Deep Approach. However, there is a quarter of young people who remain in the Superficial LeAp. In both cases there is a significant

effect of the implementation of the strategy on the Learning Approach of the students, as well as differences between the students of each group. The implementation of the didactic strategy based on inquiry has different results in each of the students, who are also in different stages of their growth and development: some are in the prepubertal period, while others are in different phases of adolescence, a period that entails "intense physical, psychological and social changes, which turn the child into an adult" (Hidalgo-Vicario & González-Fierro, 2014, p. 42). As a group, it can be observed that indeed, students with a preferential Superficial Learning Approach (LeApS) have a positive change with the application of the Didactic Strategy based on inquiry, by significantly improving their Learning Approach (46.5%) and reaching the higher levels of the SOLO taxonomy (N3 and N4). The factors that classify young people into groups with significant differences with respect to their Learning Approach are related to academic ease and socioeconomic aspects detailed in the SISBEN. Thus, young people with academic difficulty have an average of -1.41 (LeApS) and those with academic proficiency an average of 2.63 (LeApD), which supports the articulation between the quantitative and qualitative analysis advanced. Students living in rural housing have an average of -0.71 (LeApS), while those in urban housing have an average of 3.09 (LeApD). Here it is important to mention that 76.1% of students with urban housing show academic proficiency. For their part, 56.5% of young people living in rural housing have academic difficulties. Taking into account that the differentiation between the students in each group is significant, a more in-depth analysis is carried out to review its possible effect on the Learning Approach. To this end, the group of students with a preferential LeApD is analyzed (see Table 2), in order to glimpse which of these factors could be related to the deterioration of LeAp in 19.4% of them (32.4% remain in LeApD, compared to an initial 51.9% of students).

Table 2. Changing LeAp in students with preferred Deep Learning Approach.

			Initial LeAp	Final LeAp	Signif Dif*	
					DIS	EST
Academic Ease	Difficulty	Average	5.17	2.94	No	No
		SD	3.03	6.13		
		% Students	16.7%	16.7%		
	Proficiency	Average	7.87	3.11	Yes	Yes
		SD	5.51	7.55		
		% Students	35.2%	35.2%		
Location	Rural	Average	6.56	3.32	Yes	No
		SD	5.32	6.64		
		% Students	23.1%	23.1%		
	Urban	Average	7.35	2.84	Yes	Yes
		SD	4.76	7.50		
		% Students	28.7%	28.7%		

Table 2 shows that students with rural housing do contribute significantly to the reduction of the Learning Approach, and it could be said that they make up a homogeneous group, since there are no significant differences between them. Several of the students who have a better relationship with learning (14.8%) significantly decreased

their intrinsic motivation during the research, probably for reasons associated with adolescent experiences. It is important to mention that qualitative factors such as academic ease and structural factors (location of housing, gender, age, economic situation of the family), do not affect the learning process of students (Biggs et al., 2019; Hattie et al., 1996; Wang et al., 2013). This shows that all subjects are likely to improve their relationship with learning, when it is implemented in an interesting way, regardless of individual factors that are usually related to poor academic performance (Biggs et al., 2019; Biggs & Tang, 2011; Hattie et al., 1996; Kember et al., 2004; Wang et al., 2013).

The majority of students (57.4%) show academic proficiency, that is, they manage to develop the necessary activities when they are urged to do so, without having major inconveniences. Young people with academic difficulties require the support of their peers and teachers to better understand the activities, and they are mostly from rural areas (56.5%) who work in the fields (58.3%) (Table 4). However, most of these young people (55.4%) achieve the higher levels of the SOLO taxonomy, which implies that the inquiry-based didactic strategy promotes the use of higher-level cognitive operations, which is consistent with what has been described in other research (Wang et al., 2013). It is interesting to note that students with better socioeconomic conditions (SISBEN D), although they have academic proficiency (64.7%), are the ones who give up in greater proportion to their hedonic objectives, which is consistent with a higher proportion of students who stay in levels 1 and 2 (52.9%).

This phenomenon is also observed in young people from the urban area of the municipality, who have a significant effect on the decrease in the overall LeAp after the strategy is implemented. It is important to mention that just as there are young people who reduce their LeAp, there are also those who improve it, giving rise to internal variation among students within these two factors, which could explain the results regarding the level SOLO achieved: a proportion of 50.0% of young people with urban housing at higher levels, and 61.3% of students with academic proficiency at these levels. Students from villages (rural locations) with a preferential Deep Learning Approach have a reduction in LeAp, which implies that most of them decreased their intrinsic motivation. The proportion of students who reach higher levels is 50.0%, which is still in line with the expected results with the implementation of the strategy. Students in urban areas have better study habits than their peers in rural areas, due in part to factors related to the type of work and the level of study achieved by parents, which increases the possibility of accompanying their children's academic duties. On the other hand, students in the rural sector mostly present academic difficulties, however, the strategy formulated from inquiry-based learning allows both groups of students to achieve similar results in their learning process.

Analysis of the Level in the SOLO Taxonomy Achieved by Students

The levels achieved by students according to the SOLO taxonomy are articulated to the factors described in the Learning Approach, in addition to the extra-classroom occupation of young people. In this sense, the quantitative analysis of the LeAp is supported by the qualitative examination of the Intended Learning Outcomes (ILO), the student's learning diary and the observations made by the teacher. When analyzing the learning outcomes, it can be observed that the majority of young people reached the Multistructural level (N2) (33.3%), followed by the Expanded Abstract level (N4) (29.6%), the relational level (N3) (20.4%), and a minority remained at the

Unistructural level (N1) (16.7%) (see Table 3).

Table 3. Relative Percentage of Students who Reach Each Level of the SOLO Taxonomy

Factor	Category	1	2	3	4	Total	1 & 2	3 & 4
Initial LeAp	LeApP	19.6%	25.0%	19.6%	35.7%	100.0%	44.6%	55.4%
	LeApI	22.2%	44.4%	33.3%	0.0%	100.0%	66.7%	33.3%
	LeApS	11.6%	41.9%	18.6%	27.9%	100.0%	53.5%	46.5%
Academic Ease	Difficulty	21.7%	43.5%	13.0%	21.7%	100.0%	65.2%	34.8%
	Proficiency	12.9%	25.8%	25.8%	35.5%	100.0%	38.7%	61.3%
Location	Rural	14.5%	35.5%	21.0%	29.0%	100.0%	50.0%	50.0%
	Urban	19.6%	30.4%	19.6%	30.4%	100.0%	50.0%	50.0%
Gender	Female	12.7%	32.7%	20.0%	34.5%	100.0%	45.5%	54.5%
	Male	20.8%	34.0%	20.8%	24.5%	100.0%	54.7%	45.3%
Age (Years)	13	22.7%	27.3%	22.7%	27.3%	100.0%	50.0%	50.0%
	14	14.3%	31.0%	16.7%	38.1%	100.0%	45.2%	54.8%
	15	20.6%	35.3%	26.5%	17.6%	100.0%	55.9%	44.1%
	16	0.0%	50.0%	10.0%	40.0%	100.0%	50.0%	50.0%
Sisben	A	12.1%	30.3%	24.2%	33.3%	100.0%	42.4%	57.6%
	B	23.3%	32.6%	14.0%	30.2%	100.0%	55.8%	44.2%
	C	6.7%	40.0%	26.7%	26.7%	100.0%	46.7%	53.3%
	D	17.6%	35.3%	23.5%	23.5%	100.0%	52.9%	47.1%
Has A Job	No	17.7%	30.2%	21.9%	30.2%	100.0%	47.9%	52.1%
	Yes	8.3%	58.3%	8.3%	25.0%	100.0%	66.7%	33.3%
Academic Activities	No	17.6%	35.3%	16.5%	30.6%	100.0%	52.9%	47.1%
	Yes	13.0%	26.1%	34.8%	26.1%	100.0%	39.1%	60.9%
Artistic Activities	No	16.4%	37.0%	21.9%	24.7%	100.0%	53.4%	46.6%
	Yes	17.1%	25.7%	17.1%	40.0%	100.0%	42.9%	57.1%
Sport Activities	No	13.6%	32.2%	15.3%	39.0%	100.0%	45.8%	54.2%
	Yes	20.4%	34.7%	26.5%	18.4%	100.0%	55.1%	44.9%
Total		16.7%	33.3%	20.4%	29.6%	100.0%	50.0%	50.0%

When observing the distribution of students taking into account their initial Learning Approach and discriminating the level SOLO achieved (see Figure 4), it can be observed that the latter is independent of the former, finding different levels in all the ranges found. Therefore, it is confirmed that the Didactic Strategy motivates students to reach higher levels (3 and 4), regardless of their preferred Learning Approach. The majority of students with a job reached the N2 (58.3%), those in academic activities the N3 (34.8%), those in artistic activities the N4 (40.0%), and athletes the N2 (34.7%) (see Table 3).

The students with the initial Deep Learning Approach mostly reached N4 (35.7%), the young people with the

Superficial Learning Approach mostly reached the N2 (41.9%), while 46.5% reached levels 3 and 4, which implies a success of the strategy. Likewise, students who have difficulties in learning environmental sciences manage to achieve a higher proportion of N2 (43.5%), which implies that, although some find it difficult to reach higher levels, 34.7% achieve it, despite the fact that 4.6% of students have Special Educational Needs. On the other hand, the majority of young people with academic proficiency achieved N4 (35.5%), which demonstrates the success of the didactic strategy (see Table 3). Regarding the location of the home, it can be observed that students in rural locations mostly reach N2 (35.5%), while those in urban locations mostly reach N2 (30.4%) and N4 (30.4%). It is noteworthy that male students mostly reach N2 (34.0%), while female students mostly reach N4 (34.5%).

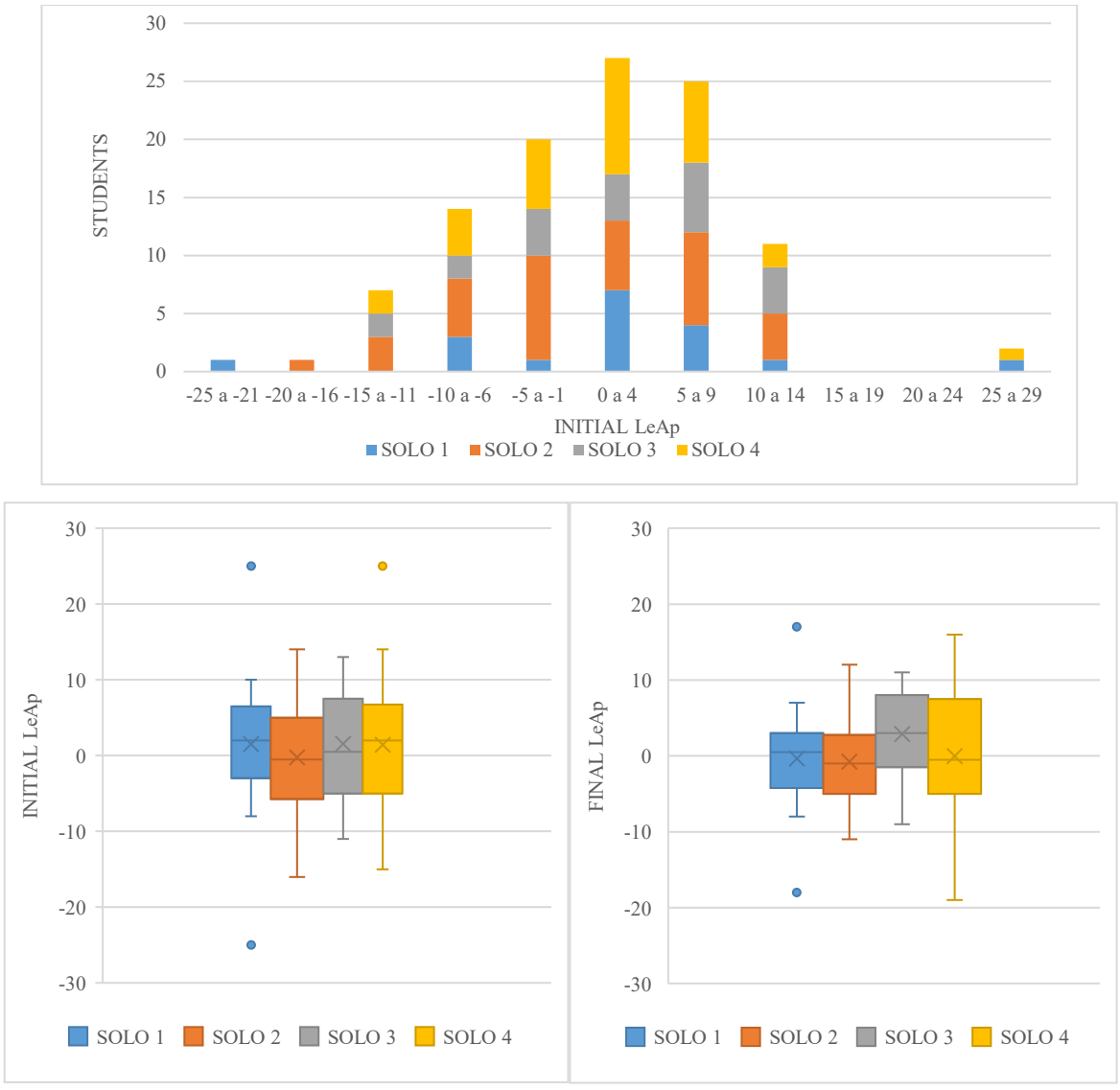

Figure 4. Distribution of the SOLO Level Achieved by Students

13-year-old students do not have a dominant level, but 14-year-olds mostly reach N4 (38.1%), 15-year-olds N2 (35.3%), as well as 16-year-olds (50.0%) (see Table 3). These results can be related to the development of responsibility and autonomy of young people. It is worth noting that 13-year-old adolescents do not seem to be affected by the didactic strategy, while 14-year-olds show affinity with the training proposal, which could imply greater autonomy in their learning process. On the other hand, 15 and 16-year-old students, being repeaters, may

not have a good relationship with the process, which can affect the goal they want to achieve. It is significant to find that half of the 13-year-old students reach the upper levels of the SOLO taxonomy, achieving transitions to Deep LeAp (see Table 4).

Table 4. Percentage of Students according to Age and Differentiated by Each Factor of Analysis

Factor	Category	Age (Years)			
		13	14	15	16
Academic Ease	Difficulty	50.0%	38.1%	44.1%	40.0%
	Proficiency	50.0%	61.9%	55.9%	60.0%
Location	Rural	59.1%	57.1%	61.8%	40.0%
	Urban	40.9%	42.9%	38.2%	60.0%
Solo Level Reached	1	22.7%	14.3%	20.6%	0.0%
	2	27.3%	31.0%	35.3%	50.0%
	3	22.7%	16.7%	26.5%	10.0%
	4	27.3%	38.1%	17.6%	40.0%
	1 and 2	50.0%	45.2%	55.9%	50.0%
	3 and 4	50.0%	54.8%	44.1%	50.0%
Total		100.0%	100.0%	100.0%	100.0%
Initial LeAp	Average	-0.95	1.55	1.15	1.50
	SD	5.61	9.01	8.63	6.93
	%	20.4%	38.9%	31.5%	9.3%
Final LeAp	Average	-1.41	0.67	0.62	1.10
	SD	5.60	8.01	6.54	5.36
	%	20.4%	38.9%	31.5%	9.3%

According to the results obtained, it is highlighted that although there is a lower relative proportion of women (52.7%) than men (62.3%) with academic proficiency, more than half of women are located in higher levels of the SOLO taxonomy (54.5%), compared to 45.3% of men. This misleads some gender-related cultural barriers, particularly the tendency to believe that women are not good at science. Another factor that could affect the performance of students with respect to the SOLO level reached, has to do with the time spent outside the institution, that is, if they work or perform sports as extracurricular activities, both conditions related to a higher proportion of students in lower SOLO levels (66.7% and 55.1% respectively). This result could be related to the lack of time to carry out academic activities at home, or due to loss of interest in their academic training. However, the group that participates in artistic activities has a higher proportion of students at higher levels (57.1%), which contrasts with those students who are engaged in other extracurricular activities and reach lower levels of the SOLO taxonomy.

Finally, the percentage of students who reach the higher SOLO levels (N3 and N4) is 50.0%, while 33.3% reach N2, which demonstrates the success of the didactic strategy based on Inquiry-Based Learning and the importance of using the SOLO taxonomy in the development of clearer evaluation rubrics for participants (Rembach & Dison,

2016). When students recognize the Learning Outcomes to be assessed, they are motivated to achieve the highest SOLO levels (Biggs et al., 2001, 2019; Biggs & Tang, 2011; Hattie et al., 1996; Kember et al., 2004; Rouffet et al., 2023; Wang et al., 2013). It is highlighted that students with LeApS tend to have better learning outcomes, which helps them to be more involved in their learning process, and although young people with LeApD decrease their LeAp due to the psychosocial and biological effects of adolescence, they reach higher cognitive levels thanks to the didactic strategy.

Conclusion

The advantages of the inquiry-based strategy focus on improving teaching and learning processes, achieving that half of the students reach the higher levels of cognitive operations in the SOLO taxonomy (relational and extended abstract) and, therefore, the development of critical and systemic thinking. These results are not affected by the preferential or final Learning Approach, nor by qualitative factors such as the student's academic ease in environmental sciences, nor by structural factors such as housing location, gender, age, and economic conditions of the family nucleus. It is worth mentioning that inquiry improves the relationship of students with the use of cognitive operations of a higher level of complexity, which generates greater satisfaction of young people with their learning processes, which leads to greater academic commitment.

Similarly, in this study, three conditions that affect adolescents' relationship with learning are observed: 1) the physical and psychosocial changes typical of adolescence, which can influence their priorities and decision-making; 2) the end of the school year; and 3) the extracurricular activities they engage in, which can reduce the time available to fulfill academic responsibilities and decrease their interest in studying. Therefore, it is important to strengthen psychosocial development processes during adolescence to encourage decisions aligned with each student's life project.

Finally, it is recommended to further investigate the effects that adolescence can have on young people learning processes, in order to contribute to their educational development. Additionally, conducting similar studies in other countries, contexts, and age groups is essential to identify potential variations in the inquiry model.

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