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Administration and Evaluation of a Mobile Photovoltaic Energy Classroom as a Pedagogical Strategy for the Social Appropriation of Knowledge and Energy Transition

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Abstract — THIS project seeks to contribute to educational quality by generating appropriate conditions for meaningful learning through pedagogical, community, research, and technological activities. It contributes to innovation in learning environments and sustainable development through the implementation of a mobile photovoltaic classroom as a pedagogical strategy for teaching and learning, contributing to the energy transition from school to school.

Thus, it is based on the appropriation of theoretical and practical knowledge based on learning environments, mobile classrooms, renewable energy, energy sustainability, and meaningful learning.

Therefore, it follows a mixed approach, through the interrelation of quantitative and qualitative variables that intervene at different stages of the proposal's development; this approach is framed within the positivist paradigm. Applied research is defined by Murillo (2008) as "practical or empirical research."

As a result, the mobile classroom becomes a meaningful and community-based learning space, leveraging clean energy management and, consequently, improving the quality of life. This supports the goals of sustainable development and educational innovation in rural and urban contexts.

Key Words mobile classroom, learning environments, meaningful learning, renewable energy, energy sustainability

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Introduction

Research is fundamental in the teaching-learning process, especially for initial teacher training programs and in university teaching, since it offers the educational community the possibility of contributing new knowledge from the awakening of curiosity and the desire to understand realities based on the relationships that human beings establish with others. Therefore, the research process proposes effective solution strategies in the educational context that become another way of learning from experience, breaking academic stereotypes such as: believing that research is only of a scientific nature,

that it implicitly resorts to complex processes, limited to certain specialized actors by the belief that the researcher is the only possessor of the truth (Gajar, 2024).

This project is a vehicle that adapts competencies of the research process with technological resources in the teaching of photovoltaic energy to the educational community and the community in general. The mobile photovoltaic energy classroom is a pedagogical strategy that allows educational institutions to be linked to the energy transition process, expanding knowledge in renewable energies, from the local resources of the communities, likewise, in the teaching-learning dynamics it becomes the space where theory is combined with practice in the instruction on renewable energies; This strategy allows the appropriation of the knowledge imparted to students, generating a direct interaction that strengthens the social appropriation of knowledge, since it provides the opportunity to; Identify the process of the transformation of photovoltaic solar energy, make connections, take measurements and carry out tests to train from active-participatory learning through practice. Additionally, through modules and booklets, the theoretical knowledge taught is built, acquiring knowledge and experiences about clean energies and the energy transition.

The energy transition shows the importance and potential of renewable energies (such as photovoltaic energy) to reduce pollution, reduce economic costs and cover energy needs, in a context of sustainable development and environmental protection. On the other hand, the structural conversion to clean energies implies that educational institutions include the chair of environmental education in the curriculum, which provides significant knowledge by promoting changes in the practices and thoughts of communities, aligned with the principles of energy sustainability. Implicitly, the mobile photovoltaic energy classroom requires teacher and community training processes on technological skills of clean and renewable energies, promoting leadership and social transformation from education (Esteban et al., 2020).

Thus, this project becomes an opportunity to develop a formative research process, where the social appropriation of knowledge is made visible, based on local needs and resources, promoting the conservation of the environment and the use of clean energies in social, community and educational contexts. In the same way, the application of these technologies from the mobile classroom favors the design of active learning environments, this challenge entails, indisputably, the strengthening of pedagogical, labor and research competencies and the generation of an environmental culture, promoting reflective and critical thinking processes based on real problems within the educational environment and in the community. through the strengthening of personal competencies characterized by a variety of knowledge, in social, academic, economic and cultural fields.

This project seeks to contribute to educational quality by generating the right conditions for the construction of meaningful learning, inclusion processes and improvement of school coexistence for young people through activities; pedagogical, community, research and technological, contributing to innovation in learning environments and sustainable development through the implementation of a mobile photovoltaic energy classroom, as a pedagogical strategy for the inclusion and coexistence of

students from the first to the fourth semester in the programs of Industrial Electricity Technology and the Bachelor's Degree in Basic Primary Education of the Faculty of Distance Studies of the Duitama-UPTC section. Likewise, as a general objective, it is proposed to implement the mobile classroom, as a strategy in the social appropriation of knowledge and as an active learning environment in the Duitama section of the UPTC.

In this sense, it is necessary to identify the research competencies in the environment of the teaching-learning process of UPTC technology teachers, evidenced in the reading of contexts through pedagogical practices, which as a central axis establishes as a starting point, the lack of an active learning space for the study and application of renewable energies (Ballesteros and Gallego 2019). The virtual classroom as a pedagogical element inserted into the research in the teaching-learning process of UPTC technologies, is based on the appropriation of theoretical-practical knowledge, whose process is located in controlled learning environments, and whose topics focus on renewable energies and energy sustainability, in a framework of significant learning. inclusion and school coexistence.

Among the key concepts associated with the research, the educational concept and the actors that are part of its effectiveness were evidenced as relevant. The first of these concerns society, which includes contexts and daily life, including the institutions in charge of designing and executing strategies conducive to teaching-learning. The second (the actors) referred to teachers and students. The teacher is seen as a facilitator of learning, who must present personal competencies such as suitability, ethics and a set of positive attitudes and aptitudes towards students, since he is the one who directs the formative and integral processes in education. On the other hand, students as the main agents in this process and last but not least parents who are the primary trainers in norms, attitudes and responsible for preparing them for life in society. (Unknown, 2014,2022).

The Greeks affirmed that life was summarized in two (work and rest). The purpose of work was survival and rest was aligned with the enjoyment that pursued the free knowledge of the individual that fed the soul (etece 2021). According to Astete (2017), knowledge is taught in school, becoming a kind of cultural field, a place where instruction is given to replicate and perpetuate inequality and lack of opportunities (Romero, 2018). On the contrary, Crespo (2021) determined that school is a technology, governed by the concept of "pan sophia" oriented to universal wisdom which must be shared. The understanding of the above vision aims to transform traditional education, allowing equity for those who access it, as Crespo (2021) states that it is the route to peace. Education began to be structured in school by ages, levels, schedules and clear objectives, going beyond the transmission of information and involving students as participants in their own learning in a gradual way, this being the definition of peace for Zubiria (2018).

For Dewey (1896) cited by Rodriguez (2015), the school must be considered as part of society and the student must be inserted into the educational context with active strategies, since he believed that children have innate skills to inquire, communicate and build knowledge. Dewey (1986) also established that infants should be guided by teachers through experiential education fundamental in the

training process, thus, the school became a system of socialization in which citizenship is built and functional competencies for life are helped, without ignoring its evolution and the need to be constantly evaluated (Vaillant, 2020).

Education in school has presented several challenges, in which the teaching-learning process shows that playful strategies improve students' behavior and relationships, contributing to a peaceful school environment (Desarrollo et al., 2014). Interactive mobile games can foster social-emotional learning (SEL) skills and foster harmonious interactions between students from diverse backgrounds (Colella et al., 2024).

Thus, when reviewing the pedagogical strategy of the Mobile Classroom, its theoretical foundation in social pedagogy with a direct relationship in popular education is evident, this being a system of dynamic ideas which have their basis in actions and in life, not being an inert concept, but a biographical concept, to the extent that this translated look at life allows the subject to conduct himself through it from his " praxis", assumed as a human expression, the result of the transformation of previous behaviors given from actions; raison d'être of popular education as a rediscovery of subjectivity.

Juliao (2014) brings the concept of social pedagogy even closer, mentioning the possibilities of placing it in the field of reflection: His thought is structured on concepts from an anthropological perspective, culturally contextualized, which are the basis of a utopian, critical and radical pedagogy, ethical, of autonomy, conscientizing, dialogic, praxeological, reflexive and of the question. And his pedagogical discourse becomes a strategy for the liberation of human consciousness; that is, more than a cultural and social revolution, a process of cognitive mobility is initiated for the achievement of social equality; all this within the methodological framework of seeing, judging and acting, in a reflective process of creative feedback, and having as a principle individual and collective participation in all processes of transformation. It is a true social pedagogy. (p. 161).

This educational proposal seeks to provide a solution to a problem from the work of education professionals, which, through the articulation of theory, practice and research, identifies and reflects on a need, and from this, an action plan is designed and implemented to minimize or transform it.

Thus, the training of the teacher and the professional in Colombia as leaders is seen in constant relationship in other contexts (not only in the classroom). Educational praxis extends beyond the four walls, allowing the creation of experiential elements important for growth. By investigating and analyzing everyday events, an invented world is built in correspondence with each generation and human group. Praxis enriches people as innovative subjects and creators of their environment. Therefore, the classroom should not be conceived as an immobile place, it should promote meaningful experiences, implementing active didactics and favoring processes of school inclusion and school coexistence that promote the development of communities and networking. This is how Wasserman (2011), former rector of the National University, mentions it.

> Another important reason to have research as a pillar of higher education is the pressing need we have for leaders capable of guiding their respective communities in an intelligent, imaginative and

> enlightened way. The developed world invests enormous capital and efforts in its flagship universities. […] These universities are true social laboratories. They are not like our laboratories in which we "teach" students techniques and procedures (sometimes not even the most modern ones). In these 'social laboratories', students, future leaders of humanity, are learning to explore the limits of what is possible; they are the ones who are going to mark development in the coming decades. We need leaders like these for our development, who help us understand the world and our position in it; Good professionals are not enough for us. (p. 7).

The Mobile Classroom proposal highlights the importance of participating in order to understand the place as a symbolic starting point, inviting them to interpret dreams, illusions and pedagogical postures, opening educational possibilities for students in training and the professional future. A theoretical path is proposed that allows new poetic, real and utopian perspectives, developed in a practical path that links the search for innovative solutions to problems identified by the communities potentiated by didactics, interdisciplinary learning and the processes of inclusion and educational innovation.

For the project, it is necessary to link the pedagogical conceptualization with the environmental and focus on renewable energies, which are conceived as an opportunity to lower the high levels of environmental pollution, lower economic costs and meet the energy needs of the population in urban and rural areas. To corroborate the above, (Broman, 1994; Jennings & Lund, 2001; Islam & Amin, 2012; Ocetkiewicza et al., 2017; Ballesteros-Ballesteros, 2019) state that in order to efficiently implement and take advantage of renewable energy sources, greater public trust, policies, legislation, economic incentives, and education are required to promote the growth, development, and implementation of these technologies.

Therefore, it is imperative to reform public policies to generate a change in the energy consumption of energy generating companies, which strengthens the aforementioned. Islam and Amin (2012) and Kandpal and Broman (2014) allude that in order to achieve a large-scale deployment of renewable energies (RE), training and education must be available, to raise awareness among the world population about the benefits of this technology and the local resources that can be counted.

Educational communities are the agents of change in different populations, which with their management of institutional educational projects must respond to needs, in this case the production of clean energy. For Karatepe et al., (2012) education should not only be provided to students and teachers in primary, secondary and post-secondary institutions, but also to business owners, employees and decision-makers in the field of renewable energies, who are also actors in the process of the country's energy transition, which will benefit the population in general. with the local sustainable and sustainable environment in renewable energy.

On the other hand Gutiérrez (2016)) and Mishra (2016)), affirm that it is important to strengthen research in this type of energy; since it increases knowledge, creates favorable attitudes, changes open behaviors and becomes aware of the need for a change in energy production. Likewise, this

education, as stated by Karabulut et al., (2011), Stone (2011) and Jaber et al., (2017) is a relatively new field in general education, which has occurred in the last decade, emphasizing the importance of teaching RE content in colleges and universities. The lack of knowledge in communities makes it difficult to grasp effective information, but information about the benefits of RDs allows anyone to access and learn about the sources that can be used to obtain energy from local resources (Guven y Sulun, 2017; Ciriminna et al., 2016).

It is therefore that the community in general must broaden the vision of RDs, projecting the short and long-term benefits in the environment since the use of fossil minerals is reduced, which increase environmental deterioration, Aragón et al., (2018) state that it is desirable then that children, young people and professionals, recognize and respond from their role, to the energy needs of the environment.

In the last four decades, especially since the energy crisis of 1970, Kandpal and Garg (1998) state that there is an increase in interest in researching wind, solar photovoltaic, thermal and biomass energies (Bojic, 2004; Niu, He, Desideri, Zhang, Qin, & Wang, 2014). However, Kandpal and Broman (2014) report that not only the public policies of nations in the transition to RD are enough, they must be accompanied by educational, informative, investigative and imaginative programs. Benchikh (2001) considers that these programs should include the recognition of the advantages and disadvantages of different energies. For their part, Chen, Huang and Liu (2013) and DeWaters and Powers (2011) emphasize the need to recognize the right of future generations to find a suitable planet to live on. The former consider it essential to change the anthropocentric approach to modify the behaviors of relationship with the other living beings that accompany us on the planet. However, for Kandpal and Broman (2014), these proposals must be accompanied by educational packages with teaching guides, activities for students, development of prototypes and computer applications. According to these authors, curriculum development in the field of REs must take into account: an educational level, course objectives, active learning methods and assessment activities. Aspects such as: variety and flexibility must be considered; updating of contents, creation of communities for the development of work and cooperative learning, as explained by Chen, Huang and Liu (2013).

In addition, Hasnain (1998) states that in basic education the important thing is demonstration. However, not all the educational materials available for the subject meet high quality criteria (Buckingham, 2008; Kandpal & Broman, 2014) and sometimes there is no clarity regarding concepts related to energy on the part of students and teachers (Trumper, Raviolo, & Shnersch, 2000). Kandpal and Broman (2014) propose: to address scientific bases that explain the behavior of RDs; to promote the interpretation of results in different areas of technology and the environment; reflect on the importance of energy for the sustainability of the planet; stimulating learning by discovery, addressing political and legal issues, and developing attitudes related to a change in lifestyle, values, and behaviors (Chen et al., 2013) since sensitivity to the context must be promoted to facilitate active social participation.

Knowledge of the appropriate use of energy allows us to study the social and environmental impact on the production and consumption of different types of energy, to recognize the importance of

the development and use of alternative energies, and finally to develop critical thinking (Huijts, Molin, & Steg, 2012). These aspects are also framed in three fields proposed by DeWaters and Powers (2011): cognitive, affective, and behavioral. Previous studies suggest a significant difference between knowledge (Trumper et al. 2000) and attitudes towards the efficient use of energy; the use of RD among primary and secondary school students (Karatepe, Neşe Keçebaş, & Yumurtacı, 2012).

The implementation of renewable energies in the Colombian case presents significant experiences, Murcia (2008) speaks of the use of solar energy through the acquisition of panels by universities such as the Industrial University of Santander, the Andes, the National University and the pioneering work of the Gaviotas Center. Another compilation of the use of solar energy was developed by the former Institute of Nuclear Sciences and Alternative Energies in 1996, emphasizing the use of solar energy for the rural sector; this study was updated with the work done by Guerrero and Daníes (2011) where a diagnosis of the photovoltaic solar sector in the Caribbean region was made. Other previous experiences of using these energies are the Jepírachi Wind Farm built by Empresas Públicas de Medellín (epm) in La Guajira, the work with biodigesters carried out by entities such as the Botanical Garden of Bogotá, the San Fernando Wastewater Treatment Plant in Medellín and the La Pradera Sanitary Landfill. Many of the previous reports highlight the geographical advantages that Colombia has for the development of alternative energies, but they coincide, as is the case of Isaac, González and Biechl (2008) and Marín, Castro and Arroyave (2011) in the lack of infrastructure and regulations.

Likewise, the search for background information on solar panels has shown significant and promising growth. Solar PV, in particular, is gaining traction due to the declining costs of solar modules and their scalability, from residential installations to large-scale solar farms. In addition, economic feasibility studies have been carried out on the implementation of these panels in office buildings in Colombia, considering the environmental benefits and tax incentives offered by the state; These developments reflect the potential and growing interest in solar energy as a sustainable and economically viable source in the country. In Boyacá and Duitama, studies and projects related to solar panels have made significant progress. For example, in Boyacá, an Environmental Impact Study was carried out for a photovoltaic solar energy project, where environmental impacts were identified and an environmental management plan was formulated. This study is crucial to ensure that solar energy projects are sustainable and respectful of the local environment.

Likewise, in Duitama, the Rafael Reyes educational institution has implemented the first laboratory of photovoltaic solar systems in the country. This laboratory is a historic milestone and represents an important step towards the energy transition with clean energy in the region. In addition, the Rafael Reyes Industrial Technical School has become a pioneer in teaching photovoltaic solar systems to students, which is essential for the development of technical capacities in renewable energies. These efforts reflect the region's commitment to innovation and energy sustainability, and highlight the potential of solar panels in the department of Boyacá and the city of Duitama.

In this sense, renewable energy education requires a training process that responds to the demands of the context, an aspect that demands a student-centered organization of the educational teaching process, developed in an interactive and collaborative way and that allows lifelong learning to be acquired (Capote et al., 2016), with the aim of comprehensively educating students who respond to the needs of the twenty-first century, an education in RE is proposed from a Science, Technology and Society (STS) approach, in which topics are addressed from an interdisciplinary perspective, in the context of energy development, both rural and urban, in order to promote scientific and technological literacy so that people can make democratic and responsible decisions on issues controversial issues related to quality of life (Acevedo, 1997).

Methodology

This project is a mixed approach, due to the interrelation of quantitative and qualitative variables that intervene in the different moments of the development of the proposal, which is why Hernández, Fernández and Baptista (2003) mention that mixed designs: (...) represent the highest degree of integration or combination between qualitative and quantitative approaches. Both are intermingled or combined throughout the research process, or, at least, in most of its stages (...) it adds complexity to the study design; but it contemplates all the advantages of each of the approaches. (p. 21).

For the above, this work is structured in the positivist paradigm since it has the following moments: the first has to do with the construction of the object of study, understanding the hypothetical formulation of the problem addressed; the second, related to the methodological design of the research, supported by the choice of data collection techniques that provide the possibilities of measurement, verification and comparability, including instruments for the standardization and verification of the data, and the third, the discussion and presentation of results that account for the scope of the measurement exercise (Martínez, 2013).

On the other hand, it is necessary to mention the importance of the use of the research project in the context of the student community and its transcendence, therefore, it is framed in the applied research defined by Murillo (2008), as "practical or empirical research", which is characterized by seeking the application or use of the knowledge acquired, while acquiring others, after implementing and systematizing the practice based on rigorous, organized and systematic investigation of reality. The data collection instruments were; the observation, survey and interview of both the actors in the process and the possible allies of the process. The instruments were designed by the authors and validated qualitatively by expert judges through a validation grid.

The sample corresponded to 100 students from the Duitama Faculty of Distance Studies of FESAD. The inclusion criteria corresponded to students of industrial electricity technology and the FESAD Sectional (Duitama) bachelor's degree in primary basic education, who were currently studying one of the two academic programs mentioned.

The phases carried out in this process were: a bibliographic and infographic review for the preparation of the introduction, the realization of a diagnosis and the characterization of the context

through the documentary consultation at the UPTC specifically at the Duitama headquarters; subsequently, the choice and design of the instruments and their subsequent application and collection of information were made, finally the data analysis and elaboration of research conclusions were made

Results

Table 1 shows that the highest percentage of students surveyed corresponds to those in the ninth and tenth grades with 26% and 32% respectively.

Board 1 Grade Distribution of Student Respondents

Grado	Porcentaje	Número de estudiantes
Octavo	18%	18
Noveno	26%	26
Décimo	32%	32
Undécimo	21%	21
Inferiores	3%	3

Note. Own elaboration

Table 2 shows that the percentage of knowledge level corresponds to the intermediate level with 58%

Table 2 Knowledge about Renewable and Non-Renewable Energies

Nivel de Conocimiento	Porcentaje
Bajo	35%
Intermedio	58%
Alto	7%

Note. Own elaboration

Table 3 shows that the percentage of knowledge level corresponds to the intermediate level with 58%

Table 3 Knowledge about technological devices with renewable energy

Ítem	Frecuencia
Desconocimiento / Intermedio	72%
Conocimiento claro	28%

Note. Own elaboration

Table 4 shows that the percentage of knowledge about affectation corresponds below or none with 55%

Table 4 Knowledge about technological devices with renewable energy

Frecuencia	Porcentaje
Alta	10%
Media	35%
Baja o ninguna	55%

Note. Own elaboration

Table 5 shows that the percentage of assessment of weak or medium disposition on disposition corresponds to medium or weak with 75%

Table 5 Assessment and disposition to efficient use of energy

Fuerte disposición	25% (estimado
Disposición media o débil:	75% (estimado)

Note. Own elaboration

Energy training: Educational, informative or investigative?

Most frequent answer: Combined (educational, informative, investigative) with distinction by school level.

The diagnosis and context development phase was carried out through interviews with students and documentary analysis of the UPTC. The active participation of the students of the two academic programs was fundamental in the research process, determining a minimum of knowledge about photovoltaic energy, identifying the weaknesses in the development of the prototypes and through training (workshops) on renewable energy, the reduction of the knowledge gap was achieved.

In this stage, the minimum contents that will be part of the training and education program for the students of the schools are established; in addition to the design, a course in training of trainers in the field of energy sustainability. This course was designed for students of industrial electricity technology and undergraduate students in basic education who will act as facilitators and/or trainers in the educational units. The course will consist of practical modules of the different teaching prototypes of renewable energy at scale, seeking in this way that the community develops the social appropriation of knowledge, uses the local resources of each community, integrates and includes all members of the community to understand about the good use of clean energies, encouraging the energy transition that the government's policies seek.

Prior to the execution of the project, students must carry out a period of training or reinforcement of skills. The first section is related to energy sustainability, where related aspects, basic concepts associated with types of energy, usable local resources, energy units, energy efficiency, and applications of knowledge about clean energies for everyday life are taught.

Among the results are established that in the training and education of the communities can be created (energy communities), which strengthens the transition in clean energies, motivating students of different levels on the importance of using the resources that are at hand for the generation of non-fossil energies. (Othman y Sopian, 1999; Karatepe et al., 2012; Kandpal y Broman, 2014; Guven y Sulun, 2017) state that therefore, in order to provide the entire population with functional knowledge and understanding of facts, concepts, principles and technologies for the use of renewable energy sources.

Likewise, other results arise from the application of the following interview script carried out to the sample:

What renewable and non-renewable energies do you know?

When reviewing the responses, there is a recognition of the main renewable and non-renewable energies, and there is a tendency to mention solar, wind and hydro energy as the main ones.

Do you think that citizen culture should be modified in relation to the use of renewable and non-renewable energies?

Most of the responses recognize the appropriate behavior regarding the use of energy; however, the reasons given are far from the recognition of ethical, theoretical, and anthropocentric factors considered, according to the background, the basis of the problem.

Should classroom training processes on the topic of renewable energies be: educational, informative or investigative?

In the answers there is a tendency to address the three aspects and as shown by the background, it is suggested to make a distinction in the school according to the degree of

Complexity. To recognize the perceptions of the students, 100 students were consulted: 32% in tenth grade, 26% in ninth, 21% in eleventh, 18% in eighth grade, and the rest in lower grades.

How much do you know about the principles and existence of renewable and non-renewable energies? According to the responses, the distribution of data shows that knowledge is at an intermediate level, and that few students, 7%, claim to have sufficient knowledge of the subject.

What knowledge do you have of technological devices in rural or urban environments where some of the following energies are used: wind, hydro, solar? The distribution of the answers obtained shows that less than the average of the students consulted have concrete knowledge about the options for the use of renewable energies in urban and rural contexts. 72% are located between a complete lack of knowledge of the subject and intermediate knowledge.

What is the frequency of conversations with family and friends, in and out of school, that relate to the history and use of renewable and non-renewable energy? According to the data obtained, there is a central trend equivalent to 35% where students claim to address with a medium frequency, extracurricular conversation related to the use of renewable energies. This shows that even though it is low, there is an insertion of the issue in everyday culture.

How much do you value and are willing to do about the efficient use of renewable and non-renewable energies available? In this answer, the data are not completely polarized and not all students are convinced of making efficient use of energy. This response is a special case because in the background there are analyses in which people, even if they are unaware of the subject, express their willingness to undertake

Actions that improve the conditions of the planet, unlike the population surveyed that apparently is not yet aware of the issue and the environmental impact generated by apathetic attitudes towards the environment. This reaffirms the need to incorporate the issue critically from school.

How do you rate your knowledge of artifacts that use renewable energies, such as wind, hydro, solar? The answers demonstrate a basic knowledge of appliances that use renewable energy sources for their operation. One cause of this behavior has to do with the students' urban environment, where education in this type of energy makes it possible to develop an awareness among students about the nature and cause of the current energy crisis (such as the increase in scarcity and prices of fossil fuels, concerns about climate change, etc.). etc.).

Thus, by making students aware of the various types of renewable and non-renewable energy sources, the potential of their resources and the existing technologies to take advantage of them, functional values and attitudes are also developed in students towards the use of energy sources and also allow them to appreciate the socio-cultural, economic, and cultural dimensions. political, environmental and institutional related to their development and use.

The mobile classroom then becomes a dynamic, active space; where interdisciplinary learning in turn favors the knowledge of the different areas of knowledge, enabling the exchange of ancestral knowledge, critical tradition, meaningful, collaborative and community learning. To allow students to suggest alternative strategies to solve the energy crisis in the future, to address and solve real problems related to energy, the need to conserve energy and to use renewable energy sources.

Taking into account the positive impacts it brings to the environment, this research is important to know the effectiveness of technology in the municipality, not only to solve the current problem, but as a starting point or prior knowledge for a future energy transition from conventional sources to renewable sources, since, due to the environmental crisis of climate change and the deterioration of natural resources, The need to make a change in the energy matrix is undeniable.

In the same way, for the purposes of the proposal, students assume a planning according to the learning environment that allows them to observe the results resulting from the didactic application of the learning environment together with the observations that emanate in the course of their practice.

In conclusion, the mobile classroom as a pedagogical strategy becomes a significant experience of educational innovation, of popular education that contributes to the training of teachers and professionals with a critical sense, capable of reading their context collectively with the communities and building, also in an associated way, some simple, understandable alternative solutions to complex problems such as those in the populations under study. in the use of clean energy management and therefore the improvement of the quality of life. This favors the objectives of sustainable development in rural and urban contexts.

This is how this project has an impact Rumbayan et al., (2025), who determine benefits in the following terms with the application of the photovoltaic mobile classroom:

Transformation of the Mobile Classroom into a community learning space The mobile classroom was consolidated as an environment that promoted meaningful and participatory learning, generating positive impacts on the quality of school and community life. Values such as solidarity, cooperation and inclusion in rural and urban environments were strengthened.

Active participation in the construction of knowledge, students were actively involved in collaborative learning processes, developing personal and group skills that allowed them to appropriate knowledge about renewable energies.

Improvement in school coexistence through academic and practical activities, it was possible to improve communication and interpersonal relationships between students, favoring the peaceful resolution of conflicts and respect for differences.

Strengthening environmental thinking. Greater awareness was generated about the importance of caring for the environment. The mobile classroom was used as a stage for problem solving and the development of projects with an ecological approach, focused on photovoltaic energy.

Reflection on school curricula. The activities made it possible to identify curricular gaps in sustainability, which generated proposals for the inclusion of environmental and energy content in the curricula of the participating institutions.

Training for educational institutions and social actors. Training processes were carried out for teachers, students and community actors that encouraged the use of clean technologies, promoting critical thinking and paradigm shifts in the face of sustainable development.

Diagnosis of technological lag in rural areas The project made visible the backwardness in infrastructure and access to technologies in rural communities, which strengthened the call for more inclusive and sustainable public policies.

Promotion of energy communities. Based on the experience of the mobile classroom, local initiatives were promoted for the formation of school energy communities, aimed at energy self-management through clean sources.

Effective educational inclusion. It was possible to integrate students with different social, cultural and academic characteristics, developing personal skills and strengthening their training process within an environment of respect and equity.

Overcoming school conflicts. School coexistence was addressed as a transversal axis of the project, and the mobile classroom provided spaces for dialogue, recognition of the other and the collective construction of agreements and solutions.

At the conclusion of this stage of diagnosis and characterization, the results of the application of information collection techniques such as observation, survey and interview with both the actors of the process and the possible allies of the process were systematized. The little knowledge of the communities about clean energy, the lack of training for teachers of educational institutions on clean energy and energy transition was evident.

Likewise, a problem tree was developed where among the possible direct causes, the insufficient knowledge about the territorial capacities that allow the identification and use of renewable energy systems at the local level, for the energy transformation of Duitama, as well as the low innovation and implementation of technological solutions that incorporate renewable energy systems to generate added value in the production chains small-scale mining and industrial at the local level.

Next, the indirect causes were established as the limited development of energy analysis and planning tools at the territorial and sectoral level, the low execution of pilot projects for the implementation of sustainable energy solutions in local production chains, insufficient collaboration between local communities, researchers, the business sector and government entities for the exchange of knowledge and the co-creation of projects Energy.

In addition, the following were established as direct effects: the lack of development of local tools for the planning and implementation of efficient renewable energy projects for the energy transition, the reduced technical and administrative capacities for the development and management of renewable and efficient generation projects in energy communities, and as an indirect effect, the weakness in formulating territorial public policy guidelines. which makes it difficult to ensure the energy transition, as well as low research and technology transfer capacities, which hinders the energy transition in the territories, low environmental sustainability due to CO2 emissions generated by energy consumption in production processes, which deteriorates air quality and negatively affects public health and the limited adoption of

The implementation of the Photovoltaic Energy Mobile Classroom in educational institutions in Duitama evidenced its potential as a comprehensive pedagogical strategy to strengthen the social appropriation of knowledge, educational inclusion and school coexistence.

In terms of social appropriation of knowledge, it was observed that the students managed to integrate technical concepts related to renewable energies from practical experiences, promoting a contextualized understanding of the use of solar energy. Active participation in the installation, manipulation and analysis of photovoltaic devices allowed them to connect scientific knowledge with real problems in their environment, especially in relation to the efficient use of energy resources and environmental sustainability.

Regarding educational inclusion, the mobile classroom generated accessible and dynamic learning spaces in which students from different academic levels, rural areas and diverse social contexts were integrated. This strategy reduced traditional barriers to participation and promoted equity in access to meaningful science and technology training experiences. In addition, it encouraged the development of soft skills such as cooperation, communication, and critical thinking.

The project has generated a diversity of thoughts in which the lack of preparation of the communities in the use of new technologies and their application in their geographical environments is emphasized. It should also be mentioned that educational institutions must change curricula that implement significant learning in the environmental field, in the field of renewable energies and practice that respond to energy deficiencies.

Taking into account that communities have the necessary resources to meet energy needs through the training of public and private educational and productive entities that generate a change in thinking and praxis in their own areas of coexistence.

Likewise, there was evidence of the backwardness in infrastructure, technology due to the lack of public policy and follow-up on projects that generate social growth and conservation of resources for the benefit and growth of the population.

The training and education of communities can create and develop energy communities where the energy transition can be strengthened, motivating students at different levels about the importance of using the different resources that are available for the generation of clean energy.

Discussion

The results obtained allow us to recognize that the Photovoltaic Energy Mobile Classroom has transcended its technical function as an educational device, becoming a means to strengthen contextualized learning processes, appropriation of knowledge and social transformation in urban and rural educational contexts (Rumbayan et al., 2025).

One of the most relevant findings was the intermediate awareness of renewable energies, showing that although there is a basic recognition of sources such as solar, wind and hydro, there is still a gap in the in-depth knowledge of their applications and technological artifacts. This situation reflects

the urgent need to systematically integrate renewable energy content into the school curriculum, through active and meaningful methodologies such as those proposed by the mobile classroom.

Likewise, the analysis shows that energy training processes must combine educational, informative and research components, differentiating their depth according to the school level. This integration favors the development of critical thinking and informed citizen participation in energy and environmental decisions.

Another noteworthy aspect was the limited frequency of conversation about renewable energies in family and social contexts, which highlights the weak insertion of the topic in everyday culture. In this sense, the Mobile Classroom not only provides knowledge, but also activates intergenerational and community dialogues around sustainability, strengthening the social appropriation of knowledge.

In relation to inclusion and coexistence, the mobile classroom provided spaces for collaborative interaction that promoted the active participation of all students, regardless of their academic or social conditions. The joint practice of problem solving, use of technologies and environmental care made it possible to build bonds of trust and strengthen interpersonal relationships in the school environment.

Finally, the experience shows that the project contributes to the transition towards a more critical, interdisciplinary education with a territorial approach, which responds to the energy realities of rural communities, still lagging behind due to a lack of public policies and technological infrastructure.

Key Takeaways

General knowledge about renewable energy is intermediate, but there is little practical recognition of technologies that employ them.

There is little conversation about the topic outside the classroom.

The willingness to act for the efficient use of energy is not yet well established.

Training must be differentiated according to school level, including informative, educational and research aspects.

The need to include the issue in a critical and transversal way in basic and secondary education is evident.

Reference

Cano Pina, José. Solar thermal energy. Spain: Cano Pina, 2021. Digitalia, https://www-digitaliapublishing-com.biblio.uptc.edu.co/a/103148

Ballesteros, V. y Gallego, A. (2019). Model of Education in Renewable Energies from the Public Engagement and the Energetic Attitude. Universidad Pedagógica y Tecnológica de Colombia https://repositorio.uptc.edu.co/handle/001/14242

Delgado, J. Peralta, J. Guevara and M. Naranjo, «Application of significant learning for the socialization and systematization of techniques in home energy efficiency,» Conference Gamboa Mora, María Cristina, Yenny

García Sandoval, and Vicky del Rosario Ahumada De La Rosa. Design of teaching-learning environments: Considerations based on NLP and learning styles: Universidad Nacional Abierta y a Distancia - UNAD, 2017. Digitalia, https://www-digitaliapublishing-com.biblio.uptc.edu.co/a/133736

Hernández, R., Fernández, C., & Baptista, P. (2003). Research Methodology (3rd ed.). Mexico: Editorial Mc Graw-Hill.

Interconsulting Bureau.E, (2015). Renewable energy uses. Editions of the U. https://www-ebooks7-24-com.biblio.uptc.edu.co/?il=7922

Juliao, C. (2011). The Praxeological Approach, Faculty of Education. Corporación Universitaria Minuto de Dios: (1st, edition). Bogota:

Martínez, V. (2013). Research paradigms. Multimedia manual for the development of research work. A vision from critical dialectical epistemology. Mexico: Comprehensive Postgraduate Degree in Social Sciences from the University of Sonora. Retrieved from https://pics.unison.mx/wpcontent/uploads/2013/10/7_Paradigmas_de_investigacion_2013.pdf.

Murillo, W. (2008). Scientific research. Retrieved April 18, 2008, from http//www.monografias.com/trabajos15/invest-científica/investcientífica.shtm

Proceedings Laccei International Multi- Conference For Engineering, Education And Technology, Julio 2016.

Challenges for sustainability and social, educational and economic-labor development: Analysis of experiences. Spain: Dykinson, 2022. Digitalia, https://www-digitaliapublishing-com.biblio.uptc.edu.co/a/115945

Ricardo Barreto, Carmen. Virtual Learning Environments: Challenges for Training and Intercultural Dialogue: Universidad del Norte, 2017. Digitalia, https://www-digitaliapublishing-com.biblio.uptc.edu.co/a/54929

Rodríguez Palmero, Mª Luz. The theory of significant learning in the perspective of cognitive psychology. Spain: Octaedro, 2012. Digitalia, https://www-digitaliapublishing-com.biblio.uptc.edu.co/a/14780

VV. AA. Mobile Classroom: Itinerant Experience, Approaches to Popular Education: Corporación Universitaria Minuto de Dios, 2020. Digitalia, https://www-digitaliapublishing-com.biblio.uptc.edu.co/a/131332

VV. AA. Experiences from rurality: Armed conflict, peasant resilience, oral tradition and gender: Corporación Universitaria Minuto de Dios, 2019. Digitalia, https://www-digitaliapublishing-com.biblio.uptc.edu.co/a/131628

UNESCO, "Sustainable Development Begins with Education," Paris, 2014.