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Evaluation of AI-Driven Learning Strategies and Business Innovation for SDG Dissemination in Meta Colombia

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Abstract

The problem encountered is the deficient knowledge about the Sustainable Development Goals (SDG) adopted by the United Nations as part of the 2030 agenda in Mesetas and Lejanías, in Meta, Colombia. The problem was solved by sharing at the local level a learning strategy with Artificial Intelligence (AI) and emerging technologies for sustainable innovation with the participation of undergraduate students levels 10 and 11, small business agricultural entrepreneurs and rural producers from the localities of study, useful for the dissemination of the SDGs in the rural sector of the Ariari in Colombia using as a model a successful sustainable business that obtained inherent results to the evaluation of the effectiveness of techniques for the dissemination of knowledge, attitudes and practices as well as metacognitive strategies and AI at the local level useful for the dissemination of the SDGs in Meta Colombia. The data obtained in the research imply effective support strategies for self-assessment and practice for consolidation of learning about the SDG for rural communities using AI. The findings show that AI-powered systems increase learner motivation, engagement, and knowledge retention while providing scalable solutions for various educational scenarios. Limitations include the scope of the implementation and the necessity for additional quantitative study. The paper continues by identifying areas for further research and practical implementation tactics and establishing significant contribution from AI in rural education about the SDGs.

Keywords: Learner Engagement, Personalized Learning, Sustainable Development Goals (SDG), Artificial Intelligence, Business Innovation

1. Introduction

The problem that is the subject of this paper is the deficient knowledge about the 2030 Agenda and the Sustainable Development Goals (SDG) by part of the inhabitants of the rural areas of the Ariari in Colombia and the need to establish effective mechanisms for their dissemination.

From this framework, the purpose of this study is to make an analysis of mechanisms to disseminate the SDGs in rural communities following a sustainable model that incorporates digital strategies of Artificial Intelligence (AI) emerging technologies for sustainability and business innovation with the participation of students, small entrepreneurs in the tourism sector and rural producers from the municipalities of

Mesetas, in which the Territorial Space for Training and Reincorporation 'Mariana Páez' is located, and Lejanías that stands out for having a viable business for development in these territories.

This study has been structured as follows: the first section describes the background and objectives by reviewing the literature, geographical location, and the relationship of the SDGs and proposes specific strategies for AI emerging technologies and business innovation; the second details the methodology used with the evaluation of the study design, the participants evaluated, and expected results where through interviews and surveys carried out with the participants in the Sustainable Tourism Goal program, and the Colombia sustainable initiative the information of the year 2022 first quarter was collected for the analysis, the work environment, the interventions and the statistical analysis; the third, describes the data, the results, the suggestion, the recommendations and at the end the conclusions are presented, where the models that have been positive for the integration of rural communities around the SDGs are deduced, among other aspects.

The impacts of this project are related to the evaluation of specific effective mechanisms for socialization of the SDGs in rural communities of Ariari using digital AI and business innovation strategies exploring how AI and emerging technologies are transforming rural environments, enhancing decision-making, and fostering sustainable development across various sectors.

2. Background and Objectives

The set of previous studies carried out on the subject incorporates fieldwork and theoretical studies in the Colombian rural sector and leads to references that seek to establish the effectiveness of mechanisms for the dissemination of the SDGs specifically in the municipalities of the department of Meta in Colombia.

The Colombian rural sector and specifically the municipalities of Mesetas and Lejanías, as part of the Development Programs with a Territorial Approach of the Colombian government in the Ariari faces extreme poverty, health care deficiencies, discrimination due to gender inequality, deficient production and irresponsible consumption, low availability of basic water and energy services, climate effects, energy poverty, and constant attacks to the biodiversity. The social, economic and environmental relevance is increasingly important in these areas considering that "... development must meet the needs of the present without compromising the capacity of future generations." (1).

These aspects, which are addressed by some of the Sustainable Development Goals (SDGs) contained in the 2030 Agenda adopted by the United Nations, are considered a global public policy. Despite efforts at the public and private levels, the SDGs have not yet been internalized by high school students, small and medium-sized entrepreneurs, or rural producers in the department of Meta.

This situation arises because the thematic contents of the SDGs is unknown, and in particular those related to the rural sector, which requires a defined strategy for knowledge transfer and socialization at the local level and effective tools that allow the implementation and compliance of public policies defined by the Colombian government incorporated in “Consejo Nacional de Política Económica y Social” CONPES (2).

The location of the project can be seen in Figure 1 that presents the Ariari Subregion with Mesetas and Lejanías, which constitutes an important agricultural pantry for the department of Meta, providing 35% of the country's essential production such as rice, cassava, bananas, fruit trees, livestock and fish farming (3). Both municipalities are known for their stunning natural beauty and adventure tourism opportunities.

Figure 1: Location of the Project in Colombia

Esta región posee gran diversidad biogeográfica, por su posición geográfica que se caracteriza por variabilidad en sus pisos térmicos de flora fauna y riqueza hídrica, por ello se puede encontrar una "cobertura vegetal que corresponde a bosques húmedos

Source: IGAC Agustin Codazzi Geographic institute, DANE Statistics Administrative Department National (4)

This region has great biogeographic diversity by its geographical location that is characterized for variability in its altitude zones, fauna and flora and wealth of water resources. Its identification is as tropical rainforest.

The challenges for this region, that need to consolidate compliance with the Colombian agreement for peace, is seen by effective incorporation of learning strategies related to the SDGs 4 (Quality Education), 7 (Affordable and Clean Energy) and 12 (Responsible Production and Consumption) through the community of students, small entrepreneurs and producers in the rural sector.

The Territorial Space for Training and Reincorporation 'Mariana Páez' located in the municipality of Mesetas and defined by the government of Colombia for the Development Program with a Territorial Approach (PDET) 2021 offers an excellent opportunity for scalability of the results of the study.

The strategy is preparing high school students, small entrepreneurs and leaders of producer organizations through personalized learning AI and emerging technologies for sustainable innovation in aspects of the SDGs that will improve quality of life in the region, achieve social well-being that leads to economic growth without depleting the renewable natural resource base, without deteriorating the environment or

biodiversity ensuring a better future for new generations. Personalized learning meets learners' requirements by tailoring the educational experience to their preferences, abilities, and learning styles (5)
Based on these references, the general objective of the study is to establish the effectiveness of mechanisms to disseminate the SDGs 4, 7 and 12 with analysis (6) carried out on students grade 10 and 11, small businesses entrepreneurs participating in the Colombia Sustainable Goal project (7) (Sustainable Colombia Goal, 2022) (8), and rural producers in the municipalities of Mesetas and Lejanías located in the Ariari Subregion of Colombia, using AI and emerging technologies for sustainable innovation and the benefits of the modern digital society, remote virtual environments, and innovation and sustainability concepts considering as reference a successful sustainable business model (9).
To meet this general objective, the specific objectives are set as follows: Evaluation of learning strategies related to SDGs to high school students grade 10 and 11 of the mentioned municipalities and leaders of the participating producer organizations in aspects of the SDGs; verify techniques to inform, internalize and learn about successful cases of implementation of the SDGs (10) in the region useful to replicate the concept nationally and internationally; apply AI and emerging technologies for sustainable innovation in ventures aimed for disseminating and fulfilling the SDGs.
The measurement contemplates evaluating knowledge, attitudes and practices considering the potential for acceptance of AI powered techniques and business innovation strategies among the participants evaluated in the Colombia Sustainable Project (11), students in grades 10 and 11 of the local educative system and agro-industrial leaders identified as local producers in the region.
These guidelines are based on the research question that is related to the general objective: How can an effective dissemination technique using AI and emerging technologies for the SDGs be carried out among students and entrepreneurs in the PDET municipalities, with emphasis on Mesetas and Lejanías, Ariari Meta Colombia, which serves to define a programmatic route for the execution of successful actions in the rural sector for the fulfillment of the SDG goals towards the year 2030?

3. Methodology

This study used "Aula Viva Tropical" farm located in the town of Lejanías in the department of Meta Colombia as model for sustainable innovation and protection to biodiversity (12) in the region. The study collected data from students, agro-entrepreneurs and the participants evaluated in the Sustainable Colombia project, cataloged as the main articulator of all regional, national and international efforts to make reality to the society the strengthening of an inclusive and harmonious economy with the conservation of natural resources in one of the most biodiverse countries in the world (13).
Aula Viva Tropical farm is an agritourism business located in a rural area belonging to Lejanías Meta in the foothills of Colombia surrounded by exuberant nature, native vegetation and tropical fauna (14). This business is a training center in peasant innovation participating in the Colombian Sustainable Tourism program for tourism entrepreneurs in the Meta department. It is an example of sustainable entrepreneurship with unparalleled characteristics of water resources, solar energy and wind energy where the strategies for mitigation and adaptation to climate change, the enabling of solid and liquid waste, the production of bio-inputs, the agro-industrial process of products of the peasant economy, and responsible consumption for food sovereignty, represent innovation as the foundation of sustainable rural development (15). A business project that is suitable for the promotion and dissemination of the SDGs in this region.

Its owner has also held the position of Secretary of Agriculture of the Government of Meta, supporting this research initiative, ecology and conservation (16).

Photo 1: Participants in the Project. Photo Courtesy "AulaViva Tropical".

For the development of this project, three phases were proposed exploring the effectiveness of the mechanisms for the dissemination of the SDGs: the first phase, sought the evaluation of the students of 10 and 11 level, the entrepreneurs participants in the project Sustainable Colombia, and rural producers of the region through digital transformation techniques using booklets through e-learning techniques and AI powered systems; the second verified the socialization of the SDGs for the organizations of producers in the rural sector and participants in the Sustainable Goal project as multipliers of information with their associates through cases and videos of virtual reality incorporating Artificial Intelligence (AI) systems (17); and the third, highlighted innovative enterprises in the region based on the model for sustainable innovation Aula Viva Tropical to evaluate economic, social and environmental impact, the respective business plans that contributed to the fulfillment of the SDGs and potentiality to multiplying sources of knowledge, promoting accessibility to AI and emerging technologies (18) with models of low energy consumption that generating income for their members. An input and output evaluation were carried out, which made it possible to identify the knowledge acquisition and progress made related to the SDGs valuable to improving people's quality of life. Practical workshops remote and virtual were developed on the e-learning content of the Sustainable Meta Colombia project, promoting accessibility to AI systems (19) for information dissemination based on the "Aula Viva Tropical" business, to recognize the experiences and early victories and thus evaluate the other participants. The video content that led to the obtaining of the certificate of the e-learning platform of Ministry of Trade and Colombia Productiva, as well as the accessibility to AI-powered systems, served as a model to verify the concepts of the SDGs of the participants.

The specific outputs and expected results of the project sought to establish the effectiveness of digital transformation with the use of AI-powered systems (20) for the consolidation of knowledge about SDGs based on the evaluation and verification of learning techniques, as well as the effectiveness of the application of business creativity models in the rural sector leading to relevant metacognitive strategies for the dissemination of SDG 4, 7 and 12 in this area of the Ariari. The specific outputs based on

teaching, research and social projection experiences expected the definition of appropriate strategies and the pertinent results of effectiveness on the application of concepts, techniques and methodologies that promote accessibility to AI systems (21) in processes of effective dissemination of the SDGs.

The methodological approach was oriented towards the effectiveness of the application of AI powered technologies and sustainable business innovation for the dissemination of the SDGs that contributed to filling knowledge gaps about them seeking natural advantage(22). The digital uses that allow new types of innovation and creativity were evaluated from the unit of analysis made up of participants in the Sustainable Goal Colombia project, incorporating students, workers in the rural sector and small entrepreneurs in the region to inquire about the effectiveness of digital tools and business innovation promoting access to structured data and promoting tangible advances based on AI. Given the need to solve the problem of effectiveness in the dissemination of the SDGs through educational articulation with digital transformation, AI and business innovation (23), cases and controls were used to evaluate the knowledge acquisition strategies with e-learning booklets contained in the Sustainable Goal project with AI and emerging technologies, with attitudes about cases contained in videos of virtual reality and with practices on innovation and business creativity based on AI using the AulaViva model (24) for the formulation of business plans focusing on AI in agriculture that highlighted the SDGs.

4. Data, Results and Recommendations

The data collected during the project led to suggestions and applications with the innovative criteria based on elements of judgment, measurements and observations on the participants.

The study sample was drawn from participants actively engaged in the government of Colombia's e-learning and AI-powered program for sustainable management for entrepreneurs, allowing for direct interaction with the research team.

It was established that 100 participants of the program are between 18 and 35 years old, 40% men and 60% women, 60% white and 40% mestizo with a high school education. 40% of students grade 10 and 11 and 60% agribusinessmen.

The study subjects of the Sustainable Colombia program had two interventions, one before applying the methodology and another after verifying what was learned, to evaluate e-learning content using AI powered techniques and verifying videographic cases. The instruments used were online surveys with the surveyMonkey platform with AI powered support that allowed the creation of simple online surveys and the use of free forms. For this evaluation, data taken from surveys carried out on 140 self-employed entrepreneurs participating in the Sustainable Colombia project were reviewed, of which 100 responded for each analysis, as well as national and international literature covering the topic of digital transfer, AI and emerging technologies, and business innovation in sustainability to improve the effectiveness in the dissemination of the SDGs in rural communities were reviewed. The topics covered in the surveys carried out on the participants incorporated policy and sustainability, significant environmental aspects, the environmental footprint, good environmental practices, criteria for selecting alternatives, the implementation of good environmental practices and digital transformation using AI towards sustainability. Surveys were carried out to characterize enterprises with the description of public policies for sustainability, with the baseline on basic knowledge of the subject, with concepts on the environmental footprint, on the carbon footprint and on good sustainable environmental practices, incorporating the criteria for the selection of alternatives, the implementation of good environmental

practices, case monitoring using AI and emerging technologies and the respective transformation towards sustainability with digital transformation and AI. The effectiveness of the study was contemplated: digital e-learning and AI booklets contained in the Sustainable Goal platform to disseminate basic knowledge, storytelling videos from the same platform selected with AI to highlight attitudes, and models of innovation and business entrepreneurship based on Aula Viva as an effective practice to consolidate concepts about the SDGs among participants based on digital transformation and AI (25).

Metacognitive techniques and AI powered applications constituted a great potential for the dissemination of the SDGs (26) in the groups evaluated in terms of the following points: problem-based learning where real challenges related to the SDGs were presented, encouraging critical thinking and ownership of the objectives; self-assessment, including activities that allowed participants to reflect on their knowledge and practices in relation to the SDGs, identifying areas for improvement; promotion of teamwork and open discussion to enrich learning and generate innovative ideas; informative chatbots (27) to answer questions about the SDGs in a personalized and accessible way, including indigenous languages of the region; immersive experiences that transported participants to different scenarios in the Orinoquía showing the impacts of the SDGs and the actions to achieve them; the data analysis with the use of AI with the potential to evaluate large amounts of data and generate useful information to make decisions and design more effective dissemination strategies; digital e-learning platforms of the Sustainable Goal project adapting the content and activities to the needs and previous knowledge of each user using metacognitive techniques and AI algorithms; and games and challenges related to the SDGs that made learning more fun and engaging, using elements of gamification and AI to personalize the experience.

Table 1 below shows the contrast between the pre-test and the post-test for knowledge, attitudes and practices regarding digital strategies and business innovation as mechanisms for disseminating the Sustainable Development Goals in rural communities in the registered study area.

Table 1 - Potential for Acceptance of Digital Strategies AI and Business Innovation Among the Participants Evaluated in the Sustainable Tourism Goal Project for Effectiveness in the Dissemination of the SDGs in Rural Areas

KAP	Pretest		Postest		95% IC	*t*	*p*
	M	DE	M	DE			
Knowledge	53,16	23,49	69,22	31,33	[-23,78, -8,32]	-4,09	0,0001
Attitudes	67,70	10,08	70,45	12,38	[-5,91, 0,40]	-1,74	0,086
Practices	78,10	14,20	80,49	14,14	[-6,34, 1,56]	-1,44	0,23

Note: Proof of t Student. KAP = Knowledge, attitudes and practices; M = Media; DE = Deviation standard; IC = Confidence interval.

Source: (González Pineda, J. 2002) (28)

The research produced results related to the effectiveness of mechanisms to dissemination of SDGs 4, 7 and 12 from metacognitive strategies for acquiring knowledge, attitudes through cases and innovation and entrepreneurship practices using digital transformation AI and emerging technologies (29). The participants were characterized by belonging to the study area, interacting with the Sustainable Development Goal project that sought to strengthen entrepreneurs and businessmen, micro, small and

medium-sized in the department of Meta through knowledge transfer and good practices of sustainability and circular economy.

The e-learning and AI booklets facilitated knowledge acquisition components using the digital platform, metacognitive techniques and AI algorithms. The AI videos with cases of virtual reality provided procedural components promoting access with tangible advances to AI creating immersive experiences that transported participants to different scenarios in the Orinoquía, showing the impacts of the SDGs and the actions to achieve them and worked together with community leaders, local organizations and experts in environmental and social issues to ensure the relevance and sustainability of the initiatives of the business plans with innovation and digital transformation promoting accessibility to AI systems deciphering practice components for evaluation and relevant mechanisms to disseminate the SDGs.

The strengthening of entrepreneurship with practices using AI systems, highlighting creativity and innovation for the dissemination of the SDGs in rural areas of the Department of Meta, in Colombia, constitute the recommended strategy derived from this study, with a probability of acceptance of 23%.

The Recommended Model for the application of Metacognitive Learning Strategies highlights the incorporation of practical techniques with the implementation of models of AI systems, innovation and business creativity for the effective dissemination of the SDGs in Meta Colombia and is represented in Figure 2 ACRA Model of Learning Strategies (Source, 2003) (30).

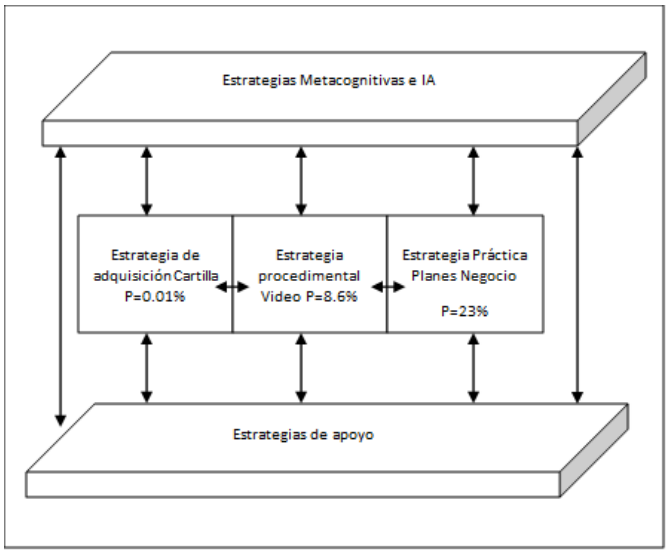

Figure 2: ACRA Model of Learning Strategies (Source, 2003)

Thus, practical strategies with accessibility to AI systems represented in innovative business plans that generate tangible income are fundamental elements for the effective dissemination of SDGs 4, 7 and 12 in this study area, as shown in Figure 2 with the acceptance probability of 23%.

Metacognitive techniques and Artificial Intelligence offer great potential for meducation (31) and for dissemination of Sustainable Development Goals (SDGs) in the Colombian Orinoquía, as shown by the following suggestions resulting from this work:

The experience of presenting these study communities with real challenges related to the SDGs and guiding them to find solutions fostered critical thinking and ownership of the goals.

Activities that allowed participants to reflect on their knowledge and practices in relation to the SDGs led to the identification of areas for improvement.
The promotion of teamwork and open discussion allowed to enrich learning and generate innovative ideas.
The development of informative chatbots that answer questions about the SDGs in a personalized and accessible way, including in indigenous languages, was a potential effective application of AI for the dissemination of the SDGs.
The creation of immersive experiences with remote virtual environments that transport people to different scenarios in the Orinoquía made it possible to show the impacts of the SDGs and the actions to achieve them.
Using AI to analyze large amounts of data and generate information was useful for decision-making and design strategies that can potentially be increasingly effective for dissemination.
The development of digital platforms such as the e-learning platform used by the Colombia Sustainable Goal project, made it possible to adapt the content and activities to the needs and previous knowledge of each user, using metacognitive techniques and AI algorithms.
The creation of games and challenges related to the SDGs to make learning more fun and engaging, using gamification and AI elements to personalize experiences is one of the features of the e-learning platform used.
The messages and activities of this work were adapted to the reality and culture of the Orinoquía, using examples and local case studies.
The findings showed that AI-powered systems increase participants' motivation, engagement, and knowledge retention, while providing scalable solutions for various educational scenarios.
The provision of information in different languages, including indigenous languages, to ensure the accessibility of all the working groups selected in the study, as well as working together with community leaders, students, local organizations, and experts in environmental and social issues ensured the relevance and sustainability of the initiatives.
Mobile applications that use augmented virtual reality made it possible to show how different everyday actions impact the SDGs. When scanning a tree, for example, the system takes care to display information about the importance of forest conservation and how it contributes to achieving the related SDGs.

5. Conclusions

This study aimed to investigate the fundamental problem presented by the effectiveness of learning strategies with digital transfer AI emerging technologies and business innovation for the effective dissemination of the SDGs in the Ariari Subregion in Meta Colombia.
The following conclusions are presented as a result of the research useful to promote tangible advances in AI in society, environment and economy in other similar study areas in Colombia and potential projections to Latin America:
The incorporation of sustainable business innovation models among the rural population provides the best mechanisms for the dissemination of the SDGs in the rural sector of Meta Colombia.
Innovation and transformation promoting accessibility to AI systems is a fundamental aspect for small and medium-sized enterprises, promoting the increase in competitiveness that leads to effectiveness in the dissemination of the SDGs in rural areas.

The incorporation of technologies with digital transfer and AI in teaching processes entails benefits such as metacognitive strategies for knowledge acquisition, attitudes towards procedures and practical contextualization of the SDGs in the rural sector, showing business models with the use of AI as the best mechanism for dissemination.

For many years, the inhabitants of the Department of Meta have suffered from poverty, violence, drugs, attacks on the environment and the neglect of the state, which were recently added to the effects of the pandemic, so solutions are required that generate economic benefits based on an effective dissemination of the SDGs in the rural sector.

Digital transfer, AI and innovation are excellent mechanisms, as evidenced by the interest in e-learning primers, videos incorporating virtual reality and, especially, business plans with a sustainable innovation approach that produce short-term income.

The decision to use digital learning strategies and business innovation to disseminate the SDGs through innovation and entrepreneurship generates effective social interaction among citizens in the rural sector with respect to the urgent need for dissemination of the SDGs, where AI, added to metacognitive techniques, offer great potential for this purpose.

Through statistical tests such as the student t test and the Wilcoxon Test, it was possible to know that in order to be effective in digital transfer strategies, AI and innovation in the agricultural sector, business models that require AI support must be considered to diversify the knowledge that the rural sector has about the 2030 Agenda.

An additional study that will allow this research work to be deepened will be carried out by this same research team to dissemination of the SDGs through the specific sustainable business model in the Department of Meta in Colombia, for which academic innovation events have been carried out with the participation of experts from Canada, Argentina and Colombia.

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