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Teaching With Artificial Intelligence in Rural Communities for Microenterprise Development

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ABSTRACT

This study explains the use of artificial intelligence (AI) as an educational tool to train rural fishing communities in sustainable development and microenterprise creation, with a focus on Atractosteus tropicus (tropical gar). AI played a pivotal role in designing tailored educational materials that aligned with the community's cultural and socioeconomic context. Visual learning techniques, using AI-generated images, promoted the understanding of sustainable fishing practices, value-added product development, and business strategies. The integration of traditional knowledge with sustainable approaches empowered fishermen to manage natural resources efficiently, increase income, and reduce reliance on intermediaries. The study demonstrates that AI-driven education can enhance the sustainability and economic development of rural communities, offering new business opportunities while promoting biodiversity conservation.

Keywords: Artificial intelligence, Communities, Economic and social development, Enterprises, Teaching

INTRODUCTION

This study shares the use of artificial intelligence (AI) as an educational tool to train rural communities in sustainable development and microenterprise creation. The initiative aimed to strengthen knowledge on the sustainable use of native species, particularly *Atractosteus tropicus* (tropical gar) (Oropeza *et al.*, 2024), and to foster economic growth through the development of innovative products and the creation of small businesses. The communities were trained on the importance of conserving biodiversity while sustainably utilizing these natural resources for economic purposes. AI played a principal role in creating customized educational training materials (Oropeza-Tosca *et al.*, 2024) designed to meet the needs of knowledge and cultural context of the communities. These instructional materials focused on sustainable fishing practices as well as the development of products derived from this local species. AI helped bridge the gap between existing community practices and new sustainable approaches by applying traditional knowledge with

personalized teaching techniques. This integration empowered communities to balance environmental management with economic opportunities.

AI has emerged as a powerful tool that is used in multiple fields, including education (Martinez-Gutierrez *et al.,* 2022) and business development. In the context of southeastern Mexico, specifically in the state of Tabasco, the fishing and marketing of Atractosteus tropicus (tropical gar), an endemic species with great cultural, economic and gastronomic value, faces multiple challenges related to sustainability and economic efficiency. Overfishing, the lack of adequate technical training in sustainable practices, and the intervention of intermediaries in the marketing chain that increase costs are some of the factors that have limited the economic development of fishing communities that depend on this resource.

The tropical gar is an iconic species in the gastronomy of the region; it has historically been a source of sustenance and cultural heritage for fishing communities as well as for Mexican society in southeastern Mexico for years. However, unregulated exploitation, climate change and the lack of direct marketing strategies has generated the need to implement new practices that can balance the conservation of natural resources with the generation of sustainable income that favours the economy of the region and create new job and business opportunities for residents who depend on fishing. In this context, AI offers an innovative solution to address these problems through the creation of personalized and contextualized educational tools that promote sustainability.

Fishing communities, often located in rural areas where some only have access by water and with limited access to formal educational resources, lack the necessary training to adopt new technologies and practices that ensure the conservation of tropical gar and the aggregation of value to their products. Furthermore, intermediaries in the marketing process capture a significant part of the profits, leaving fishermen with limited income and forcing them to buy inputs that they themselves offer to make the product even cheaper. Through AI, personalized and contextualized teaching materials have been developed that can allow these communities to improve their fishing practices aimed at sustainability, integrate traditional knowledge of food preparation (Rodríguez *et al.,* 2024) by rescuing popular recipes among the community and most importantly, develop sustainable microbusinesses that can add value to products derived from the tropical gar.

This educational approach with AI has allowed members of fishing cooperatives to acquire skills in fishing and production of value-added foods, such as tamales and tropical gar empanadas, which can trigger an entry into the ready-to-eat packaged food market and new direct marketing opportunities through government alliances such as the Ministry of Economy and restaurants in the region. In addition, AI facilitates the creation of efficient production plans that comply with quality and labelling regulations, such as NOM-051-SCFI/SSA1-2010, for pre-packaged products. This can empower communities to strengthen the efficiency of their natural resource management, increase their income and reduce their dependence on intermediaries, favouring the diversification and creation of sources of

employment that can reduce migration trends to neighbouring cities as well as diversify the economic activities developed in the community.

AI was used to tailor educational content to the specific needs of these communities, facilitating access to up-to-date information on sustainable fishing techniques, food processing, and marketing strategies.

Figure 1: Context of the educational environment in fishing communities in the Mexican southeast (photograph taken by Diana Rubi Oropeza-Tosca in Ismate and Chilapilla second section, Tabasco, Mexico, 2024).

MATERIALS AND METHODS

Design of Educational Materials for Fishermen With DALL·E

For the design of the manuals, the artificial intelligence DALL·E was used, which allowed the generation of visual images based on textual descriptions from observations of the flora, fauna, and socioeconomic activities carried out in the community. This made it possible to create graphic representations adapted to the reality of the community, using concrete and visual examples of everyday situations in the lives of the fishermen. The images depicted examples related to their daily life, the application of sustainable fishing practices, the management of economic resources, types of value-added products, selection of competitive strategies for products, distribution channels, and the commercialization of products in local markets.

AI-Assisted Adaptive Learning Strategy Applied to Educational Materials.

This study implemented a combination of situated learning, contextual learning, visual learning, and AI-assisted adaptive learning to create educational materials for fishermen in rural communities focused on sustainable fishing practices and microenterprise development. The methodology is described in the following steps:

1. Situated learning approach. The educational materials were designed to be directly relevant to the real-world context of the fishing communities. By observing daily activities such as fishing techniques, preparation of food products, and the community's socio-economic challenges, we ensured that the instructional content was grounded in the everyday experiences of the fishermen. The aim was to make learning meaningful by incorporating examples and challenges that fishermen face in their natural environment. This approach aligns with the concept of situated learning, where knowledge is best acquired and applied within its context of use.
2. Contextual learning. The educational materials emphasized contextual learning by integrating the community's cultural, social, and economic context (Beltrán *et al.*, 2024) into the training process. The focus was on connecting the fishermen's traditional practices with modern, sustainable techniques. For instance, the instructional content covered the traditional

knowledge of tropical gar (*Atractosteus tropicus*) fishing, alongside sustainable management practices as community gardens with organic fertilizers (Manzano-Gómez *et al.*, 2023), new products and value-added processing techniques. The content was adapted to the community's specific needs, such as the selection of suitable fishing times, seasonal patterns, and management of fishing yields, to ensure practical relevance and applicability.

3. Visual learning through AI-Generated Images. To enhance understanding, visual learning was incorporated using the artificial intelligence tool DALL·E. This tool generated images based on textual descriptions that reflected the fishermen's community environment. The images depicted real-life scenarios such as the flora, fauna, and the socio-economic activities of the community. These visual aids played a principal role in simplifying complex ideas and providing clear, culturally relevant examples. The visuals included representations of sustainable fishing practices, resource management, and examples of value-added products such as tamales and empanadas made from tropical gar. The images were used to create visual guides within the manuals, ensuring that the content was easily comprehensible, even for participants with limited literacy skills.
4. AI-Assisted Learning. The project utilized AI-assisted learning to create personalized educational experiences for each participant. This was done by collecting feedback from the fishermen on their prior knowledge and specific challenges they faced. The AI tool then adjusted the educational content to match the learner's level of understanding and pace. For example, participants with more experience in fishing but less knowledge of product commercialization received focused content on business strategies and market development, while others were guided through basic fishing techniques and sustainability practices. This adaptive strategy ensured that each learner's experience was tailored to their individual needs, maximizing the learning outcome.
5. Development of microenterprise skills. A significant part of the educational materials focused on fostering skills in the creation and management of microenterprises. Through a combination of visual learning and AI-assisted learning, fishermen were introduced to concepts such as market analysis, product differentiation, and competitive strategy. They were trained on how to add value to their products by introducing packaging, branding, and direct-to-market sales strategies, with practical examples of successful initiatives in similar rural settings. These educational tools empowered fishermen to transition from raw product suppliers to entrepreneurs who could control more of the value chain, thus increasing their income and reducing reliance on intermediaries.
6. Application of regulatory knowledge. To ensure compliance with food safety and labelling regulations, such as NOM-051-SCFI/SSA1-2010, the educational content included sections on the importance of quality control and regulatory requirements. The AI-generated images provided visual guides on how to package, label, and market the products derived

from tropical gar. This not only helped fishermen comply with national regulations but also improved the marketability of their products in local and regional markets.

7. Feedback and continuous improvement. Throughout the training process, continuous feedback was gathered from the participants. This feedback loop was essential in refining the educational materials and ensuring they remained relevant to the learners' evolving needs. The adaptive AI tools used this feedback to further personalize the content, adjusting to the learning progress and specific areas where additional support was needed. Once the manuals were completed, they were presented to the fishermen in training sessions held within the community, where their interaction with the materials was observed through the WhatsApp platform. Focus groups were conducted to gather feedback on the topics covered, allowing for the identification of areas for improvement and adjustments to the content to make it even more relevant and understandable for the participants.

RESULTS

The results obtained from the implementation of the five educational manuals designed using artificial intelligence (AI), applying the visual teaching technique through images generated by DALL·E, were positive and satisfactory. The manuals presented everyday situations related to sustainable fishing, the management of tropical gar, and the commercialization of derivative products, which facilitated the fishermen's understanding, including those with low literacy levels. The fishermen who participated in the training sessions demonstrated a high level of receptivity towards the images, especially those depicting common situations in their work environment, allowing them to understand and relate what was explained to their daily lives.

The use of clear and realistic images allowed for a straightforward assimilation of the presented content without relying on complex texts. Adoption of sustainable practices improved: the visual training enhanced the fishermen's understanding and their willingness to implement more sustainable practices in their daily activities. 85% of the participants stated that, thanks to the visual content in the manuals, they were able to identify improvements in their fishing techniques that they had not previously considered.

The visualization of scenarios illustrating the preparation and commercialization of products derived from tropical gar (empanadas, tamales) resulted in significant motivation to explore new business models. Seventy percent of the fishermen expressed interest in the possibility of expanding the range of products offered and improving their presentation to access new markets.

Participants suggested that the visual approach, through AI-generated images, was an effective method for conveying technical and complex information. They indicated that including more visual examples of how to

sell products in local and international markets would be beneficial in future editions of the manuals.

The results of the study show that the use of artificial intelligence for designing visual educational manuals represents an effective tool for training fishermen in rural communities, particularly in contexts with low literacy levels. The images generated through DALL·E allowed the fishermen to intuitively understand concepts related to sustainability and commercialization, while also fostering a proactive attitude towards adopting new techniques and business models.

In particular, the visual approach proved to overcome educational barriers and facilitate knowledge transfer for producing products derived from tropical gar, suggesting an opportunity to develop a more robust market based on local gastronomy. The positive feedback on the manuals indicates that this type of tool can enhance the capacity of fishing communities to adapt to market demands, including the adoption of sustainable practices (Martinez-Gutierrez & Correa, 2020) and the long-term viability of tropical gar as a resource. The implementation of more AI-supported training programs could be a key strategy to promote inclusive, sustainable economic development in these communities, considering that these works can contribute to the development of tourism projects such as the Mayan train (Ramírez-Espín *et al.*, 2023) where innovative products with added value generated from a robustly trained community can be offered.

CONCLUSION

AI for the design of visual educational manuals has proven to be an effective tool in training fishermen from rural communities with low literacy levels. Using images generated by DALL·E, the fishermen were able to understand concepts related to the sustainable fishing of tropical gar (Atractosteus tropicus), which promoted interest in adopting sustainable practices and in diversifying derivative products, such as tamales and empanadas.

However, the study also revealed significant barriers, such as the lack of infrastructure and funding, which limit the scope of these initiatives. Despite this, AI, combined with a participatory approach and continuous technical support, has the potential to drive sustainable economic development in these communities. It is concluded that technology can serve as a foundation to integrate sustainability with the economic development of rural communities, improving the living conditions of fishermen and ensuring the conservation of this emblematic resource.

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