



RESEARCH PAPER

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Proposed science communication plan of school plus home cacao project: Insights from the Penta Helix Model of innovation towards community development

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Abstract

This qualitative study explores the role of science communication in enhancing community engagement and supporting sustainable development through the School + Home Cacao Project, implemented by the Cagayan State University in the Municipality of Lasam, Cagayan, Philippines. The study aims to develop a comprehensive science communication plan that effectively engages stakeholders from government, academia, industry, civil society, and the public, inspired by the Penta Helix Model. By integrating data from various sources and employing directed qualitative content analysis, the study provides valuable insights into community needs, challenges in cacao farming, and the impact of the project. The findings emphasize the commitment of stakeholders to community development and underscore the significance of interdisciplinary collaboration and inclusivity in driving positive change. With support from government, academic expertise, industry linkages, civil society advocacy, and public enthusiasm, the School + Home Cacao Project exemplifies the transformative potential of effective science communication and collaborative efforts. The proposed science communication plan encompasses tailored communication materials and activities, promoting maximum stakeholder engagement and ownership. The plan's success is reinforced by sustaining positive perception and enthusiasm among parents and families, thus fostering strong community support and involvement. As a model for community development initiatives, this study showcases how effective communication, guided by the Penta Helix Model, can empower local communities, address challenges, and promote sustainable outcomes. The study offers recommendations for strengthening multi-stakeholder collaboration, implementing long-term monitoring and evaluation, and scaling up similar projects. Emphasizing the importance of inclusive communication, this research contributes to the growing body of knowledge on science communication and its role in community development. Ultimately, the insights gained from this study provide valuable guidance for practitioners and researchers worldwide, supporting their endeavors in driving positive change and progress through effective science communication.

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Introduction

Abandoned In the face of interconnected global challenges such as climate change, biodiversity loss, and social inequality, effective science communication and community engagement play a pivotal role in driving positive change and sustainable development. As these urgent issues threaten the well-being of our planet and its inhabitants, it is crucial to address them with a sense of collective responsibility and urgency. Scientific research and technological advancements offer potential solutions, but their impact is limited without successful communication and widespread engagement. Informed decision-making and public understandings are essential for driving meaningful actions and policy changes that can lead to transformative outcomes.

Among the pressing challenges, climate change stands as one of the most formidable threats to the environment. Rising global temperatures, extreme weather events, and melting ice caps all underscore the urgency of reducing greenhouse gas emissions and transitioning to sustainable energy sources (IPCC, 2021, Leiserowitz *et al*, 2017). However, without effective science communication, the gravity of climate change may not be fully grasped by the public, hindering collective efforts to mitigate its impact. Biodiversity loss is another critical issue that imperils the delicate balance of ecosystems and compromises essential ecological services. Human activities, such as deforestation, overfishing, and habitat destruction, contribute to the rapid decline of biodiversity. Engaging communities in understanding the value of biodiversity and the consequence of its loss is crucial for promoting conservation and sustainable practices (IPBES, 2019). In regions where scientific literacy is lacking, communities may be disproportionately affected by environmental changes, natural disasters, and resource depletion. Without understanding the scientific basis of these challenges, communities may struggle to adopt sustainable practices, exacerbating the impact on their livelihoods and well-being. By

incorporating scientific literacy, stakeholders can promote awareness, education, and knowledge exchange among community members. This approach equips individuals with the tools to make informed decisions and actively participate in the project's initiatives. By fostering understanding of sustainable agricultural practices, environmental conservation, and climate resilience, the project can empower cacao farmers and local communities to adapt to changing circumstances and improve their livelihoods. Moreover, inclusive science communication can bridge the gap between academia and local communities, ensuring that research findings are accessible and applicable to the target population's needs. Ultimately, by addressing poverty through the lens of scientific literacy and inclusive communication, the project can contribute to breaking the cycle of vulnerability and promoting community-driven development. Empowering communities with knowledge and understanding not only enhances their resilience but also facilitates their active participation in creating solutions to global challenges.

Science Communication

Science communication refers to the process of conveying scientific information and knowledge to various audiences in a clear, accessible, and engaging manner. It involves translating complex scientific concepts into language and formats that non-experts can understand and appreciate. The goal of science communication is to bridge the gap between scientists and the general public, policymakers, stakeholders, and other relevant communities, fostering mutual understanding and informed decision-making. Authors Burns, O'Connor, and Stockmayer (2003) define science communication as a contemporary practice that seeks to make science relevant and meaningful to a diverse range of knowledge users, promoting scientific literacy, public engagement with science, and the dissemination of evidence-based information for societal benefit. As pointed out by Fischhoff (2013), making informed decisions about various issues, both at the individual and societal

levels, requires a solid understanding of the relevant science. This understanding is crucial for private decisions, such as choosing fuel-efficient vehicles, opting for robot-guided surgery, or selecting dairy products labeled as "produced by animals not treated with bovine growth hormone—not known to cause health effects." Additionally, it is essential for public decisions, such as supporting politicians who advocate for fuel efficiency, advocating for disclosing the risks of medical devices, or voting for referenda that address agricultural biotechnology.

Effective science communication plays a vital role in providing people with the necessary information about the benefits, risks, and other costs associated with their decisions (Palani, et al, 2023, Chan & Albarracín, 2023). By doing so, it empowers individuals to make sound choices that align with their values and priorities. This comprehension of scientific knowledge allows individuals to weigh the advantages and disadvantages of various options, enabling them to make informed and rational decisions.

In its broadest sense, effective science communication involves the dissemination of science-related knowledge in a way that genuinely impacts knowledge users (Burns *et al.*, 2003). Similar to teaching, there is no one-size-fits-all approach to science communication (Weigold, 2001), and success can take various forms. Scientists interact with a diverse range of audiences, from interested and non-interested laypeople to engaged stakeholders, policymakers, and colleagues from different scientific disciplines. The motivations behind scientists' engagement in science communication are also diverse (Poliakoff and Webb, 2007). Some engage due to grant requirements, while others have a genuine interest in public engagement or feel a moral obligation to share their knowledge with the broader public. Science communication activities can have a wide range of intended outcomes. These outcomes can vary from seeking to change human behavior, such as increasing participation in recycling programs

or influencing voting decisions, to more straightforward goals like educating, informing, or entertaining the audience.

The Role of Higher Education Institutions in Community Development

Higher education institutions (HEIs) occupy a central position in society as key contributors to community development and progress. Through their commitment to research, education, and innovation, HEIs play a pivotal role in addressing local and global challenges (Jaeger *et al.*, 2017). These institutions serve as hubs of knowledge creation and dissemination, producing groundbreaking research that can drive social change and transformative outcomes (Slaughter & Leslie, 1997). By engaging in collaborative partnerships with communities, governments, industries, and civil society, HEIs contribute to the development and implementation of evidence-based solutions to pressing issues (Holland, 2016). The expertise and resources within HEIs enable them to offer valuable insights, technical assistance, and capacity-building initiatives that support community needs (Bingle & Hatcher, 2002). Moreover, through their educational programs, HEIs nurture a skilled and informed workforce, empowering individuals with the knowledge and skills needed to contribute to societal advancement (O'Meara *et al.*, 2008). As engines of innovation and social progress, higher education institutions play an indispensable role in shaping a sustainable and equitable future for communities worldwide.

Despite their significant potential to contribute to community development through science communication, higher education institutions (HEIs) may encounter certain challenges in effectively engaging with local communities. One key challenge is the "ivory tower" perception, where HEIs are perceived as disconnected from the real-world concerns of communities (Kezar, 2011). This perception can hinder effective collaboration and hinder the uptake of research findings by community stakeholders (Eve, 2019).

Additionally, the lack of institutional support and incentives for faculty members to engage in science communication and community-based research can deter meaningful engagement (Jaeger *et al.*, 2017). Limited resources and funding for science communication initiatives within HEIs can also impede their ability to effectively reach and engage diverse community audiences (Holland, 2016). Overcoming these challenges requires a proactive approach by HEIs, fostering a culture of community engagement, providing support for faculty involvement in science communication, and dedicating resources to community-driven initiatives (Jaeger *et al.*, 2017). By addressing these challenges, HEIs can maximize their potential as agents of positive change and meaningful contributors to community development through science communication.

Penta Helix Model among Higher Education Institutions

The Penta Helix Model is a conceptual framework that emphasizes the significance of collaborative partnerships among five key stakeholders: government, academia, industry, civil society, and the public as shown in Figure 1. This model recognizes that addressing complex challenges, especially in the context of higher education institutions (HEIs), requires active engagement and coordination among these diverse actors. Government institutions play a vital role in setting policies, regulations, and funding priorities that shape the landscape of higher education and research (Carayannis & Campbell, 2009). Their involvement in the Penta Helix Model ensures that initiatives align with national development goals and are adequately supported by relevant policies. Academia, represented by HEIs, is the hub of knowledge creation, research, and innovation (Carayannis *et al.*, 2012). Universities and research institutions generate cutting-edge knowledge and expertise that can be harnessed to address societal challenges effectively.

Industry, as a key stakeholder, brings practical experience, resources, and market-oriented perspectives to the table (Etzkowitz & Leydesdorff, 2000). Collaborating with industry allows HEIs to better understand real-world challenges and opportunities, leading to the development of solutions that have a direct impact on society. Civil society organizations, including non-governmental organizations (NGOs) and community groups, represent the interests and concerns of the public (Carayannis *et al.*, 2018). Their involvement in the Penta Helix Model ensures that community needs and perspectives are integrated into research and development processes, leading to more relevant and inclusive outcomes. Finally, the public, as the ultimate beneficiaries of research and innovation, plays a crucial role in the Penta Helix Model (Carayannis *et al.*, 2015). Engaging the public in the research process fosters greater understanding, acceptance, and uptake of research findings, leading to more significant societal impact. By promoting collaboration among these five stakeholders, the Penta Helix Model fosters an ecosystem of innovation and knowledge-sharing, enabling HEIs to address complex challenges more effectively and contribute to the sustainable development of societies (Carayannis *et al.*, 2017). This model's multi-stakeholder approach ensures that research, innovation, and knowledge creation are not limited within the walls of academia but are connected to real-world needs and solutions.

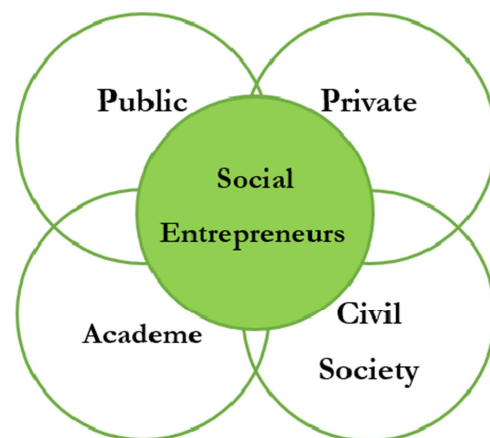


Fig. 1. Penta helix Model of Innovation (Model by Calzada, 2016 cited by Hibas, Sibayam & Maata, 2017).

The Penta Helix model, rooted in the Triple Helix concept by Etzkowitz and Leydesdorff (2000), expands the collaborative network to include academia, industries, and government, fostering innovative research projects within educational institutions that can be transformed into viable commercial products or services. To further enhance the model's effectiveness, NGOs, civil society, and social entrepreneurs were integrated into the Penta Helix, playing significant roles in supporting shared innovation goals (Rampersad, Quester, & Troshani, 2010) and contributing to the socio-economic progress of the region. According to von Stamm (2004), successful innovation thrives through strong collaboration and partnership among all key stakeholders involved in the Penta Helix model.

The School + Home Cacao Project embodies a transformative initiative led by Cagayan State University at Lasam, Philippines, that exemplifies the power of the Penta Helix Model in driving community development. By harnessing collaborative partnerships among government, academia, industry, civil society, and the public, the project aims to address complex challenges faced by rural communities in the Municipality of Lasam. As an innovative participatory action research endeavor, the project empowers communities through the College of Teacher Education, focusing on the potential of cacao to enhance literacy, nutrition, and livelihood in the target areas. By engaging students, teachers, families, and local community members, the project creates a holistic impact on education, health, and economic well-being. The science communication plan, influenced by the Penta Helix Model, plays a crucial role in fostering active engagement from stakeholders, ensuring the project's impact extends far beyond its immediate scope. Through diverse communication channels, the plan facilitates knowledge exchange, interdisciplinary learning, and inspiration for other communities and institutions to adopt similar initiatives. By connecting academia, government, industry, civil society, and the public, the School + Home Cacao Project exemplifies how higher education institutions can actively contribute

to sustainable community development and address pressing societal challenges.

Overview of the School + Home Cacao Project

The School + Home Cacao Project, led by Cagayan State University at Lasam, Philippines, is an innovative and transformative initiative aimed at empowering selected schools and homes in the Municipality of Lasam, Cagayan. The project's primary objective is to address the core problem gap analysis, which identified limited educational opportunities, nutritional deficiencies, and unemployment as significant challenges faced by the community. To achieve its goals, the project focuses on harnessing the potential of cacao as a catalyst for comprehensive community development. It adopts a multi-dimensional approach, engaging students, teachers, parents, and local community members. Through experiential learning activities, participants will gain practical insights into cacao farming, processing techniques, and the nutritional benefits of cacao-based products. One of the key objectives is to increase the diversity and availability of nutritious food within the local community by promoting cacao-based products. Cacao's nutritional value can help address deficiencies and improve overall health. Additionally, the project seeks to create an alternative source of income for families through cacao processing, fostering economic prosperity and resilience.

The School + Home Cacao Project are three-year institutionally funded RDE project of Cagayan State University, launched and implemented in July 2022. Its conceptual framework addresses the interconnected issues of health, literacy, and education in rural communities, particularly in Municipality Lasam, Cagayan, Philippines. By presenting a comprehensive approach that combines the efforts of schools and homes, the project offers a novel perspective on using the cacao industry for sustainable development. The project's relevance to higher education institutions lies in its capacity to inspire transformative and inclusive approaches to education, research and community engagement,

fostering a positive impact on rural communities and contributing to the country's sustainable development goals. Policymakers can draw insights from this project to design programs that promote community-based initiatives, interdisciplinary collaboration, and entrepreneurship in the agriculture sector. Despite the potential of agriculture to uplift communities, challenges hinder its full impact on livelihoods and well-being in the Municipality of Lasam, Cagayan, Philippines. The participatory action research project aims to address these gaps and foster sustainable development by harnessing the transformative potential of cacao production and processing technologies. The expected output of the School + Home Cacao Project includes enhanced knowledge and skills in cacao processing, production, and nutrition among at least 500 students, 50 teachers, and 100 parents. Promotion of diverse cacao-based products will contribute to better community nutrition and access to nutritious food options, while engaging families in cacao processing will create alternative income opportunities, fostering improved economic prosperity and resilience. The expected outcomes include improved literacy levels among students, leading to better academic performance and personal growth. Enhanced community nutrition is expected through a reduction in nutritional deficiencies, and families engaged in cacao processing will experience increased monthly incomes, driving sustainable community development and entrepreneurship.

Practical and Literature Gap

The practical gap in this research lies in developing effective science communication and community engagement strategies for the School + Home Cacao Project. The project's goals of enhancing literacy, nutrition, and livelihood in rural areas require active collaboration from various stakeholders, and the Penta Helix Model provides valuable insights for fostering such cooperation. However, the plan needs to tailor communication approaches to suit the specific context of the target communities, considering traditional and digital platforms. Additionally, clear indicators and evaluation methods

are necessary to measure the plan's impact and refine its approach throughout the project's implementation. The Science Communication Plan aims to empower communities through Cacao Backyard Farming and Processing, aligning with the Sustainable Development Goals and contributing to poverty reduction and sustainable development in the Municipality of Lasam, Cagayan, Philippines. Drawing from the Penta Helix Model, the plan seeks active engagement from stakeholders and knowledge exchange through various communication channels to foster interdisciplinary learning and inspire similar initiatives in other communities. This research emphasizes the role of higher education institutions in community development and environmental protection, showcasing collaborative efforts' potential for positive change in sustainable agriculture and community empowerment. In like manner, the research literature gap in the Science Communication Plan of the School + Home Cacao Project lies in the need for tailored and practical science communication strategies that effectively engage diverse stakeholders in rural communities, particularly in the context of cacao farming and processing. While the Penta Helix Model provides valuable insights for collaboration among government, academia, industry, civil society, and the public, there is limited research on its application in the specific context of community development projects focused on agriculture. Additionally, the literature lacks comprehensive studies that examine the effectiveness of science communication plans in addressing the unique challenges of rural areas, such as limited access to digital platforms and educational resources. There is a practical gap in understanding how to effectively communicate research outputs, promote interdisciplinary learning, and inspire positive change in communities through innovative communication channels that suit the context of the target areas in the Municipality of Lasam, Cagayan, Philippines. To bridge this gap, further research is needed to develop and evaluate science communication approaches that resonate with the diverse audiences involved in the School + Home Cacao Project, ensuring meaningful community engagement and sustainable development outcomes.

Objectives of the Study

Generally, this study aims to contribute to the field of science communication, enhance community engagement, and support sustainable development in rural areas through the School + Home Cacao Project. Specifically it aims to: (1) establish baseline data to develop a science communication plan for the School + Home Cacao Project that effectively engages stakeholders from government, academia, industry, civil society, and the public; and (2) present the science communication plan as roadmap for higher education institutions and community development workers on effectively communicating research outputs and driving community development initiatives, with insights from the Penta Helix Model to foster collaborative efforts among stakeholders.

Materials and methods*Research Design*

In this qualitative study, a comprehensive science communication plan for the School + Home Cacao Project was developed by integrating data from multiple sources, following Denzin's (1970) approach of data triangulation. By combining data from various sources, such as semi-structured interviews, books, documents, policies, and official websites, a robust and well-rounded body of data was created, enhancing the completeness, balance, reliability, and validity of the findings (Yeasmin & Rahman, 2012). The research design employed qualitative content analysis, specifically directed qualitative content analysis, to analyze and interpret the data collected from different sources. Through this approach, the study sought to converge several perspectives to corroborate the present findings effectively. The science communication plan was designed to encompass diverse communication channels, ensuring active engagement with stakeholders. Workshops, field visits, seminars, and digital platforms were identified as key channels to facilitate knowledge exchange, promote interdisciplinary learning, and inspire other communities and institutions to adopt similar initiatives. To ensure the communication plan's effectiveness, feedback mechanisms and data collection were integrated to

assess its impact and make necessary adjustments for continuous improvement. By adopting this research design, the study aimed to develop an inclusive and tailored science communication plan, allowing the School + Home Cacao Project to effectively empower communities through the College of Teacher Education. Utilizing multiple data sources and qualitative content analysis, the research emphasized the significance of collaborative efforts among government, academia, industry, civil society, and the public as proposed by the Penta Helix Model. Through this approach, the study contributes to the growing body of knowledge on effective science communication in the context of community development and environmental protection.

Participants/ Informants and Sources of Data

The study included 5 selected informants coming from, the government, academe, industry partners, civil society, and the public. To develop an effective science communication plan for the School + Home Cacao Project, the researchers utilized a qualitative data collection approach, conducting interviews with each of these specific individuals represented by the Penta Helix Model to name, one from the LGU involved in agricultural policies, rural development, and community programs was interviewed to gain insights into community needs and potential support for the project. Secondly, one project coordinator leader of the School + Home Cacao Project, representing academia (Cagayan State University at Lasam), was interviewed to understand the project's objectives, challenges, and ongoing activities. Thirdly, one representative from local cacao farmers' associations or cooperatives, as part of the industry, provided valuable information on the challenges and opportunities in cacao farming and processing. Additionally, one representative from non-governmental organizations (NGOs) working in rural development, education, or nutrition, were engaged to offer insights from the civil society perspective. Lastly, parents and families of students participating in the project were interviewed to provide valuable feedback on their level of engagement and perceptions.

By gathering data from these diverse stakeholders, the science communication plan was tailored to meet their specific needs, ensuring active engagement and collaboration in achieving the project's goals of enhancing literacy, nutrition, and livelihood in the target areas. This qualitative research utilized multiple data collection methods, including interviews, literature reviews, and document analysis, to explore the participants' perceptions on how to effectively communicate research results. The research instrumentation involved a literature review to identify relevant theories and concepts related to science communication approaches. Semi-structured interviews were conducted with 14 informants who actively participated in the project. The interviews were recorded and later transcribed for analysis. Additionally, document analysis was carried out, involving a review of research results and relevant documents.

Data Analysis

For the data analysis, the research employed a Directed (Deductive) Qualitative Content Analysis (DQCA) approach, which is widely used in social sciences research to analyze textual data, including interview transcripts and documents. This method allowed the researchers to utilize both deductive and inductive coding techniques. They started with predefined categories or a theoretical framework (deductive) to guide the analysis while also being open to the emergence of new themes and codes (inductive) from the data. The study's focus on effective science communication is particularly relevant and timely, as it addresses the crucial aspect of properly conveying research results to different stakeholders involved in the School + Home Cacao Project. By employing the Directed Qualitative Content Analysis approach, the research ensures a systematic and rigorous analysis of the qualitative data collected. This approach provides valuable insights into the perceptions of the participants, enabling the development of science communication strategies that resonate with the diverse audiences involved. By understanding the perspectives of key stakeholders and tailoring the communication plan

accordingly, the project can foster active engagement and collaboration among government, academia, industry, civil society, and the public. This alignment of communication strategies with stakeholders' needs will contribute to the successful implementation of the School + Home Cacao Project and its goals of enhancing literacy, nutrition, and livelihood in the target areas. Ultimately, this research can pave the way for more effective science communication practices in community development initiatives, thereby benefiting not only the School + Home Cacao Project but also similar projects worldwide.

Results and discussion

Objective 1.

Establish baseline data to develop a science communication plan for the School + Home Cacao Project that effectively engages stakeholders from government, academia, industry, civil society, and the public

The thematic analysis of the interviews provided valuable insights into the motivations and perspectives of key stakeholders involved in the School + Home Cacao Project. The identified themes guided the development of the science communication plan, which aimed to effectively engage each stakeholder group and promote sustainable development through cacao farming and processing. By leveraging insights from the Penta Helix Model, the communication plan sought to foster active engagement and collaboration among government, academia, industry, civil society, and the public, contributing to the holistic development of the Municipality of Lasam, Cagayan, Philippines. The effective science communication strategies developed in this study have the potential to inspire positive change and drive community development not only in the School + Home Cacao Project but also in other similar initiatives worldwide.

Community Development and Support

The interviews with government officials revealed their recognition of the importance of community development in the context of the School + Home Cacao Project.

They acknowledged that the project aligns with their goals of empowering communities through sustainable agricultural initiatives. The potential impact on literacy, nutrition, and livelihood in the target areas was acknowledged, and the government officials expressed their commitment to supporting the project by providing necessary resources, facilitating collaborations, and ensuring alignment with existing rural development and community programs.

Interdisciplinary Collaboration and Engagement

The project coordinator from academia emphasized the significance of interdisciplinary collaboration in achieving the School + Home Cacao Project's goals. They highlighted that addressing the complex challenges in the community requires expertise from various fields to develop holistic and sustainable solutions. Community engagement was identified as a vital component for success, as it ensures that initiatives are in line with the needs and aspirations of the community members.

Challenges and Opportunities in Cacao Farming

The industry representatives shed light on the challenges faced by cacao farmers in the area. Access to technical assistance and resources for implementing best practices in cacao farming and processing were identified as primary challenges. Additionally, finding stable markets for cacao products was recognized as a difficulty. However, the representatives saw opportunities for the project to address these challenges by providing training and technical support to farmers, establishing market linkages, and promoting sustainable farming practices to improve productivity and income opportunities.

Inclusivity and Equity in Community Development

The civil society representatives emphasized the importance of inclusivity and equity in community development. They highlighted their organization's commitment to prioritize the participation of marginalized groups and ensure that the benefits of the School + Home Cacao Project reach everyone,

regardless of social or economic status. The representatives also advocated for considering environmental aspects in all development activities to ensure sustainability.

Positive Perception and Enthusiasm

The interviews with parents and families of students participating in the project revealed their positive perception and enthusiasm about the School + Home Cacao Project. They expressed excitement about the educational opportunities it offered to their children and were hopeful that the project would not only improve education but also enhance nutrition and livelihood opportunities for the community.

Generally, the findings of the thematic analysis have several general implications for the development of a science communication plan that effectively engages stakeholders in the School + Home Cacao Project and similar community development initiatives. Firstly, recognizing the importance of community development and securing support from government officials lay a strong foundation for successful project implementation, as it ensures access to resources and policy backing. Secondly, promoting interdisciplinary collaboration and community engagement facilitates the generation of innovative and context-specific solutions, fostering a sense of ownership and involvement among stakeholders. Thirdly, addressing the challenges faced by cacao farmers through technical assistance, market linkages, and sustainable farming practices can enhance livelihood opportunities and promote economic growth. Fourthly, ensuring inclusivity and equity in community development initiatives can lead to more equitable outcomes, fostering social cohesion and empowerment. Lastly, the positive perception and enthusiasm of parents and families signify strong community support, which is essential for project sustainability and long-term impacts. By considering these implications, the science communication plan can be tailored to effectively engage stakeholders, maximize their contributions, and drive positive change in the Municipality of Lasam, Cagayan, and beyond.

Several studies emphasize the importance of community involvement and support from local government officials in driving successful development projects (Bebbington, 1999; Cornwall & Gaventa, 2001). Engaging stakeholders from different sectors, such as academia, industry, civil society, and the public, has been recognized as essential for addressing complex challenges and promoting sustainable development (Sachs, 2015; Bremer *et al.*, 2019). The emphasis on interdisciplinary collaboration echoes the literature highlighting the value of integrating diverse perspectives to develop innovative solutions (Clark, 2003; Osman & Koch, 2016). Moreover, addressing the challenges faced by cacao farmers through technical assistance and sustainable practices aligns with research advocating for capacity-building and environmentally responsible approaches in agriculture (Akter *et al.*, 2017; Sibhatu & Qaim, 2018). The call for inclusivity and equity in community development resonates with studies emphasizing the need for social inclusion and equitable distribution of benefits to achieve positive outcomes (Brennan & Stuart, 2018; Asare-Kyire & Dinye, 2020). Additionally, the positive perception and enthusiasm expressed by parents and families align with research suggesting that community support and buy-in are essential factors for project success and sustainability (Conrad & Hilchey, 2011; Shomaker *et al.*, 2021).

Objective 2.

Present the science communication plan as roadmap for higher education institutions and community development workers on effectively communicating research outputs and driving community development initiatives, with insights from the Penta Helix Model to foster collaborative efforts among stakeholders.

On Raising awareness of the School + Home Cacao Project

The science communication plan outlined in Table 1 focuses on raising awareness of the School + Home Cacao Project and its objectives among key stakeholders, including government officials, academia, industry, civil society, and the public. By utilizing a range of communication materials and activities, the plan aims to effectively engage each stakeholder group and foster collaborative efforts in driving community development initiatives. The plan also seeks to maximize the positive perception and enthusiasm of parents and families, which has been shown to be vital for project sustainability and long-term impacts (Conrad & Hilchey, 2011). By providing a roadmap that fosters collaborative efforts and effective communication, higher education institutions and community development workers can leverage these insights to drive positive change and promote sustainable community development in projects like the School + Home Cacao Project and beyond.

Table 1. Science Communication on Raising awareness of the School + Home Cacao Project and its objectives.

Science Communication Objectives	Intended Stakeholders	Communication Materials	Communication Activities
Raise awareness of the School + Home Cacao Project and its objectives.	Government Officials	Informational Brochures	Organize a project launch event with government representatives.
	Academia	Project Fact Sheets	Conduct seminars and workshops at Cagayan State University.
	Industry	Digital Presentations	Participate in industry conferences to showcase the project.
	Public	Social Media Posts, Local News Articles	Share project updates and success stories on social media.
	Civil Society	Posters	Engage with NGOs in community events and outreach activities.

Government officials play a critical role in supporting and enabling community development projects (Bebbington, 1999). The provision of informational brochures and organizing a project launch event allows for comprehensive dissemination of project information and encourages government representatives to actively participate and provide necessary support (Datta, 2020). For academia, the use of project fact sheets and conducting seminars and workshops at Cagayan State University promotes knowledge exchange and interdisciplinary learning, aligning with research emphasizing the role of higher education institutions in driving sustainable development (Clark, 2003; Corley *et al.*, 2021). Engaging industry partners through digital presentations and participation in conferences enables the project to establish market linkages and gain support for cacao farmers' livelihoods (Sibhatu & Qaim, 2018; Snijders *et al.*, 2021). The science communication plan also utilizes social media and local news articles to reach the public, recognizing their importance as active participants in community development (Conrad & Hilchey, 2011; Lidskog *et al.*, 2022). Lastly, the use of posters and engagement with non-governmental organizations allows civil society stakeholders to be actively involved, ensuring inclusivity and equity in the project (Brennan & Stuart, 2018; Salafsky *et al.*, 2020).

The communication plan's multifaceted approach, informed by insights from the Penta Helix Model, underscores the significance of collaborative efforts among stakeholders (Carayannis & Campbell, 2009; Meijerink *et al.*, 2022). By employing tailored communication strategies for each group, the plan aims to build a sense of ownership and involvement in the project, aligning with studies that highlight the value of community engagement in driving successful development initiatives (Cornwall & Gaventa, 2001; Rehman *et al.*, 2022). Moreover, the use of diverse communication channels acknowledges the varying preferences and accessibility of information for different stakeholders, enhancing the overall effectiveness of the communication plan (Shomaker *et al.*, 2021; Vries *et al.*, 2022).

On promoting interdisciplinary collaboration and community engagement in project activities

The objective of promoting interdisciplinary collaboration and community engagement in project activities is crucial for ensuring the success and impact of any scientific endeavor. In Table 2, the various stakeholders involved in the project are identified, and specific communication materials and activities are outlined to effectively engage with each group. For government officials, meeting agendas and invitations serve as valuable tools to establish regular communication channels. Organizing frequent meetings allows researchers to update officials on project progress, share insights, and seek potential areas of collaboration. This collaboration ensures that the project aligns with government priorities and policies, facilitating support and resources. Academia, being a key partner in interdisciplinary research, requires specialized communication approaches. Collaborative platforms, workshops, and focus group discussions offer opportunities for researchers from different fields to exchange ideas, explore synergies, and foster interdisciplinary cooperation. These activities promote the integration of diverse expertise, leading to innovative solutions and a richer understanding of complex issues. Engaging with the industry is essential, particularly in projects with practical applications. Field visits and demonstrations are excellent methods to showcase research outcomes and innovations to stakeholders in the industry. By involving industry representatives in these activities, researchers can better understand real-world challenges and tailor their findings to meet industry needs effectively.

Community engagement is pivotal in projects that impact local populations. For civil society stakeholders, organizing community forums and interactive sessions provides an avenue for residents to actively participate, share their perspectives, and contribute to the decision-making process. This involvement ensures that the project's outcomes address the needs and concerns of the community, fostering a sense of ownership and sustainability.

Finally, engaging with the wider public is essential for transparency and public acceptance. Public forums and Q&A sessions create an open space for sharing project information, answering queries, and

addressing potential concerns. These townhall-style meetings enable researchers to build public trust, gather feedback, and integrate valuable insights from diverse perspectives into the project.

Table 2. Science Communication on Promoting interdisciplinary collaboration and community engagement in project activities

Science Communication Objectives	Intended Stakeholders	Communication Materials	Communication Activities
Promote interdisciplinary collaboration and community engagement in project activities.	Government Officials	Meeting Agendas, Invitations	Organize regular meetings with government officials.
	Academia	Collaborative Platforms, Workshops, Focus Groups	Conduct interdisciplinary workshops and focus group discussions.
	Industry	Field Visits, Demonstrations	Arrange visits to cacao farms and processing facilities.
	Civil Society	Community Forums, Interactive Sessions	Facilitate forums for community members to voice their opinions.
	Public	Public Forums, Q&A Sessions	Host townhall-style meetings for public engagement.

Effective science communication plays a pivotal role in promoting interdisciplinary collaboration and community engagement in project activities (Besley & Nisbet, 2013). By tailoring communication materials and activities to cater to the specific needs and interests of various stakeholders, researchers can create a collaborative environment that enhances the project's outcomes and strengthens its societal impact (Nisbet & Scheufele, 2009). This approach fosters a sense of ownership and active involvement among all parties, including government officials, academia, industry, civil society, and the public (Bubela *et al.*, 2009). Such inclusive communication strategies have been shown to lead to a deeper understanding of complex issues and foster innovation through the integration of diverse expertise (Fischhoff, 2013). By actively engaging with stakeholders through meetings, workshops, field visits, and interactive sessions, projects can better align with societal needs

and preferences, resulting in a shared journey towards positive change and progress (Cacciatore *et al.*, 2016). In summary, evidence from literature emphasizes that effective science communication is a key driver in promoting collaborative and community-oriented project activities, enhancing their overall impact on society and driving meaningful outcomes.

On promoting interdisciplinary collaboration and community engagement in project activities

Table 3 highlights the science communication strategies aimed at promoting interdisciplinary collaboration and community engagement in addressing challenges in cacao farming. The table identifies five key stakeholders, namely Government Officials, Academia, Industry, Civil Society, and the Public, each with their respective roles and communication materials. Government Officials play

a crucial role in supporting cacao farming initiatives through evidence-based decision-making. To achieve this, they are provided with Technical Reports and Policy Briefs, which communicate research findings and policy recommendations related to cacao farming. By staying informed about the latest scientific insights, government officials can better advocate for policies that foster sustainable agricultural practices and address the challenges faced by farmers. Academia's contribution involves equipping farmers and stakeholders with the necessary knowledge and skills to overcome challenges. Training Materials and Best Practice Guides are used to conduct training sessions, empowering farmers with practical know-how and innovative techniques. By engaging with academia, cacao farmers can adopt improved farming practices and enhance their productivity and resilience. Industry stakeholders have a vital role in connecting farmers to market opportunities and insights. Market Analysis and Value Chain Reports are shared with

cacao farmers, providing them with valuable information about market trends and potential buyers. This enables farmers to make informed decisions, access better market prices, and improve their economic prospects. In like manner, Civil Society actively participates in promoting sustainable farming practices in cacao cultivation. They distribute Sustainable Farming Guides to farmers, focusing on environmentally friendly and socially responsible practices. By disseminating these guides, civil society supports the adoption of sustainable methods, fostering a more resilient and eco-friendly cacao farming sector. The Public's involvement is essential in creating awareness and understanding of cacao farming and its challenges. Educational Videos are utilized to reach a broader audience and raise public awareness about the complexities of cacao farming. By fostering public support and empathy for farmers, the videos can encourage consumers to make socially responsible choices, benefiting the entire cacao farming community.

Table 3. Science Communication on Promoting interdisciplinary collaboration and community engagement in project activities Provide technical assistance and information to address challenges in cacao farming.

Science Communication Objectives	Intended Stakeholders	Communication Materials	Communication Activities
3. Provide technical assistance and information to address challenges in cacao farming.	Government Officials	Technical Reports, Policy Briefs	Share research findings and policy recommendations.
	Academia	Training Materials, Best Practice Guides	Conduct training sessions for farmers and stakeholders.
	Industry	Market Analysis, Value Chain Reports	Share market insights and opportunities with cacao farmers.
	Civil Society	Sustainable Farming Guides	Distribute guides on sustainable cacao farming practices.
	Public	Educational Videos	Create videos on cacao farming techniques for public awareness.

The science communication strategies presented in Table 3 foster a collaborative environment, bringing together stakeholders from different sectors to address challenges in cacao farming. By disseminating pertinent information and offering

technical assistance, these approaches ensure that all involved parties are well-informed and actively participate in seeking sustainable solutions. Through interdisciplinary collaboration and community engagement, the cacao farming sector can flourish,

yielding benefits for farmers, consumers, and the environment. Research has shown that effective science communication plays a vital role in enhancing interdisciplinary cooperation and community involvement in projects (Besley & Nisbet, 2013). Tailoring communication materials to specific stakeholders' needs promotes their active engagement and ownership of the project (Bubela *et al.*, 2009). Such inclusive communication fosters a deeper understanding of complex issues and encourages innovative problem-solving (Fischhoff, 2013). Furthermore, involving diverse stakeholders in decision-making processes improves the implementation and sustainability of development initiatives (Cacciatore *et al.*, 2016). As a result, the cacao farming sector can achieve long-term success, ensuring economic growth, social equity, and environmental conservation in cacao-producing regions.

On Fostering inclusivity and equity in community development initiatives

Table 4 illustrates science communication strategies aimed at fostering inclusivity and equity in community development initiatives. The identified stakeholders, including Government Officials, Academia, Industry, Civil Society, and the Public, each have specific roles and communication

approaches to promote inclusivity and equity. Government Officials are crucial in advocating for inclusive policies and equitable resource allocation, ensuring that development initiatives prioritize marginalized communities and address their unique needs. Academia's role involves offering Capacity-Building Programs that empower marginalized groups with valuable skills and knowledge, providing them with opportunities for social and economic advancement. The Industry's contribution lies in promoting Market Linkages and Fair Trade Initiatives, enabling marginalized groups to access fair and equitable market opportunities, thus bridging economic disparities. Civil Society plays a pivotal role in fostering inclusivity by facilitating Community Engagement Platforms and Cultural Exchanges, giving marginalized groups a voice and space for active participation in decision-making processes. Lastly, the Public's involvement is vital, gathering feedback from all community members through Community Surveys and Feedback Mechanisms, ensuring that development initiatives reflect the needs and aspirations of the entire community. By employing these science communication strategies, community development initiatives can become more inclusive, equitable, and impactful, leading to improved social cohesion and sustainable progress for all members of the community.

Table 4. Science Communication on Fostering inclusivity and equity in community development initiatives

Science Communication Objectives	Intended Stakeholders	Communication Materials	Communication Activities
Foster inclusivity and equity in community development initiatives.	Government Officials	Inclusive Policies	Advocate for inclusive policies and resource allocation.
	Academia	Capacity-Building Programs	Offer training programs to marginalized groups.
	Industry	Market Linkages, Fair Trade Initiatives	Promote fair and equitable market opportunities.
	Civil Society	Community Engagement Platforms, Cultural Exchanges	Facilitate platforms for marginalized groups to participate.
	Public	Community Surveys, Feedback Mechanisms	Gather feedback from all community members for decision-making.

Through the active involvement of Government Officials, Academia, Industry, Civil Society, and the Public, these approaches aim to prioritize marginalized communities and address their unique needs. Government Officials' advocacy for inclusive policies and equitable resource allocation (Besley & Nisbet, 2013) ensures that development efforts are directed towards marginalized groups, promoting social equity. Academia's Capacity-Building Programs empower marginalized communities with skills and knowledge (Bubela *et al.*, 2009), creating opportunities for social and economic advancement. The Industry's promotion of Market Linkages and Fair Trade Initiatives (Fischhoff, 2013) bridges economic disparities, granting marginalized groups access to equitable market opportunities. Civil Society's facilitation of Community Engagement Platforms and Cultural Exchanges (Cacciatore *et al.*, 2016) provides marginalized communities with a voice in decision-making processes, enhancing inclusivity. Lastly, the Public's involvement through Community Surveys and Feedback Mechanisms (Nisbet & Scheufele, 2009) ensures that development initiatives align with community aspirations. Implementing these strategies can lead to enhanced social cohesion and sustainable progress, benefiting all members of the community.

On Sustaining positive perception and enthusiasm among parents and families.

Table 5 outlines science communication strategies aimed at sustaining positive perception and enthusiasm among parents and families. The main objective is to actively engage and involve parents in the project activities to foster a sense of ownership

and support for the initiatives. Government Officials are provided with Project Updates and Impact Reports, which keep them informed about the progress and success of the project. By sharing these reports, officials can see the tangible benefits of the project and advocate for continued support and funding. Academia's role involves conducting Parental Engagement Workshops, providing a platform for parents to actively participate in the project's activities. These workshops enable parents to understand the project's objectives, contribute their ideas, and actively engage in their children's learning experiences, which positively impacts parental perception and enthusiasm. The Industry's contribution lies in organizing Community Showcases, where they demonstrate the impact of the project on livelihoods and the community. By showcasing the project's tangible benefits, industry stakeholders can strengthen parents' positive perception and enthusiasm, as they witness the direct outcomes of the initiatives. Civil Society plays a crucial role in hosting Family-oriented Activities and Community Celebrations, which provide opportunities for parents and families to come together and celebrate project milestones. These events foster a sense of belonging and pride in the community, further enhancing support and enthusiasm among parents. The Public's involvement is essential in featuring Community Testimonials and Success Stories, particularly from parents. By sharing these inspiring stories, the wider public becomes more connected to the project's goals and achievements, leading to increased support and positive perception.

Table 5. Science Communication on Sustaining positive perception and enthusiasm among parents and families.

Science Communication Objectives	Intended Stakeholders	Communication Materials	Communication Activities
5. Sustain positive perception and enthusiasm among parents and families.	Government Officials	Project Updates, Impact Reports	Share progress and success reports with government officials.
	Academia	Parental Engagement Workshops	Conduct workshops to involve parents in project activities.
	Industry	Community Showcases	Organize events showcasing the impact on livelihoods.
	Civil Society	Family-oriented Activities, Community Celebrations	Host family-oriented events to celebrate project milestones.
	Public	Community Testimonials, Success Stories	Feature success stories and testimonials from parents.

The implications of science communication strategies that engage parents and families in community development initiatives are significant and well-supported by recent research. Studies have shown that involving parents in their children's education and community projects leads to improved outcomes and increased student achievement (Fan & Chen, 2020; Hill & Tyson, 2009). Positive parental perception and enthusiasm have been identified as crucial factors in sustaining the success and long-term impact of such initiatives (Christenson *et al.*, 2016). When parents are active stakeholders and advocates for the project, it enhances their sense of ownership and commitment, contributing to stronger community support and sustained benefits (McWayne *et al.*, 2012). By fostering a collaborative environment that includes parents and families, community development projects can tap into their valuable insights, support, and contributions, resulting in more effective and sustainable outcomes (Grolnick & Slowiaczek, 1994; Nye *et al.*, 2021). Therefore, effective science communication that sustains positive perception and enthusiasm among parents and families is crucial for ensuring the success and lasting impact of community initiatives, ultimately benefiting the entire community.

Conclusion

This qualitative study on the School + Home Cacao Project has demonstrated the significance of science communication in enhancing community engagement and supporting sustainable development in rural areas. By integrating data from multiple sources and utilizing directed qualitative content analysis, the research has developed a comprehensive science communication plan that effectively engages stakeholders from government, academia, industry, civil society, and the public. The plan, inspired by the Penta Helix Model, fosters collaborative efforts and knowledge exchange among diverse stakeholders, ultimately driving positive change and progress in the Municipality of Lasam, Cagayan, Philippines. The study's findings have shed light on the motivations and perspectives of key stakeholders, revealing their commitment to community development and the

importance of interdisciplinary collaboration and inclusivity. Government officials' support, academia's expertise, industry's market linkages, civil society's advocacy, and the public's enthusiasm collectively contribute to the success of the School + Home Cacao Project. This project exemplifies the power of the Penta Helix Model in orchestrating joint efforts for sustainable development. The science communication plan presented in this research serves as a roadmap for higher education institutions and community development workers, providing insights into effectively communicating research outputs and driving community development initiatives. By utilizing tailored communication materials and activities, such as workshops, seminars, and digital platforms, the plan maximizes stakeholder engagement and ownership. Additionally, sustaining positive perception and enthusiasm among parents and families reinforces community support and involvement, key elements for the project's long-term impact. The School + Home Cacao Project serves as a model for other community development initiatives worldwide. By adopting effective science communication strategies and leveraging the collaborative potential of the Penta Helix Model, similar projects can address complex challenges, promote sustainability, and foster equitable and inclusive development. As science communication continues to play a pivotal role in bridging the gap between research and practice, it becomes an indispensable tool for driving meaningful outcomes in community development. This study contributes to the growing body of knowledge on science communication and its role in community development. The School + Home Cacao Project exemplifies the transformative potential of effective communication and collaborative efforts, showcasing how stakeholders from different sectors can unite to achieve sustainable and impactful outcomes. By replicating and adapting the science communication plan, higher education institutions and community development workers can empower communities, drive positive change, and pave the way for a more equitable and prosperous future.

The findings and science communication plan developed through this study hold several important implications for both practice and research in the field of community development and science communication. This study on the school + Home Cacao Project has provided valuable insights into the power of science communication in driving community development and sustainability. The science communication plan proposed for the project serves as a roadmap for higher education institutions and community development workers to effectively engage stakeholders and achieve positive outcomes. The recommendations put forth emphasize the importance of collaboration, monitoring, and scaling up initiatives to create lasting impacts, while the implications highlight the significance of empowering local communities through inclusive communication. Future research directions can further enrich the field of science communication by exploring comparative studies, innovative communication tools, and cultural influences on development projects, ultimately contributing to more effective and sustainable community development practices worldwide.

Recommendation

Based on the insights gained from this study, it is recommended that other community development projects consider adopting the Penta Helix Model and implementing effective science communication strategies. By fostering multi-stakeholder collaboration and inclusive communication, projects can harness the collective expertise and resources of diverse stakeholders to achieve sustainable and positive outcomes.

Implication

The findings of this study highlight the importance of empowering local communities through scientific literacy and inclusive communication. By providing communities with access to knowledge and information, they can actively participate in decision-making processes and contribute to the success of development initiatives.

Limitation

One limitation of this study is the focus on a specific geographical area, the Municipality of Lasam in the Philippines. While the School + Home Cacao Project serves as an insightful case study, future research should explore the generalizability of the science communication plan and the Penta Helix Model in different contexts and regions.

Future research direction

To further enrich the field of science communication and community development, future research can explore the integration of innovative communication tools, such as social media and virtual reality, to engage diverse audiences effectively. Additionally, conducting comparative studies between different community development projects and their science communication approaches can provide valuable insights into best practices and strategies for achieving sustainable outcomes. Furthermore, investigating the role of culture in shaping attitudes towards sustainable development initiatives can inform the design of culturally relevant and impactful science communication strategies.

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