Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram
https://e-journal.undikma.ac.id/index.php/prismasains/index
e-mail: prismasains.pkpsm@gmail.com

April 2026. Vol. 14, No. 2
p-ISSN: 2338-4530
e-ISSN: 2540-7899
pp. 995-1033

Sciencepreneurship-Based Community Empowerment Model for Developing Appropriate Technology to Improve Rural Communities' Entrepreneurial Intention

***Zulpan, Saiful Prayogi, Nova Kurnia**

Master of Science Education Study Program, Universitas Pendidikan Mandalika, Mataram, Indonesia

*Corresponding Author e-mail: zulpan@undikma.ac.id

Received: March 2026; Revised: March 2026; Published: April 2026

Abstract

This study aimed to evaluate the effectiveness of a sciencepreneurship-based community empowerment model in developing appropriate technology to improve the entrepreneurial intention (EI) of rural communities. The study was conducted in Krayan Jaya Village, Long Ikis District, Paser Regency, East Kalimantan, involving 40 participants divided into two groups: an appropriate technology group for producing tote bags made from spunbond fabric (Group A) and an appropriate technology group for developing a solar-powered water pump (Group B). This study employed a mixed-methods approach with an explanatory sequential design. The quantitative phase used a quasi-experimental multi-group pretest-posttest design, while the qualitative phase involved observation and semi-structured interviews. Entrepreneurial intention was measured using a 20-item Likert-scale questionnaire covering entrepreneurial orientation, internal motivation, risk-taking courage, and self-perception as a prospective entrepreneur. The data were analysed using descriptive statistics, assumption testing, the Wilcoxon signed-rank test, N-gain, ANCOVA, and thematic analysis. The results showed that the mean EI score of Group A increased from 50.80 to 78.45, with an N-gain of 0.56, while that of Group B increased from 52.00 to 74.50, with an N-gain of 0.48. The Wilcoxon test indicated significant improvement in both groups ($p < 0.001$). ANCOVA showed a significant difference in effectiveness between the groups after controlling for pretest scores ($F = 7.156$; $p = 0.011$; partial eta squared = 0.162), with the adjusted mean of Group A higher than that of Group B. The qualitative data revealed that involvement in appropriate technology development, institutional support, and business opportunities strengthened EI, whereas limited capital, fear of failure, technical complexity, and marketing challenges acted as barriers. This model is relevant for participatory, contextual, and sustainable rural community empowerment, particularly when supported more systematically by village-owned enterprises and local facilitators.

Keywords: Sciencepreneurship; Appropriate technology; Entrepreneurial intention; Community empowerment; Rural communities

How to Cite: Zulpan, Z., Prayogi, S., & Kurnia, N. (2026). Sciencepreneurship-Based Community Empowerment Model for Developing Appropriate Technology to Improve Rural Communities' Entrepreneurial Intention. *Prisma Sains: Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*, *14*(2), 995–1033. https://doi.org/10.33394/j-ps.v14i2.20942

https://doi.org/10.33394/j-ps.v14i2.20942

INTRODUCTION

Entrepreneurial intention (EI) has increasingly been discussed in entrepreneurship studies because it is regarded as a psychological "gateway" preceding actual entrepreneurial behaviour. Entrepreneurial intention refers to an individual's psychological readiness and commitment to starting a business, reflected in entrepreneurial orientation, internal motivation, risk-taking courage, and self-perception as a prospective entrepreneur (Hulyadi et al., 2025). EI does not merely represent a temporary desire to start a business, but also indicates the extent to which individuals are able to assess opportunities, consider risks, and feel capable of making decisions and managing a business. From this perspective, EI becomes an important construct for understanding why some individuals are encouraged to choose entrepreneurship, while others remain within conventional employment patterns or less productive economic activities.

At the community level, EI is often associated with economic growth, job creation, and social transformation. Various studies have shown that communities with relatively high EI tend to be more responsive to new economic opportunities and better prepared to diversify their economic activities, thereby increasing their resilience to economic shocks (Ferreira & Lisboa, 2019; Stoica et al., 2020). However, the relationship between EI and economic progress should not be understood simplistically as always positive. Without adequate institutional support, market access, business literacy, and social protection, entrepreneurial motivation may result in vulnerable micro-enterprises, excessive competition in local markets, or unsustainable economic activities. Therefore, community EI needs to be understood as the result of interactions among individual psychological factors, community social capacity, and the structure of opportunities available in the local environment.

In rural contexts, low entrepreneurial intention is an important issue because it has direct implications for economic independence and the sustainability of village development. Rural communities with low EI tend to remain in traditional economic activities with limited added value, depend on seasonal work, and show limited motivation to develop new businesses based on local innovation. This condition does not necessarily indicate the absence of economic potential in villages, but is more often related to the suboptimal capacity of communities to recognize, process, and transform local potential into productive business opportunities. Several studies have shown that low EI in rural communities is influenced by a combination of structural, cultural, and psychological factors that are interconnected, so it cannot be adequately explained by a single factor (Yuan et al., 2022; McGehee & Kline, 2008; Runcan, 2020).

Financial limitations are often the first explanation when discussing low EI in rural areas. Limited access to capital, collateral, and appropriate financing schemes makes prospective entrepreneurs reluctant to start businesses and more likely to avoid risks they cannot afford to bear (Yuan et al., 2022; Runcan, 2020). Rural workers generally do not have sufficient savings to cover start-up costs and potential losses, while formal financing programs often require administrative procedures that are difficult to meet. However, the main issue is not simply the absence of capital, but the suitability of financing program design to the social, economic, and institutional characteristics of rural communities. Several examples show that microfinance schemes and local financial institutions can support the growth of small enterprises when designed according to the needs and capacities of rural communities (Huang et al., 2022).

In addition to capital, education and skills development also play major roles in shaping EI among rural communities. Many young people and adults in rural areas have not received adequate entrepreneurship education, either through formal or non-formal pathways, making them less prepared to plan, start, and manage sustainable businesses (Purusottama et al., 2018; Maayoufi et al., 2023). This condition becomes more complex for rural women, who often face multiple barriers, including limited education, domestic responsibilities, and cultural norms that restrict their economic roles in public spaces (Ali et al., 2023; Pham-Ngoc-Huong et al., 2025; Yadav et al., 2023). At the same time, psychological factors such as fear of failure, low self-efficacy, and limited experience in managing businesses also weaken individuals' readiness to enter entrepreneurship, even when economic opportunities are available in their surroundings (Baldo et al., 2023; Yao & Lian, 2022).

Social and cultural dimensions also influence EI in rural communities in ways that are not always straightforward. On the one hand, traditional norms and conservative cultures may foster risk aversion and encourage preferences for jobs perceived as stable, thereby weakening interest in entrepreneurship (McGehee & Kline, 2008; Banerjee et al., 2025). The absence of local entrepreneurial role models and weak entrepreneurial networks also make it difficult for prospective entrepreneurs to imagine realistic models of success (Dahalan et al., 2015). On the other hand, strong social networks in villages can serve as important social capital for collaboration, knowledge sharing, risk distribution, and product marketing. Thus, the rural social context contains both barriers and potential for strengthening EI, depending on how this social potential is organized through an appropriate empowerment model.

In this situation, an approach is needed that does not only provide capital or short-term training, but also connects scientific knowledge, technological innovation, and business opportunities that are relevant to the needs of rural communities. One approach that can be used is sciencepreneurship. Conceptually, sciencepreneurship can be understood as an approach that integrates scientific understanding, technological skills, innovative creativity, and entrepreneurial orientation to generate productive solutions to real problems in society. In rural contexts, sciencepreneurship does not only emphasize the ability to create business products, but also the ability to use scientific principles to understand local problems, design appropriate technology, test product feasibility, and develop economic value from village potential.

The sciencepreneurship approach is relevant because many rural economic problems are actually related to simple science and technology issues that have not been productively addressed. These include agricultural products with low added value, underutilized organic waste, small-scale water and energy management, local product packaging that does not yet meet market standards, and weak innovation in production processes. Such problems cannot be solved merely through entrepreneurial motivation. Communities need scientific understanding, technical skills, experimentation abilities, and mentoring to transform this knowledge into appropriate technology and business opportunities. Thus, sciencepreneurship provides a stronger basis for community empowerment because it connects science as a way to understand problems, technology as a problem-solving tool, and entrepreneurship as a mechanism for creating economic value.

Appropriate technology within the sciencepreneurship framework refers to technology that is designed, developed, and utilized according to the needs, resources, capacities, and social context of rural communities. Appropriate technology should not be understood merely as a simple or inexpensive production tool, but as the result of a process involving problem identification, application of scientific principles, technology adaptation, benefit testing, and business potential development. Therefore, appropriate technology developed through sciencepreneurship should not be top-down or simply delivered to communities as ready-made technological packages. It needs to be developed through active community participation so that the resulting technology is genuinely relevant, usable, maintainable, and has the potential to be developed into a productive business.

Sciencepreneurship-based appropriate technology has the potential to promote innovation in rural communities by connecting local knowledge, scientific principles, and adaptive technology. When rural communities are able to develop and adapt technologies that are relevant to community needs, they can produce solutions to specific problems such as agricultural processing, waste management, simple energy utilization, or improving the quality of local products, while also opening new business opportunities (Sedeh et al., 2021; Mohammadali & Abdulkhaliq, 2019). Studies on innovation-based entrepreneurship show a relationship among innovative culture, entrepreneurial dynamics, and economic performance (Ferreira & Lisboa, 2019; Stoica et al., 2020). However, technological innovation that is oriented only toward production efficiency without considering access, participation, and the distribution of benefits may strengthen the dominance of certain groups in the village. Therefore, sciencepreneurship needs to be placed within a participatory community empowerment framework that is sensitive to local social structures.

The development of an increasingly collaborative entrepreneurial ecosystem, supported by advances in digital platforms, also opens new opportunities for strengthening sciencepreneurship-based appropriate technology. Broader access to information, networks, technical knowledge, and markets enables rural communities to connect with actors beyond their local communities, allowing innovation diffusion to occur more rapidly (Hoz-Rosales et al., 2019; Makhdoom et al., 2019). In this context, sciencepreneurship can become a meeting point between local knowledge, scientific literacy, adaptive technology, and external resources. However, digital opportunities also need to be examined critically because gaps in digital literacy, limited telecommunications infrastructure, and unequal access to information in rural areas remain real constraints. Strategies for developing appropriate technology through sciencepreneurship must take these conditions into account so that the benefits do not only flow to groups that already have better access to technology and information.

Sciencepreneurship-based appropriate technology can also be linked to efforts to improve economic welfare and social progress more equitably. By connecting technology development with business opportunities, rural communities can expand income sources, reduce dependence on a single commodity, and strengthen economic resilience through business diversification (Stoica et al., 2020; Khatani et al., 2021). Appropriate technology developed through scientific and entrepreneurial principles can help communities use local resources more efficiently, increase the added value of products, and design economic activities that are more adaptive to market and environmental changes (Sedeh et al., 2021; Mohammadali & Abdulkhaliq, 2019). Nevertheless, this success depends strongly on local institutional capacity, the quality of mentoring, program sustainability, and the ability of communities to manage technology as part of a business system, rather than merely as a production tool.

In relation to EI, the sciencepreneurship approach is considered to have the potential to foster entrepreneurial intention among rural communities because it makes business opportunities more concrete, closer, and learnable. By introducing appropriate technology that is simple, affordable, and relevant to economic activities already familiar to the community, technical and psychological barriers to starting a business can be reduced (Malebana, 2014; Ali & Yousuf, 2019). Exposure to scientific processes in the development of appropriate technology, such as observing problems, designing solutions, conducting trials, evaluating results, and improving products, can help villagers see that innovation is not something distant from their daily lives. This process has the potential to increase perceived capability, risk-taking courage, and the belief that businesses based on simple technology can realistically be implemented.

Education and training within the sciencepreneurship framework also play important roles in shaping EI among rural communities. Training programs that integrate scientific knowledge, technical skills, and managerial abilities such as financial management, pricing, marketing, and production organization can increase self-efficacy and readiness to start a business (Dahalan et al., 2015; Ebewo et al., 2017). Unlike entrepreneurship training that focuses only on motivation or business plan preparation, sciencepreneurship-based training positions community members as actors who learn to understand problems, develop technology, test products, and assess their economic potential. Empirical findings show that improved understanding and skills in entrepreneurship and technology are correlated with increased intention to start new businesses (Silveyra-León et al., 2023; Gujrati et al., 2019), although the conversion of intention into actual action remains influenced by access to capital, family support, social networks, and market opportunities.

Social and cultural factors also mediate the influence of sciencepreneurship on EI in rural communities. In many villages, extended families, social networks, local leaders, and communities become important references in economic decision-making. Access to role models who have successfully used appropriate technology for business activities can strengthen the belief that simple technology-based businesses are worth trying and can produce real benefits (Ali & Yousuf, 2019). Community support for sciencepreneurship-based appropriate technology initiatives can create a more conducive climate for experimentation, collaboration, and innovation, thereby fostering collective efficacy and community EI

(Silveyra-León et al., 2023). However, if social norms view new technologies as foreign, risky, or contrary to local habits, sciencepreneurship initiatives may face resistance. Therefore, intervention design needs to be sensitive to social, cultural, and power relations at the village level.

The potential of sciencepreneurship to develop appropriate technology and improve EI cannot be separated from the need for an adequate community empowerment model. This approach is unlikely to develop if it is introduced only as a training project or a ready-made technology package without involving villagers in the processes of needs identification, solution design, technology testing, and business management. An empowerment model that emphasizes participation, capacity strengthening, collaboration, and sustainability is important to ensure that appropriate technology is truly adopted and used by the community. Initiatives such as self-help groups show that organizing communities into small groups can improve bargaining positions, self-confidence, and collaboration capacity, particularly among women (Ghosh et al., 2023). Such groups can serve as social learning spaces for developing sciencepreneurship-based appropriate technology, although their effectiveness still depends on the quality of facilitation, policy support, and sustained mentoring.

Recognition and integration of local cultural values in the empowerment model are also important factors in developing sciencepreneurship-based appropriate technology. Technologies and business models that are not aligned with local norms, social structures, gender roles, and economic practices risk being rejected or used only by certain groups (Ghouse et al., 2017). Conversely, when technology design and business schemes consider the village social context, acceptance and sustainability tend to be higher. The involvement of formal and informal village leaders can help bridge tensions between innovation and tradition. However, the involvement of local leaders also needs to be managed carefully so that community participation does not become symbolic and does not reinforce the dominance of certain actors in decision-making.

Education and training placed within a community empowerment framework can strengthen residents' capacity to manage sciencepreneurship-based appropriate technology. Training programs focused on practical skills, applied science understanding, problem-solving abilities, market understanding, and innovation capacity can help rural communities become better prepared to face complex business challenges (Mahn et al., 2022). Such interventions have the potential to improve EI by improving self-perception, reducing fear of failure, strengthening experiences of success, and broadening perspectives on diverse business opportunities based on local potential (Baldo et al., 2023). However, without addressing structural barriers such as limited infrastructure, weak access to market information, lack of financing support, and weak long-term policies, increased individual capacity may remain at the level of intention without being converted into real entrepreneurial action.

In the literature on rural economic empowerment, the development of village-owned enterprises, or BUMDes, is often mentioned as an important strategy for consolidating resources and reducing individual risk (Kania et al., 2021). Through BUMDes, communities can manage collective investments in appropriate technology, such as agricultural processing units, shared production facilities, economically valuable waste management, or simple technology-based services. Such institutional structures create opportunities for villagers to participate in sciencepreneurship-based businesses without having to bear all risks personally. However, the success of BUMDes in increasing EI does not occur automatically. Governance, transparency, accountability, managerial capacity, and benefit distribution often become weak points that need to be considered in designing an empowerment model.

Various studies show that empowerment strategies that simultaneously address barriers related to capital access, infrastructure, training, social networks, and institutional support can promote entrepreneurial activity in rural areas (Ge et al., 2022; Ghouse et al., 2021). In this study, a sciencepreneurship-based community empowerment model is understood as a systemic effort to connect scientific literacy, technical capacity strengthening, appropriate technology development, group organization, social network strengthening, and local institutional arrangement to improve the EI of rural communities. Nevertheless, empirical evidence that specifically evaluates the effectiveness of a sciencepreneurship-based community empowerment model in developing appropriate technology to improve rural communities' EI remains relatively limited, particularly in developing countries such as Indonesia.

This knowledge gap underscores the need for research that explicitly examines how a sciencepreneurship-based community empowerment model is designed, implemented, and how it affects EI among rural communities. This study is important not only to determine whether EI increases after the intervention, but also to understand how the process of appropriate technology development, group dynamics, village institutional support, applied science learning experiences, and perceptions of business opportunities influence the strengthening or weakening of EI. Therefore, this study is expected to provide conceptual and practical contributions to the development of rural empowerment models that are more contextual, participatory, science-based, and oriented toward the creation of local economic value.

Based on the above discussion, this study aims to evaluate the effectiveness of a sciencepreneurship-based community empowerment model in developing appropriate technology to improve the entrepreneurial intention of rural communities, as well as to explore the factors that influence the strengthening or weakening of entrepreneurial intention in the context of implementing the model. The research questions are formulated as follows.

1. How effective is the sciencepreneurship-based community empowerment model in developing appropriate technology to improve the entrepreneurial intention of rural communities?
2. What factors influence the strengthening or weakening of entrepreneurial intention among rural communities in the context of implementing a sciencepreneurship-based community empowerment model?

LITERATURE REVIEW

Entrepreneurial Intention

Entrepreneurial intention (EI) is a key concept for understanding why individuals choose or do not choose the entrepreneurial path. EI is generally understood as an individual's tendency, intention, or predisposition to start a new business, and many studies position it as an important predictor of actual entrepreneurial behaviour. This means that before individuals actually establish a business, a relatively stable intention is usually formed, although not all intentions result in action. This intention-based approach emphasizes that the decision to become an entrepreneur is not merely the result of short-term situational impulses, but rather the outcome of a relatively complex cognitive and affective process. In the context of rural communities, EI is important because entrepreneurial intention is not only related to individual choice, but also to the community's ability to recognize opportunities, utilize local resources, and develop more productive economic activities.

One of the most widely used theoretical frameworks for explaining EI is the Theory of Planned Behavior (TPB) developed by Ajzen (1991). TPB states that behavioural intention, including entrepreneurial intention, is determined by three main components: attitude toward the behaviour, subjective norms, and perceived behavioural control (Paço et al., 2011). Attitude refers to an individual's positive or negative evaluation of entrepreneurial activity. Subjective norms relate to the perceived social pressure to perform or not perform entrepreneurial actions. Perceived behavioural control describes an individual's perception of the ease or difficulty of starting a business. This model is useful because it systematically explains the psychological factors that can encourage or inhibit EI, particularly among students and prospective young entrepreneurs (Lakmal & Fernando, 2023; Mawardi et al., 2022). However, TPB also needs to be read critically because it sometimes places too much emphasis on rational cognitive aspects and does not fully capture emotional dynamics, structural uncertainty, and contextual factors that are specific to rural areas.

Many empirical findings support the use of TPB in predicting EI. Individuals who have positive attitudes toward entrepreneurship, feel supported by their social environment, and have a strong sense of capability to run a business tend to demonstrate stronger EI (Caputo et al., 2024; Bayona-Oré, 2023). Nevertheless, cross-contextual studies also show that the strength of each TPB component may vary. In some studies, attitude and perceived behavioural control are more dominant, while subjective norms have a weaker influence. In other contexts, particularly in collectivist communities, social norms may become a relatively strong determinant. This indicates that intention models cannot be applied uniformly without considering the cultural characteristics, social structures, and economic conditions in which individuals live. In rural contexts, the decision to engage in entrepreneurship is often determined not only by personal willingness, but also by family support, community acceptance, access to social capital, and legitimacy from local actors.

To complement TPB, a number of researchers have integrated other frameworks, such as Social Cognitive Theory and Self-Determination Theory. Social Cognitive Theory emphasizes the role of self-efficacy, observation of role models, and reciprocal interaction between individuals and their environment, while Self-Determination Theory emphasizes the quality of motivation, both intrinsic and extrinsic, as a driver of intention (Al-Jubari et al., 2019; Nyoko & Hanafiah, 2024). This integration enriches the understanding of EI by highlighting how individual characteristics, environmental support, learning experiences, and motivational quality interact with one another. However, this multi-theoretical approach also creates conceptual challenges because the definitions and indicators of EI become increasingly diverse. Therefore, studies using EI need to formulate indicators clearly so that the construct being measured does not become conceptually blurred.

One relatively consistent finding in the literature is the role of entrepreneurship education interventions in shaping EI. Entrepreneurship learning and training programs designed to strengthen business knowledge, practical skills, and self-efficacy have been shown to improve EI, particularly among university students (Soria-Barreto et al., 2016; Bhunia & Shome, 2023). Exposure to entrepreneurial role models and direct experience through real entrepreneurship projects has also been reported to strengthen the intention to start a business (Bhunia & Shome, 2023; Bayona-Oré, 2023). However, not all studies report positive results. Some findings show that after receiving more complete information about risks, market uncertainty, and the difficulties of managing a business, some participants become more cautious, meaning that EI does not always increase. This suggests that the effectiveness of entrepreneurship education is strongly influenced by program design, the quality of facilitation, the direct experience provided, and the suitability of the program to participants' socio-economic contexts.

Based on this synthesis, EI in this study is positioned as a latent psychological construct that can be measured through more specific indicators. Entrepreneurial intention is understood as an individual's psychological readiness and commitment to starting a business, reflected in entrepreneurial orientation, internal motivation, risk-taking courage, and self-perception as a prospective entrepreneur (Hulyadi et al., 2025). By adapting the parameters proposed by Hulyadi et al. (2025), this study does not only capture an abstract "desire" to become an entrepreneur, but also the dimensions of value orientation, motivational strength, courage in facing risk, and belief in one's own capability. In the context of a sciencepreneurship-based community empowerment model, these indicators are relevant because the development of appropriate technology does not only require business interest, but also the ability to understand local problems, process scientific knowledge, test technological solutions, and assess their economic potential.

Sciencepreneurship in the Context of Community Empowerment

In this study, sciencepreneurship is understood as an approach that integrates scientific knowledge, technological skills, innovative creativity, and entrepreneurial orientation to generate productive solutions to real problems in society. Unlike general entrepreneurship, which may rely on trade or service activities without a strong scientific basis, sciencepreneurship places science at the centre of recognizing problems, explaining causes, designing solutions, testing feasibility, and developing the economic value of those solutions. Thus, sciencepreneurship is not only related to the ability to sell products, but also to the ability to transform scientific knowledge into technology, products, processes, or services that are useful for society.

In the context of rural community empowerment, sciencepreneurship is relevant because many village potentials remain underdeveloped not simply because of a lack of capital, but because of limited capacity to process local resources scientifically and productively. Agricultural commodities, organic waste, water resources, simple energy sources, local materials, and traditional products often have limited added value because they have not been sufficiently touched by innovation processes. This is where sciencepreneurship can function as an empowerment approach that connects local knowledge with the principles of applied science. Communities are not only invited to "become entrepreneurs," but also to learn to understand material characteristics, production processes, energy efficiency, product quality, safety, packaging, and market opportunities. In this way, the empowerment process becomes more substantive because residents are positioned as subjects who learn, experiment, and generate solutions.

The sciencepreneurship approach is also important because it can strengthen the relationship between science education and the economic life of communities. In many empowerment programs, science is often not explicitly present as the basis for designing interventions. Training programs generally emphasize business motivation, simple management, or the provision of tools. In fact, the success of appropriate technology depends heavily on the community's ability to understand the working principles of the technology, maintain the tools, modify the process, and evaluate product quality. If the scientific aspect is neglected, appropriate technology risks being understood only as a technical object received from outside, rather than as the result of a community learning and innovation process. Therefore, a sciencepreneurship-based empowerment model needs to provide space for communities to identify problems, explore local potential, design appropriate technology, test products, reflect on results, and develop businesses participatively.

In relation to EI, sciencepreneurship can strengthen entrepreneurial intention through direct experience in developing science-based solutions. When communities are involved in observing problems, designing simple technologies, conducting trials, improving products, and seeing the economic opportunities arising from these processes, they gain mastery experiences that can increase self-efficacy. Such experiences have the potential to strengthen positive attitudes toward entrepreneurship, foster the belief that businesses can be developed using local resources, and reduce fear of risk. This is consistent with the view that EI is shaped not only by business knowledge, but also by perceived capability, internal motivation, environmental support, and concrete experience in productive activities.

However, sciencepreneurship should not be understood too optimistically. Not all rural communities have equal access to knowledge, technology, networks, and institutional support. Groups with higher educational backgrounds, closer relationships with village elites, or better access to information may gain greater benefits than vulnerable groups. Therefore, the implementation of sciencepreneurship in community empowerment needs to be designed in a participatory, inclusive, and locally sensitive manner. Otherwise, this approach may become a technology project that involves only a small group of residents, while other groups remain at the margins of the innovation process. In this study, sciencepreneurship is not positioned as a slogan, but as the basis of an empowerment model that must be visible in program mapping, planning, implementation, and monitoring and evaluation.

Appropriate Technology from a Sciencepreneurship Perspective

From a sciencepreneurship perspective, appropriate technology refers to the use of technology that is designed and adapted according to the needs, resources, capacities, and social context of rural communities, while also being developed as the basis of productive economic activities. Unlike "imported" technology that is often detached from the socio-economic context of the village, appropriate technology within a sciencepreneurship framework emphasizes technical, economic, ecological, and cultural suitability. Technology must not only be operable, but also understandable in terms of its working principles, maintainable by local users, adaptable to village potential, and developable into business opportunities. In this regard, the entrepreneurial aspect remains important, but it does not stand alone. It is connected to the community's ability to use scientific and technological knowledge to create added value from local resources (Sedeh et al., 2021; Mohammadali & Abdulkhaliq, 2019).

Studies on economies that promote innovation-based entrepreneurship show that the integration of innovative culture, entrepreneurial dynamics, and economic performance is relatively strong, especially when the technology used is relevant to local environmental needs (Ferreira & Lisboa, 2019; Stoica et al., 2020). In the sciencepreneurship framework, this relevance can be seen in the ability of appropriate technology to address concrete problems such as agricultural processing, water management, small-scale energy use, waste processing, improving local product quality, or increasing production efficiency. Communities that are able to understand these problems scientifically and adapt suitable technologies can produce community-specific solutions while also opening new business opportunities that absorb labour. However, several studies also remind us that if the main orientation is only production efficiency without attention to fair access and benefit distribution, appropriate technology may reinforce the dominance of certain groups and may not significantly affect vulnerable households in the village.

The development of an increasingly collaborative entrepreneurial ecosystem, supported by digital platforms and open access to information, expands the space for developing appropriate technology from a sciencepreneurship perspective. Broader access to networks, technical knowledge, and markets allows rural entrepreneurs to connect local knowledge with external resources, enabling faster innovation diffusion (Hoz-Rosales et al., 2019; Makhdoom et al., 2019). Ideally, sciencepreneurship-based appropriate technology can function as a meeting point among grassroots innovation, scientific literacy, adaptive technology, and broader economic networks, as long as local communities are not only technology recipients but also actors involved in design and management (Sedeh et al., 2021; Ianioglo, 2022). Here, an important tension emerges. On the one hand, digitalization opens wider market opportunities. On the other hand, gaps in digital literacy and telecommunications infrastructure in rural areas may mean that only some residents are truly able to benefit from these opportunities.

Normatively, appropriate technology from a sciencepreneurship perspective is often associated with the agenda of improving welfare and reducing inequality through the diversification of income sources. By linking technology development with business opportunities, rural communities can reduce dependence on a single commodity and strengthen economic resilience against price fluctuations and climate change (Stoica et al., 2020; Khatani et al., 2021; Sedeh et al., 2021). However, this relationship needs to be interpreted carefully. Relatively positive empirical evidence generally emerges from cases supported by sufficiently strong local institutional capacity and intensive mentoring. Conversely, when appropriate technology is introduced as a short-term project package without a continuation scheme, the technology often does not function optimally, is not maintained, or is used only by a small group of residents. In such conditions, the empowerment narrative becomes weak because the technology does not truly increase community capacity.

From the perspective of entrepreneurial intention, sciencepreneurship-based appropriate technology can function as a trigger that makes business opportunities more visible and realistic for rural communities. By introducing technology that is simple, affordable, close to familiar economic activities, and explainable through applied science principles, technical and psychological barriers to starting a business can be reduced (Malebana, 2014; Ali & Yousuf, 2019). Exposure to technology designed according to the local context can potentially change how villagers view what can be done with the resources they possess, for example through processing, packaging, product quality improvement, or new services based on appropriate technology. Several studies show that familiarity with contextually appropriate technology is associated with increased motivation and courage to enter entrepreneurship (Li et al., 2022; Gulzar & Fayaz, 2021). However, this relationship still depends on family support, social networks, access to capital, and market opportunities that are genuinely accessible to the community.

Therefore, appropriate technology from a sciencepreneurship perspective can be understood as a node connecting scientific knowledge, technological innovation, local entrepreneurship, and rural social structures. On the one hand, appropriate technology offers a way to mobilize local knowledge and resources into more organized and value-added productive businesses. On the other hand, the success of appropriate technology depends on the quality of intervention design, policy support, institutional capacity, and community participation. This framework forms the basis for developing the community empowerment model in this study, which views appropriate technology not only as a technical device, but also as the outcome of a learning, innovation, and science-based entrepreneurship process expected to influence the entrepreneurial intention of rural communities.

Sciencepreneurship-Based Community Empowerment Model for Developing Appropriate Technology Innovation

Community empowerment models in the context of rural development are generally understood as a set of strategies aimed at strengthening the capacity, bargaining position, and independence of residents in managing resources and making decisions related to their economic life. In relation to innovation, empowerment models are not only intended to help communities access programs, but also to create conditions in which rural residents become the main actors in formulating, adapting, and developing solutions, including sciencepreneurship-based appropriate technology innovations. Therefore, a relevant empowerment model is not sufficient if it only transfers technology from outside to the village. It needs to integrate participation, capacity strengthening in applied science, technical skills, entrepreneurial orientation, local economic organization, and mechanisms for evaluating sustainability.

One concrete form of empowerment model frequently discussed is the organization of communities into self-help groups (SHGs). These groups have been reported to improve socio-economic status, particularly among women, through spaces for sharing knowledge, skills, and financial support (Ghosh et al., 2023). Within the sciencepreneurship framework, SHGs can potentially become social laboratories for innovation because members can learn together, experiment, manage risks collectively, and test business ideas based on appropriate technology on a small scale. However, the effectiveness of SHGs depends strongly on the quality of facilitation, consistency of mentoring, and their connection with other village economic institutions. Without these supports, groups can easily become administrative formalities that do little to change power relations and access to innovation opportunities in the village.

The integration of local values and culture is another dimension that determines the success of empowerment models in generating appropriate technology innovation. Technologies and business models that are not aligned with local norms, gender roles, and economic practices risk being rejected or used only by a small number of actors (Ghouse et al., 2017). Conversely, empowerment models that involve formal and informal leaders from the beginning and take village social structures into account tend to have greater opportunities to encourage wider adoption and adaptation of appropriate technology. However, approaches that invoke local wisdom also need to be examined critically because they may be used to legitimize the dominance of certain groups if participation mechanisms are not arranged fairly. This is where the design of a sciencepreneurship-based empowerment model needs to explicitly regulate who is involved, how the voices of vulnerable groups are accommodated, how local knowledge is integrated with applied science, and how decisions regarding appropriate technology innovation are made.

Education and training placed within an empowerment framework are important means of promoting innovation. Training programs that focus on practical skills, market understanding, problem-solving abilities, and innovation capacity help communities become better prepared to manage businesses based on appropriate technology (Mahn et al., 2022). In the context of sciencepreneurship, training needs to include the introduction of scientific principles relevant to the technology, technology operation, tool maintenance, product quality testing, cost analysis, pricing, and marketing strategies. Such training can increase self-efficacy, reduce fear of failure, and broaden residents' imagination about new possibilities in utilizing local resources (Baldo et al., 2023). However, the literature also shows that increasing individual capacity without addressing structural barriers such as infrastructure access, capital, and market information often stops at the level of increased intention, rather than leading to the realization of innovation and new business creation (Ge et al., 2022; Ghouse et al., 2021). In other words, an empowerment model that only emphasizes training is not sufficient to promote sustainable sciencepreneurship-based appropriate technology innovation.

In addition to organizing small groups, the development of local economic institutions such as village-owned enterprises (BUMDes) or Village-Owned Enterprises (VOEs) is also frequently mentioned as part of innovation-oriented empowerment models (Kania et al., 2021). Through BUMDes, communities can manage joint investment in appropriate technology, such as agricultural processing units, shared production facilities, economically valuable waste processing, or simple technology-based services. This institutional form allows for a more equitable distribution of risks and benefits, while also providing an organizational platform for collective learning, network strengthening, and innovation diffusion. However, in many cases, issues of governance, transparency, accountability, and managerial capacity mean that the contribution of BUMDes to innovation and empowerment cannot be assumed to be automatically positive. Therefore, a sciencepreneurship-based empowerment model needs to remain critical of this institutional aspect.

The literature review by Harinurdin et al. (2025) shows that the most common community empowerment models across various contexts follow a staged cycle consisting of mapping, participatory planning, program implementation, and monitoring and evaluation. When this framework is specifically linked to the development of sciencepreneurship-based appropriate technology innovation to improve the entrepreneurial intention of rural communities, the structure of the model can be described as presented in Figure 1.

As shown in Figure 1, the rural community empowerment model consists of four main phases. The first phase is mapping, which focuses on identifying village conditions and appropriate technology opportunities. This phase includes mapping local problems, available resources, potential business opportunities, key actors, and structural barriers that may affect the development of appropriate technology. From a sciencepreneurship perspective, mapping does not merely involve listing village resources, but also identifying problems that can be understood and addressed through applied science principles.

Figure 1. Rural community empowerment model

The second phase is participatory planning, which emphasizes the formulation of program plans involving residents, community groups, facilitators, and BUMDes. This phase also includes the formation of implementation groups that will develop and manage appropriate technology innovation. Community participation is important in selecting the type of appropriate technology, determining work schemes, distributing roles, and formulating realistic business opportunities.

The third phase is program implementation, which includes training, the creation and testing of appropriate technology products, and commercialization through BUMDes or other local business units. In this phase, sciencepreneurship is reflected in applied science learning, technological experimentation, product testing, product improvement, and the development of economic value from appropriate technology.

The fourth phase is program monitoring and evaluation, which focuses on assessing program implementation and outcomes. Monitoring and evaluation do not only examine technical and economic aspects, but also assess changes in participants' capacity, social networks, self-efficacy, risk-taking courage, and entrepreneurial intention. In this study, the four-phase model is positioned as an empowerment framework expected to connect sciencepreneurship processes, appropriate technology development, and the strengthening of rural communities' entrepreneurial intention in a more measurable and evaluable manner.

The Relationship among Sciencepreneurship, Appropriate Technology, and Rural Communities' Entrepreneurial Intention

The relationship among sciencepreneurship, appropriate technology, and EI in rural communities can be understood through mechanisms of capacity change and self-perception. Sciencepreneurship provides learning experiences that connect science with concrete community problems. Appropriate technology becomes the tangible form of applying this knowledge. Meanwhile, EI can increase when communities gain the experience that they are able to understand problems, generate solutions, test technologies, and see business possibilities from the products or processes they develop. Thus, the increase in EI is not expected to emerge merely from entrepreneurial motivation, but from direct experience in creating value through scientific, technological, and economic processes.

Within the TPB framework, this process can influence the three components that shape intention. Attitudes toward entrepreneurship can become more positive when residents see that appropriate technology-based businesses provide real benefits for their economic lives. Subjective norms can be strengthened when families, groups, facilitators, BUMDes, and village leaders support the innovation process. Perceived behavioural control can also increase when residents feel capable of operating technology, understanding production processes, calculating costs, and marketing products. In this way, a sciencepreneurship-based empowerment model has the potential to strengthen EI through psychological, social, technical, and institutional pathways at the same time.

However, this relationship is not automatic. EI may weaken if the appropriate technology developed does not match community needs, is too difficult to operate, has no market opportunity, or is controlled only by certain actors. EI may also fail to develop if the empowerment process is merely symbolic, training is too short, mentoring is not sustained, or BUMDes does not have governance that supports innovation. Therefore, this study is important for testing the effectiveness of a sciencepreneurship-based community empowerment model in developing appropriate technology, while also explaining the factors that strengthen or weaken the entrepreneurial intention of rural communities during its implementation.

METHOD

Research Design

This study employed a mixed-methods approach with an explanatory sequential design (Creswell, 2009). The quantitative approach was used in the first phase to examine the effectiveness of a sciencepreneurship-based community empowerment model in developing appropriate technology to improve the entrepreneurial intention (EI) of rural communities. The qualitative approach was used in the following phase to explain participants' experiences, the dynamics of model implementation, and the factors that strengthened or weakened EI during the implementation of the model.

The quantitative design used in this study was a quasi-experimental design with a multi-group pretest-posttest design. A quasi-experimental design was selected because this study did not use a control group without treatment and did not fully randomize participants. Therefore, the effectiveness of the model was examined through changes in EI scores before and after the intervention in two appropriate technology (AT) development groups, as well as through comparisons between groups after participants' initial conditions were statistically controlled.

Table 1. Research design

Group	Type of AT	Pretest	Treatment	Posttest
Group A	Production of tote bags made from spunbond fabric	O_1 (EI)	X	O_2 (EI)
Group B	Solar-powered water pump	O_1 (EI)	X	O_2 (EI)

Note:
O1 = initial measurement of entrepreneurial intention before the implementation of the model.
O2 = final measurement of entrepreneurial intention after the implementation of the model.
X = implementation of the sciencepreneurship-based community empowerment model in developing appropriate technology.

Both groups received the same intervention framework, namely the sciencepreneurship-based community empowerment model. The main difference was the type of appropriate technology developed. Group A developed appropriate technology for producing tote bags made from spunbond fabric, while Group B developed appropriate technology in the form of a solar-powered water pump. This design enabled the researchers to assess the improvement of EI within each group and compare the effectiveness of the model in two different appropriate technology contexts.

The qualitative approach was used after the quantitative data had been obtained. Its purpose was to deepen the understanding of EI change patterns emerging from pretest-posttest results, observations of model implementation, and participants' experiences during the program. The qualitative focus was directed at factors influencing the strengthening or weakening of EI, such as participants' involvement in appropriate technology development, family and village institutional support, perceptions of business opportunities, limited capital, fear of failure, competition, and the need for technical and marketing assistance.

Research Location and Context

This study was conducted in Krayan Jaya Village, Long Ikis District, Paser Regency, East Kalimantan Province. This location was selected because it has community potential that can be developed through a sciencepreneurship-based empowerment program, particularly in the development of appropriate technology relevant to local needs and rural economic opportunities. The program involved village residents, facilitators, BUMDes, and elements of the village government as part of the empowerment ecosystem.

The context of Krayan Jaya Village was important because this study did not only examine the quantitative improvement of EI, but also sought to understand how rural communities recognized local problems, developed appropriate technology, perceived business opportunities, and received social and institutional support during model implementation. Therefore, the findings of this study should be understood within the context of the Krayan Jaya Village community, rather than as direct generalizations to all villages or all types of appropriate technology.

Research Participants

The participants of this study were residents of Krayan Jaya Village, Long Ikis District, Paser Regency, East Kalimantan Province, who were involved in the sciencepreneurship-based community empowerment program. Participants were selected purposively through coordination with the village government, BUMDes, facilitators, and community groups. The participant criteria included being of productive age, willingness to participate in the entire program, interest in productive economic activities, willingness to be involved in the appropriate technology development process, and willingness to complete the EI pretest and posttest instruments.

The quantitative component involved 40 participants divided into two groups. Group A consisted of 20 participants who developed appropriate technology (AT) for producing tote bags made from spunbond fabric. Group B consisted of 20 participants who developed appropriate technology in the form of a solar-powered water pump. Both groups were drawn from the Krayan Jaya Village community and participated in empowerment activities according to the stages of the established model.

Table 2. Profile of research participants

AT group	Type of AT	N	Male	Female	Age	Dominant occupations
A	Production of tote bags made from spunbond fabric.	20	9	11	27-45 years	Traders, entrepreneurs, self-employed workers, plantation workers.
B	Solar-powered water pump.	20	11	9	27-45 years	Self-employed workers, traders, farmers, entrepreneurs.
Total	-	40	20	20	27-45 years	Various productive economic occupations.

Participants in the qualitative component were a sub-sample of members from both groups, selected purposively. Informant selection considered their involvement in the program, their experiences in appropriate technology development activities, and variations in EI changes reflected in the quantitative results. In addition to group members, qualitative informants also included facilitators involved in program implementation. The facilitator profile is presented in Table 3.

Table 3. Profile of empowerment program facilitators

Facilitator code	Gender	Main role in the program	Empowerment experience
F1	Male	Main facilitator/field coordinator	8-10 years
F2	Female	Technical facilitator for the production of tote bags made from spunbond fabric	5-7 years

Facilitator code	Gender	Main role in the program	Empowerment experience
F3	Male	Technical facilitator for the solar-powered water pump	4-6 years

The number of qualitative informants followed the principle of information sufficiency. Interview data collection was stopped when the information obtained was adequate to explain the factors influencing the strengthening or weakening of EI in the context of implementing the sciencepreneurship-based community empowerment model.

Implementation Procedure of the Empowerment Model

The sciencepreneurship-based community empowerment model was implemented among residents of Krayan Jaya Village, Long Ikis District, Paser Regency, East Kalimantan Province. The model was implemented through four phases: mapping, participatory planning, program implementation, and monitoring and evaluation. These four phases were not merely understood as general empowerment stages, but as a sequence for applying sciencepreneurship by integrating scientific understanding, appropriate technology development, and rural communities' entrepreneurial orientation.

The first phase was mapping the conditions of Krayan Jaya Village, local problems, resource potential, and appropriate technology-based business opportunities. In this phase, the researchers and facilitators, together with community representatives, identified problems relevant to the daily lives of village residents and potentials that could be developed through simple scientific principles. The mapping also included the identification of local actors, such as the village government, BUMDes, facilitators, community groups, and local business actors. The results of this mapping served as the basis for determining the type of appropriate technology to be developed in each group.

The second phase was participatory planning. In this phase, participants and facilitators developed plans for appropriate technology that were considered suitable for local needs, technical capacity, and economic opportunities. Group A was directed toward developing appropriate technology for producing tote bags made from spunbond fabric, while Group B was directed toward developing appropriate technology in the form of a solar-powered water pump. This stage also included role distribution among members, identification of tools and materials, preparation of work plans, and discussion of opportunities to use appropriate technology as the basis for productive economic activities.

The third phase was program implementation. Activities in this phase included simple science training, technical training on appropriate technology, entrepreneurship training, practice in making or testing the appropriate technology, and reflection on business opportunities. Simple science training was intended to help participants understand the basic principles related to the appropriate technology being developed. Technical training emphasized skills in making, operating, testing, or maintaining the technology. Entrepreneurship training focused on strengthening business orientation, simple cost calculation, market opportunity identification, and understanding business risks.

The fourth phase was program monitoring and evaluation. Monitoring was conducted to assess the implementation of the model, participant involvement, group cooperation, participants' ability to understand the relationship between appropriate technology and business opportunities, and the support provided by facilitators, BUMDes, and the village government. Evaluation was conducted by measuring EI through the posttest, observing model implementation, and exploring participants' experiences through interviews. The results of monitoring and evaluation were used to explain changes in EI and identify supporting and inhibiting factors during model implementation.

Data Collection and Instruments

Data were collected using three main techniques: the EI questionnaire, observation of model implementation, and semi-structured interviews. The use of these three techniques was intended to ensure that the study did not only measure changes in EI quantitatively, but also understood the processes and contexts influencing those changes.

The main instrument in the quantitative component was the entrepreneurial intention questionnaire. The EI questionnaire was developed using a 1 to 5 Likert scale, with response options of 1 = strongly disagree, 2 = disagree, 3 = moderately agree, 4 = agree, and 5 = strongly agree. The instrument consisted of 20 items covering four dimensions: entrepreneurial orientation (EO), internal motivation (IM), risk-taking courage (RC), and self-perception as a prospective entrepreneur (SP). Each dimension consisted of five items.

The total EI score had a theoretical range of 20 to 100. The total score for each dimension ranged from 5 to 25. In addition to total scores, the data were also analysed using the mean score per item, ranging from 1.00 to 5.00. EI categories were determined in two mutually consistent ways: based on the mean score per item and the total score. Based on the mean score per item, scores of 1.00-2.33 were categorized as low, scores of 2.34-3.67 as moderate, and scores of 3.68-5.00 as high. Based on the total score, scores of 20-46 were categorized as low, scores of 47-73 as moderate, and scores of 74-100 as high.

EI was measured twice using the same instrument, namely before the implementation of the model through the pretest and after model implementation through the posttest. Questionnaire completion was facilitated directly by the researchers and enumerators to ensure that all participants understood the statements and response options.

Observation of model implementation was used to assess the enactment of the sciencepreneurship-based empowerment program. Observation was conducted using an observation sheet containing seven aspects: participants' activeness in activities, ability to recognize village problems or potential, understanding of simple scientific principles in appropriate technology, involvement in making or testing appropriate technology, ability to identify business opportunities from appropriate technology, group cooperation during activities, and support from facilitators, BUMDes, or the village government. Each aspect was assessed using a scale of 1 to 5. Observation results were used to strengthen the interpretation of quantitative data and explain the quality of the model implementation process.

Semi-structured interviews were used to obtain qualitative data on participants' experiences during the program. The interviews focused on participants' experiences in empowerment activities, their understanding of village problems and potential, involvement in appropriate technology development, perceptions of business opportunities, changes in entrepreneurial intention, supporting factors, inhibiting factors, family and village institutional support, and expectations for program sustainability. Interviews were conducted with purposively selected sub-samples of participants and facilitators.

Data Analysis

Quantitative data were analysed in several stages. The first stage was descriptive analysis to describe EI pretest and posttest scores in each group. Descriptive analysis included the number of participants, mean total score, mean score per item, standard deviation, minimum score, maximum score, gain, N-gain, and EI category. Analysis was also conducted for each EI dimension to identify changes in entrepreneurial orientation, internal motivation, risk-taking courage, and self-perception as a prospective entrepreneur.

The second stage was assumption testing for statistical analysis. The normality test was conducted using the Shapiro-Wilk test because the number of participants in each group was less than 50. Homogeneity of variance was tested using Levene's test. For ANCOVA, the analysis also examined the linearity of the pretest-posttest relationship, homogeneity of regression slopes, residual normality, and outlier detection based on standardized residuals.

The third stage was testing the improvement of EI within each group. If the data met the normality assumption, improvement could be tested using a paired-samples t-test. However, because the assumption test results showed that the gain data were not normally distributed, the pretest-posttest improvement in this study was tested using the Wilcoxon signed-rank test.

This test was used to determine whether there was a significant difference between EI scores before and after model implementation in each group.

The fourth stage was analysing improvement effectiveness using gain and N-gain. Gain was calculated as the difference between posttest and pretest scores. N-gain was calculated to determine the effectiveness of improvement by considering the theoretical maximum score of the instrument. The N-gain formula for the total EI score was as follows:

$$N\text{-}gain = (posttest\ score - pretest\ score) / (100 - pretest\ score)$$

N-gain for each dimension was calculated using the following formula:

$$gD = (\bar{X}D\text{-}post - \bar{X}D\text{-}pre) / (25 - \bar{X}D\text{-}pre)$$

or it could also be calculated based on the mean score per item:

$$gD = (\bar{x}D\text{-}post - \bar{x}D\text{-}pre) / (5 - \bar{x}D\text{-}pre)$$

The N-gain category was determined using the following criteria: $g < 0.30$ = low, $0.30 \leq g < 0.70$ = moderate, and $g \geq 0.70$ = high.

The fifth stage was testing differences in model effectiveness between groups. Because the study involved two groups with pretest and posttest measurements, the main analysis for comparing final outcomes between groups was conducted using ANCOVA. In this analysis, the EI posttest score was used as the dependent variable, group as the independent variable, and EI pretest score as the covariate. ANCOVA was used because it allows comparison of posttest scores between groups while controlling for differences in participants' initial conditions. Therefore, the interpretation of differences in model effectiveness was stronger than if it relied only on gain score comparisons.

Observation data were analysed descriptively by calculating total scores and mean scores for each aspect of model implementation. Observation results were used to explain the quality of model implementation and support the interpretation of quantitative findings. Interview data were analysed using thematic analysis. The stages of analysis included repeated reading of transcripts, coding important segments, grouping codes into categories, developing themes, and interpreting themes based on the research focus. The main themes analysed included program experience, understanding of appropriate technology, business opportunities, changes in entrepreneurial intention, supporting factors, inhibiting factors, environmental support, and expectations for sustainability.

The integration of quantitative and qualitative data was conducted at the interpretation stage. Findings on EI improvement, changes in EI dimensions, statistical testing, observation of model implementation, and participant interviews were compared to explain how the sciencepreneurship-based empowerment model influenced EI. This integration was used to understand why EI improvement was stronger in certain groups, why certain dimensions improved more prominently, and what factors strengthened or hindered changes in EI.

Research Ethics Approval

This study was conducted by observing the ethical principles of social research. Before data collection, participants were informed about the research objectives, forms of involvement, types of data collected, benefits and risks of participation, and their right to refuse or discontinue participation at any time. Participation was voluntary after participants expressed their consent to participate.

Participants' identities were kept confidential through the use of codes or pseudonyms in research notes, interview transcripts, and research reporting. The data collected were used only for academic purposes. During program implementation, the researchers and facilitators also ensured that training activities, the use of appropriate technology, and technology trials were conducted with attention to participant safety, the suitability of technology to local capacity, and the principle of fairness in involving community members.

RESULTS

Description of Pretest and Posttest Entrepreneurial Intention Data

Entrepreneurial intention (EI) was measured before and after the implementation of the sciencepreneurship-based community empowerment model. The initial measurement was conducted through a pretest, while the final measurement was conducted through a posttest after participants had completed a series of empowerment activities, appropriate technology development, and reflection on business opportunities. The EI instrument consisted of 20 statement items using a 1 to 5 Likert scale, ranging from strongly disagree to strongly agree. Thus, the total EI score had a theoretical range of 20 to 100. In addition to total scores, the results were also interpreted using mean item scores ranging from 1.00 to 5.00.

The EI instrument covered four dimensions, namely entrepreneurial orientation (EO), internal motivation (IM), risk-taking courage (RC), and self-perception as a prospective entrepreneur (SP). Each dimension consisted of five items, so each dimension had a theoretical total score range of 5 to 25. Group A was the group that developed appropriate technology for producing tote bags made from spunbond fabric, while Group B was the group that developed appropriate technology in the form of a solar-powered water pump. The descriptive statistics of the EI pretest and posttest scores are presented in Table 4.

Table 4. Descriptive statistics of EI pretest and posttest scores

Group	N	$\bar{X}$pre	$\bar{x}$pre	SDpre	$\bar{X}$post	$\bar{x}$post	SDpost	$\bar{G}$	$\bar{g}$	g category
A	20	50.80	2.54	7.10	78.45	3.92	7.74	27.65	0.56	Moderate
B	20	52.00	2.60	7.88	74.50	3.73	7.41	22.50	0.48	Moderate
Total	40	51.40	2.57	7.43	76.48	3.82	7.74	25.08	0.52	Moderate

Note:
N = number of respondents.
$\bar{X}$pre = mean total EI pretest score.
$\bar{x}$pre = mean EI item score at pretest.
SDpre = standard deviation of the total EI pretest score.
$\bar{X}$post = mean total EI posttest score.
$\bar{x}$post = mean EI item score at posttest.
SDpost = standard deviation of the total EI posttest score.
$\bar{G}$ = mean gain, or the difference between total posttest and pretest scores.
$\bar{g}$ = mean N-gain.

As shown in Table 4, both groups showed an increase in EI scores after the implementation of the sciencepreneurship-based empowerment model. In Group A, the mean total EI score increased from 50.80 in the pretest to 78.45 in the posttest. When interpreted based on the mean item score, the EI score of Group A increased from 2.54 to 3.92. In Group B, the mean total EI score increased from 52.00 in the pretest to 74.50 in the posttest, or from 2.60 to 3.73 when interpreted based on the mean item score. Overall, the mean total EI score of all respondents increased from 51.40 to 76.48.

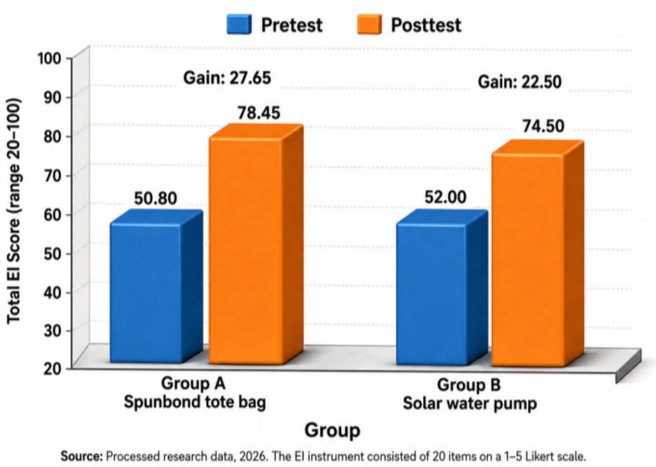

Figure 2. Mean total EI pretest and posttest scores of Groups A and B

Figure 2 shows that the mean total EI scores in both groups increased after the implementation of the model. The increase in Group A was greater than that in Group B. The mean gain of Group A was 27.65, while that of Group B was 22.50. The N-gain score of Group A was 0.56, while that of Group B was 0.48. Both were in the moderate category. These findings indicate that the sciencepreneurship-based community empowerment model improved participants' EI in two different appropriate technology contexts, although the improvement did not reach the high category.

Changes in Entrepreneurial Intention Categories

EI categories can be determined based on mean item scores and total scores. Based on mean item scores, scores of 1.00-2.33 were categorized as low, scores of 2.34-3.67 as moderate, and scores of 3.68-5.00 as high. Based on total scores, scores of 20-46 were categorized as low, scores of 47-73 as moderate, and scores of 74-100 as high. In this study, changes in EI categories are presented based on the classification of participants' pretest and posttest scores, as shown in Table 5.

Table 5. Changes in EI categories from pretest to posttest

Group	Measurement variable	Low	Moderate	High	Total
A	Pretest	8	12	0	20
	Posttest	0	4	16	20
B	Pretest	5	15	0	20
	Posttest	0	10	10	20
Total	Pretest	13	27	0	40
	Posttest	0	14	26	40

Table 5 shows a clear change in EI categories after the implementation of the model. At the pretest stage, no respondents were in the high category. A total of 13 respondents were in the low category and 27 respondents were in the moderate category. After the implementation of the model, no respondents remained in the low category. A total of 26 respondents were in the high category, while 14 respondents remained in the moderate category.

In Group A, before the intervention, 8 respondents were in the low category and 12 respondents were in the moderate category. After the intervention, 16 respondents were in the high category and 4 respondents were in the moderate category. In Group B, before the intervention, 5 respondents were in the low category and 15 respondents were in the moderate category. After the intervention, 10 respondents were in the high category and 10 respondents were in the moderate category. Thus, the implementation of the model not only increased the mean EI score, but also encouraged participants to move to better EI categories.

Changes in Entrepreneurial Intention by Dimension

The analysis of changes in entrepreneurial intention was conducted not only based on total scores, but also based on the four dimensions of EI. These dimensions were entrepreneurial orientation, internal motivation, risk-taking courage, and self-perception as a prospective entrepreneur. Each dimension consisted of five statement items using a 1 to 5 Likert scale. Therefore, each dimension had a theoretical total score range of 5 to 25, while the mean item score for each dimension ranged from 1.00 to 5.00.

The dimension-based analysis was conducted to identify which aspects of EI showed the strongest improvement after the implementation of the sciencepreneurship-based community empowerment model. In addition to mean item gain, the analysis also included dimension-based N-gain to determine the effectiveness of improvement in each EI dimension.

The changes in EI scores by dimension are presented in Table 6. As shown in Table 6, all EI dimensions improved in both groups. In Group A, the entrepreneurial orientation dimension increased from a mean total score of 13.45 in the pretest to 20.50 in the posttest. Based on the mean item score, the score increased from 2.69 to 4.10, with a gain of 1.41 and an N-gain of 0.61. This was the highest N-gain among all dimensions, although it remained in the moderate category. This finding indicates that the activity of developing appropriate technology for producing tote bags made from spunbond fabric most strongly encouraged participants' entrepreneurial orientation.

Table 6. Changes in EI scores by dimension

Group	EI dimension	X̄D-pre	X̄D-post	x̄D-pre	x̄D-post	ḠD	gD	gD category
A	- Entrepreneurial orientation (EO)	13.45	20.50	2.69	4.10	1.41	0.61	Moderate
	- Internal motivation (IM)	12.95	19.95	2.59	3.99	1.40	0.58	Moderate
	- Risk-taking courage (RC)	11.70	18.60	2.34	3.72	1.38	0.52	Moderate
	- Self-perception as a prospective entrepreneur (SP)	12.70	19.40	2.54	3.88	1.34	0.54	Moderate
B	- Entrepreneurial orientation (EO)	13.50	19.15	2.70	3.83	1.13	0.49	Moderate
	- Internal motivation (IM)	12.90	18.55	2.58	3.71	1.13	0.47	Moderate
	- Risk-taking courage (RC)	12.45	17.75	2.49	3.55	1.06	0.42	Moderate
	- Self-perception as a prospective entrepreneur (SP)	13.15	19.05	2.63	3.81	1.18	0.50	Moderate

Note:
X̄D-pre = mean total dimension score at pretest.
X̄D-post = mean total dimension score at posttest.
x̄D-pre = mean item score for each dimension at pretest.
x̄D-post = mean item score for each dimension at posttest.
ḠD = mean item gain for each dimension, or the difference between x̄D-post and x̄D-pre.
gD = dimension-based N-gain.
N-gain categories were determined using the following criteria: $g < 0.30$ = low; $0.30 \leq g < 0.70$ = moderate; and $g \geq 0.70$ = high.

The internal motivation dimension in Group A also showed a similarly strong increase, from a mean total score of 12.95 to 19.95. The mean item score increased from 2.59 to 3.99, with a gain of 1.40 and an N-gain of 0.58. This indicates that the sciencepreneurship-based empowerment model was able to strengthen participants' internal drive to learn, try, and develop business activities based on village potential. The risk-taking courage dimension increased from 11.70 to 18.60, with a mean item gain of 1.38 and an N-gain of 0.52. Meanwhile, the self-perception as a prospective entrepreneur dimension increased from 12.70 to 19.40, with a mean item gain of 1.34 and an N-gain of 0.54. All four dimensions in Group A were in the moderate N-gain category.

In Group B, all EI dimensions also improved. The entrepreneurial orientation dimension increased from a mean total score of 13.50 to 19.15. The mean item score increased from 2.70 to 3.83, with a gain of 1.13 and an N-gain of 0.49. The internal motivation dimension increased from 12.90 to 18.55, with a mean item gain of 1.13 and an N-gain of 0.47. The risk-taking courage dimension increased from 12.45 to 17.75, with a mean item gain of 1.06 and an N-gain of 0.42. The self-perception as a prospective entrepreneur dimension increased from 13.15 to 19.05, with a mean item gain of 1.18 and an N-gain of 0.50.

In Group B, the highest improvement was found in the self-perception as a prospective entrepreneur dimension, with an N-gain of 0.50. This indicates that the development of appropriate technology in the form of a solar-powered water pump primarily strengthened participants' belief that they had the potential to become entrepreneurs, particularly when supported by proper mentoring. However, the risk-taking courage dimension obtained the lowest N-gain, namely 0.42. This finding shows that although participants became more confident and increasingly saw business opportunities from appropriate technology, the courage to face business uncertainty remained an aspect that needed to be strengthened.

When compared between groups, Group A showed higher N-gain scores across all dimensions than Group B. This difference can be understood from the characteristics of the appropriate technology developed. The appropriate technology for producing tote bags made from spunbond fabric was relatively simpler, easier to practise, faster to produce, and easier to imagine as a business opportunity. In contrast, the solar-powered water pump had strong relevance to community needs, especially in providing clean water and supporting agricultural activities, but it required technical understanding, initial investment, maintenance, and a more complex management scheme. Therefore, the improvement in EI in Group B still occurred, but it tended to be more cautious, particularly in the risk-taking courage dimension.

To clarify the pattern of improvement across dimensions, the mean item gain results are visualized in Figure 3.

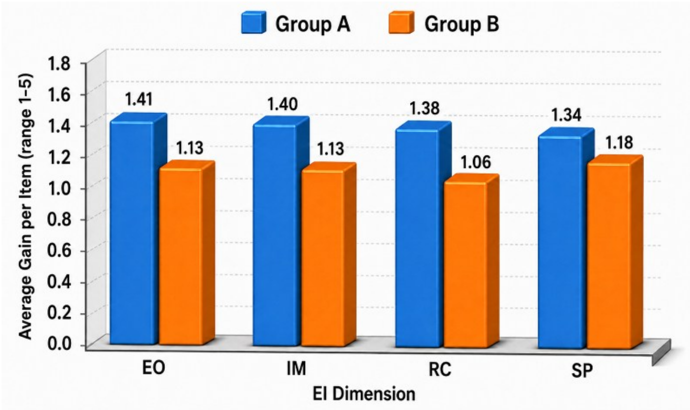

Figure 3. Mean item gain across entrepreneurial intention dimensions

Figure 3 shows that all EI dimensions in both groups improved. In Group A, the highest gain was found in entrepreneurial orientation at 1.41, followed by internal motivation at 1.40, risk-taking courage at 1.38, and self-perception as a prospective entrepreneur at 1.34. In Group B, the highest gain was found in self-perception as a prospective entrepreneur at 1.18, while the lowest gain was found in risk-taking courage at 1.06. This visualization confirms that the pattern of EI improvement in Group A was stronger and more even than that in Group B.

Overall, the dimension-based analysis shows that the sciencepreneurship-based community empowerment model improved all aspects of entrepreneurial intention, including entrepreneurial orientation, internal motivation, risk-taking courage, and self-perception as a prospective entrepreneur. However, because all N-gain scores remained in the moderate category, further strengthening is still needed. The aspect requiring particular attention is risk-taking courage, especially in Group B, so that the improvement in entrepreneurial intention does not stop at interest and self-confidence, but develops into a more concrete readiness to start and manage appropriate technology-based enterprises.

Assumption Testing for Statistical Analysis

Before inferential testing was conducted, assumption tests were first performed. These tests were used to determine the most appropriate statistical tests and to ensure that the interpretation of the analysis did not contradict the characteristics of the data. The assumption tests included normality testing, homogeneity of variance testing, linearity testing, homogeneity of regression slopes, normality testing of ANCOVA residuals, and outlier examination. The results of the statistical assumption tests are presented in Table 7.

Table 7. Results of statistical assumption testing

Aspect tested	Test statistic	Result	Decision
- Normality of Group A pretest	W = 0.936; p = 0.199	$p > 0.05$	Normal
- Normality of Group A posttest	W = 0.984; p = 0.975	$p > 0.05$	Normal
- Normality of Group A gain	W = 0.887; p = 0.024	$p < 0.05$	Not normal

Aspect tested	Test statistic	Result	Decision
- Normality of Group B pretest	W = 0.946; p = 0.315	p > 0.05	Normal
- Normality of Group B posttest	W = 0.960; p = 0.541	p > 0.05	Normal
- Normality of Group B gain	W = 0.705; p < 0.001	p < 0.05	Not normal
- Homogeneity of pretest variance	Levene F = 0.006; p = 0.940	p > 0.05	Homogeneous
- Homogeneity of posttest variance	Levene F = 0.001; p = 0.970	p > 0.05	Homogeneous
- Homogeneity of gain variance	Levene F = 11.541; p = 0.002	p < 0.05	Not homogeneous
- Linearity of pretest-posttest relationship in Group A	r = 0.505; p = 0.023	p < 0.05	Linear
- Linearity of pretest-posttest relationship in Group B	r = 0.849; p < 0.001	p < 0.05	Linear
- Homogeneity of regression slopes	F = 1.018; p = 0.320	p > 0.05	Met
- Normality of ANCOVA residuals	W = 0.964; p = 0.222	p > 0.05	Met

As shown in Table 7, pretest and posttest scores in Groups A and B were normally distributed. However, gain scores in both groups were not normally distributed. In addition, gain variance between groups was not homogeneous. This condition indicates that ANOVA on gain scores was less appropriate as the main test because the assumptions of gain normality and homogeneity of variance were not met.

In contrast, the assumptions for ANCOVA were met. The relationship between pretest and posttest scores was linear in each group. The homogeneity of regression slopes test showed $p > 0.05$, meaning that the relationship between the pretest covariate and the posttest dependent variable could be considered equivalent across the two groups. ANCOVA residuals were also normally distributed, and no extreme outliers were found. Therefore, ANCOVA was used as the main test to compare EI posttest scores between Groups A and B while controlling for pretest scores. To test EI improvement within each group, the Wilcoxon signed-rank test was used because the gain data were not normally distributed.

Testing Entrepreneurial Intention Improvement in Each Group

The EI improvement test was conducted to determine whether there was a significant difference between pretest and posttest scores in each group. Because the gain scores were not normally distributed, the Wilcoxon signed-rank test was used. The results are presented in Table 8.

Table 8. Results of the Wilcoxon test for EI pretest and posttest scores

Group	N	$\bar{X}$pre	$\bar{X}$post	Median pre	Median post	$\bar{G}$	W+	p
A	20	50.80	78.45	52.00	79.00	27.65	210.00	< 0.001
B	20	52.00	74.50	52.00	73.50	22.50	210.00	< 0.001

Note:
$\bar{X}$pre = mean total EI pretest score.
$\bar{X}$post = mean total EI posttest score.
Median pre = median total EI pretest score.
Median post = median total EI posttest score.
$\bar{G}$ = mean gain of total EI score.
W+ = sum of positive ranks in the Wilcoxon test.

Table 8 shows that there was a significant increase in EI in both groups. In Group A, the mean total EI score increased from 50.80 to 78.45, with $p < 0.001$. In Group B, the mean total EI score increased from 52.00 to 74.50, with $p < 0.001$. Thus, the sciencepreneurship-based community empowerment model was shown to improve participants' entrepreneurial intention in both research groups.

These results indicate that participants' involvement in appropriate technology development, both through the production of tote bags made from spunbond fabric and through the solar-powered water pump, was associated with increased entrepreneurial intention. The increase was not only reflected in the total EI score but also in all dimensions of EI, namely entrepreneurial orientation, internal motivation, risk-taking courage, and self-perception as a prospective entrepreneur.

Testing Differences in Model Effectiveness Between Groups Using ANCOVA

After it was found that both groups experienced significant EI improvement, the analysis continued to determine whether there was a difference in model effectiveness between Group A and Group B. The analysis was conducted using ANCOVA, with the total EI posttest score as the dependent variable, group as the independent variable, and the total EI pretest score as the covariate. ANCOVA was selected because it can compare posttest scores between groups while controlling for differences in participants' initial conditions. The ANCOVA results are presented in Table 9.

Table 9. ANCOVA results for total EI posttest scores with pretest as covariate

Source of variance	Sum of sqrs.	df	Mean sqr.	F	p	η_p^2
EI pretest	1010.814	1	1010.814	31.935	< 0.001	0.463
Group	226.506	1	226.506	7.156	0.011	0.162
Error	1171.136	37	31.652	-	-	-

Based on Table 9, the EI pretest score had a significant effect on the EI posttest score, with $F = 31.935$ and $p < 0.001$. This indicates that participants' initial EI condition needed to be considered when interpreting final scores after the intervention. After pretest scores were controlled, the group factor also had a significant effect on EI posttest scores, with $F = 7.156$ and $p = 0.011$. The partial eta squared (η_p^2) value of 0.162 indicates that group differences made a meaningful contribution to the variation in EI posttest scores after pretest scores were controlled. The corrected posttest means, or adjusted means, are presented in Table 10.

Table 10. Adjusted mean of total EI posttest scores based on ANCOVA

Group	Adjusted mean posttest EI
A	78.86
B	74.09

Table 10 shows that after pretest scores were controlled, Group A had an adjusted mean posttest EI score of 78.86, while Group B had an adjusted mean of 74.09. Thus, the improvement in EI in Group A was higher than that in Group B after initial score differences were statistically controlled.

This finding indicates that both forms of appropriate technology contributed to the improvement of EI, but the context of producing tote bags made from spunbond fabric in Group A produced higher results than the solar-powered water pump in Group B. This difference can be understood from the characteristics of the appropriate technology developed. The spunbond tote bag technology was relatively simpler, easier to practise, faster to produce, and easier to imagine as a business opportunity. Meanwhile, the solar-powered water pump had strong functional benefits for the community, but required technical understanding, costs, maintenance, and a more complex business scheme.

Observation Results

Observation was conducted to determine the quality of implementation of the sciencepreneurship-based empowerment model in each group. The observed aspects included participant activeness, ability to recognize village problems or potential, understanding of simple scientific principles in appropriate technology, involvement in making or testing appropriate technology, ability to identify business opportunities from appropriate technology, group cooperation, and support from facilitators, BUMDes, or the village government. The observation results of model implementation are presented in Table 11.

Table 11. Recapitulation of model implementation observation results

Group	Type of appropriate technology	Observ-ation	Total score	Mean	Process category
A	Production of tote bags made from spunbond fabric	1	27	3.86	Good
	Production of tote bags made from spunbond fabric	2	32	4.57	Good
B	Solar-powered water pump	1	30	4.29	Good
	Solar-powered water pump	2	34	4.86	Good

Based on Table 11, the implementation of the model in both groups was in the good category. Group A obtained a mean score of 3.86 in the first observation and increased to 4.57 in the second observation. Group B obtained a mean score of 4.29 in the first observation and increased to 4.86 in the second observation. The increase in observation scores in both groups indicates that the quality of the empowerment process strengthened as the activities progressed.

In Group A, improvement was particularly visible in participants' activeness, ability to recognize village potential, understanding of simple scientific principles, involvement in making appropriate technology, and group cooperation. In Group B, the observation score was already relatively high from the beginning and increased in the second observation, particularly in the aspects of recognizing village problems, involvement in testing appropriate technology, ability to identify business opportunities, and group cooperation. Support from facilitators, BUMDes, and the village government received very good scores in both groups. The mean observation scores for each aspect are presented in Table 12.

Table 12. Mean observation scores by aspect

Observation aspect	Group A	Group B
- Participants' activeness in activities	4.50	5.00
- Ability to recognize village problems/potential	3.50	4.50
- Understanding of simple scientific principles in appropriate technology	3.50	4.00
- Involvement in making/testing appropriate technology	4.50	4.50
- Ability to identify business opportunities from appropriate technology	4.00	4.50
- Group cooperation during activities	4.50	4.50
- Support from facilitators/BUMDes/village government	5.00	5.00
Overall mean	4.21	4.57

Table 12 shows that the highest-scoring aspect in both groups was support from facilitators, BUMDes, and the village government. This indicates that the implementation of the model did not depend only on participants' interest, but also on institutional support that facilitated the learning process, appropriate technology development, and the strengthening of business opportunities.

In Group A, the relatively lower aspects were the ability to recognize village problems or potential and understanding of simple scientific principles in appropriate technology, each with a score of 3.50. In Group B, all aspects were in the good category, with the highest scores in participant activeness and institutional support. These results show that Group B had higher process engagement in the observation, although statistically the EI improvement in Group A was greater. This difference indicates that high process quality does not always result in greater EI improvement when the type of appropriate technology developed has higher technical and economic complexity.

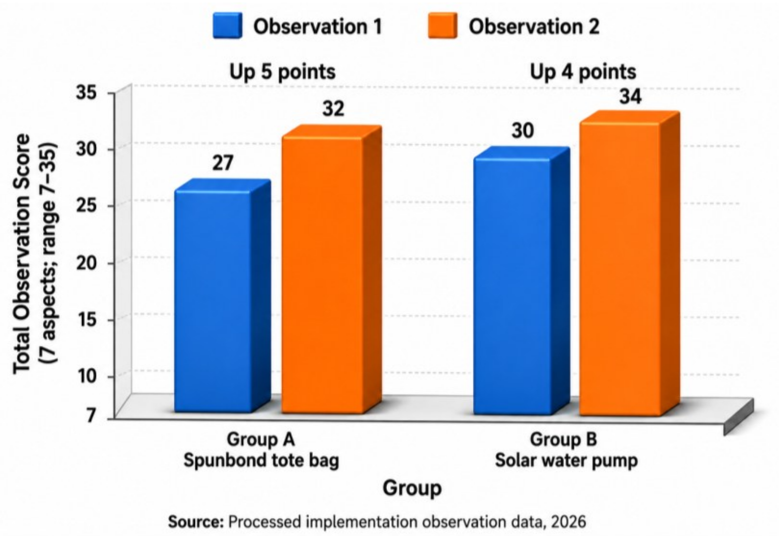

Figure 4. Observation scores of model implementation in Groups A and B

Figure 4 shows that the observation scores of model implementation increased in both groups. Group A increased from 27 to 32, while Group B increased from 30 to 34. This increase indicates that model implementation became stronger in the second observation, both in terms of participant activeness, involvement in appropriate technology, and institutional support.

Results of Participant Interviews

Interview data were used to strengthen and explain the quantitative results. The interviews explored participants' experiences during the program, their understanding of village problems and potential, their understanding of science, involvement in appropriate technology, perceptions of business opportunities, changes in entrepreneurial intention, supporting factors, inhibiting factors, environmental support, and expectations for program sustainability.

The interview results showed that participants in both groups viewed the sciencepreneurship-based empowerment program as beneficial and as providing new experiences. Participants in Group A emphasized that the activity of producing tote bags made from spunbond fabric could be linked to the issue of reducing plastic use, creating simple products, and identifying market opportunities. Participants in Group B emphasized that the solar-powered water pump was relevant to the problem of clean water during the dry season and the need for technology that could support agricultural activities. A summary of the interview themes is presented in Table 13.

Table 13. Summary of themes from participant interviews

Interview focus	Group A findings	Group B findings	Meaning for EI
- Program experience	The program was viewed as a first experience that encouraged creativity in appropriate technology development.	The program was viewed as interesting because it provided encouragement and experience related to useful appropriate technology.	Strengthened positive attitudes toward productive activities and entrepreneurship.
- Village problems/potential	Plastic waste and the need for alternative products were viewed as appropriate technology opportunities.	Clean water during the dry season and the use of solar energy became the main issues.	Helped participants view village problems as opportunities for innovation.

Interview focus	Group A findings	Group B findings	Meaning for EI
- Understanding of science	Science was understood as the development of appropriate technology from local materials to increase economic value.	Science was understood as encouragement to create simple technology from available potential.	Increased awareness that science can be used for economic solutions.
- Involvement in appropriate technology	Participants were involved in producing tote bags made from spunbond fabric.	Participants tried to develop appropriate technology that could be used by the wider community.	Strengthened direct experience and self-efficacy.
- Business opportunities	Tote bags were viewed as having market opportunities and being developable as business products.	The technology was viewed as needed by farmers, traders, entrepreneurs, and the community.	Made business opportunities feel more concrete.
- Changes in entrepreneurial intention	Intention increased, but participants still needed careful business calculation.	Participants were encouraged to create products supporting agriculture and waste utilization.	Strengthened EI, but still accompanied by caution.
- Supporting factors	The desire to improve the economy and create jobs.	The desire to create economic independence.	Strengthened internal motivation.
- Inhibiting factors	Capital and competition were the main barriers.	Fear of failure and limited capital were the main barriers.	Showed that EI does not automatically turn into entrepreneurial action.
- Environmental support	Family, village government, and BUMDes provided support, especially in marketing.	Family, BUMDes, and the village government supported business opportunities.	Strengthened social support and subjective norms.
- Future expectations	The village government was expected to support marketable appropriate technology.	The program was expected to continue as technology with economic value for the community.	Indicated the need for program sustainability.

Based on Table 13, the interviews showed that EI improvement was influenced by several main factors. First, participants gained new experiences in empowerment activities that connected science, technology, and entrepreneurship. In Group A, one participant stated that the activity was their first experience participating in an empowerment program related to appropriate technology and that it encouraged them to become more creative. In Group B, participants stated that the activity was interesting because it provided support and experience related to appropriate technology that was useful in daily life.

Second, participants began to see village problems as opportunities for innovation. In Group A, the problem of plastic waste was viewed as an issue that could be developed through appropriate technology to produce a product with selling value. In Group B, the problem of clean water during the dry season was viewed as something that could be addressed by using sunlight as an energy source to power a water pump. These findings indicate that the sciencepreneurship approach helped participants connect local problems with possible technological solutions and business opportunities.

Third, direct involvement in appropriate technology development encouraged an increased sense of capability. Participants in Group A were involved in producing tote bags made from spunbond fabric as products that could reduce plastic use and had market opportunities. Participants in Group B stated that they were trying to create appropriate technology that could be used by the wider community and had economic value. This direct experience became an important factor because participants did not merely receive material, but experienced the process of producing technological solutions themselves.

Fourth, the interviews also showed that EI improvement was still accompanied by hesitation. Participants mentioned capital, competition, fear of failure, and the need for careful business calculations as inhibiting factors. Therefore, the increase in EI should not be directly interpreted as full readiness to start a business independently. Participants still need further mentoring, business capacity strengthening, access to financing, and marketing support so that entrepreneurial intention can develop into actual entrepreneurial action.

Integration of Quantitative Results, Observations, and Interviews

This study used a mixed-methods approach, so the quantitative results, observations, and interviews needed to be integrated to obtain a more complete understanding. The quantitative data showed significant improvement in EI in both groups. The observation data showed that model implementation was in the good category and that process quality improved. The interview data explained that EI improvement was influenced by direct experience in developing appropriate technology, perceptions of business opportunities, environmental support, and motivation to improve economic conditions. The integration of the research findings is presented in Table 14.

Table 14. Integration of quantitative data, observations, and interviews

Group	Quantitative EI results	Observation results	Strengthening factors	Weakening factors	Interpretation
A	The mean total EI score increased from 50.80 to 78.45; gain = 27.65; N-gain = 0.56; significant improvement.	Observation score increased from 27 to 32; good category.	Experience in producing tote bags, market potential, creativity, family support, village government support, and BUMDes support.	Capital, competition, and the need for careful business calculation.	The model was effective in improving EI, mainly because the technology was easy to practise, close to business products, and its economic value was quickly imaginable.
B	The mean total EI score increased from 52.00 to 74.50; gain = 22.50; N-gain = 0.48; significant improvement.	Observation score increased from 30 to 34; good category.	Relevance of the solar-powered water pump to clean water needs, institutional support, and opportunities to support agricultural activities.	Fear of failure, capital, need for technical capability, and business sustainability.	The model was effective in improving EI, but the technology was more complex and therefore required stronger technical assistance, financing, and business governance.

Based on Table 14, the sciencepreneurship-based community empowerment model made a positive contribution to improving the entrepreneurial intention of rural communities. This improvement occurred through several mechanisms. First, the model helped participants recognize village problems and potential as a basis for innovation. Second, the model provided direct experience in developing appropriate technology, so participants did not only understand entrepreneurship theoretically but also experienced the process of creating products or technological solutions. Third, the model strengthened participants' perception that local resources could be transformed into economic opportunities. Fourth, support from family, groups, BUMDes, facilitators, and the village government strengthened participants' confidence in trying business activities.

However, the integrated results also show that increased EI did not completely remove entrepreneurial barriers. Limited capital, fear of failure, competition, the need for technical assistance, and marketing sustainability remained issues that needed attention. Therefore, the sciencepreneurship-based empowerment model should not stop at training and appropriate technology development. The model needs to be followed by business mentoring, financing support, strengthening the role of BUMDes, market access, and continuous monitoring so that entrepreneurial intention can develop into more concrete entrepreneurial action.

Summary of Research Findings

Based on the entire analysis, the main findings of this study can be summarized as follows. First, the sciencepreneurship-based community empowerment model improved the entrepreneurial intention of rural communities in both research groups. Group A experienced an increase in the mean total EI score from 50.80 to 78.45, while Group B experienced an increase from 52.00 to 74.50. Second, the EI improvement in both groups was statistically significant based on the Wilcoxon test, with $p < 0.001$. This indicates that the changes in EI scores after model implementation were not merely descriptive changes, but significant improvements. Third, the ANCOVA results showed a difference in effectiveness between groups after pretest scores were controlled. Group A obtained an adjusted mean posttest score of 78.86, while Group B obtained an adjusted mean of 74.09. This difference was significant, with $F = 7.156$ and $p = 0.011$. Fourth, all EI dimensions improved. In Group A, the highest improvement occurred in entrepreneurial orientation, while in Group B the highest improvement occurred in self-perception as a prospective entrepreneur.

Fifth, the observation results showed that model implementation was in the good category. The observation score of Group A increased from 27 to 32, while that of Group B increased from 30 to 34. This indicates that the empowerment process became stronger as the activities progressed. Sixth, the interview results showed that EI improvement was influenced by direct experience in developing appropriate technology, perceptions of business opportunities, family and village institutional support, and motivation to improve economic conditions. However, inhibiting factors such as capital, fear of failure, competition, and the need for further mentoring remained important concerns. Thus, the findings show that the sciencepreneurship-based community empowerment model effectively improved the entrepreneurial intention of rural communities, particularly when participants were actively involved in recognizing problems, understanding simple scientific principles, developing appropriate technology, identifying business opportunities, and receiving support from their social and village institutional environment.

DISCUSSION

The results show that the sciencepreneurship-based community empowerment model was able to improve the entrepreneurial intention (EI) of rural communities in both research groups. This improvement was reflected in the increase in total EI scores, the shift in EI categories, the increase across all EI dimensions, and the statistical test results showing significant differences between conditions before and after model implementation. These findings indicate that participants' involvement in empowerment activities integrating science, appropriate technology, and entrepreneurship was able to strengthen the entrepreneurial intention of rural communities. However, the improvement remained in the moderate effectiveness category. This means that the implemented model had a positive effect on EI, but it should not yet be understood as a final success that fully encouraged participants to become independent entrepreneurs. The improvement in entrepreneurial intention still requires further assistance, particularly in the aspects of capital, courage to face risk, market access, and business sustainability.

These findings are relevant to the basic concept of entrepreneurial intention, which positions intention as an important predictor before individuals engage in entrepreneurial action. In the framework of the Theory of Planned Behavior, the intention to perform a behaviour is influenced by attitudes toward the behaviour, subjective norms, and perceived behavioural control (Ajzen, 1991). In this study, these three components could be identified in the model implementation process. Attitudes toward entrepreneurship were strengthened when participants saw that appropriate technology could produce economically useful products or services. Subjective norms were strengthened through the support of family, groups, BUMDes, facilitators, and the village government. Meanwhile, perceived behavioural control increased when participants directly experienced the process of recognizing problems, trying technological solutions, and identifying business opportunities from the appropriate technology developed. Thus, the increase in EI in this study did not occur merely because participants were given motivation, but because they gained experiences that made entrepreneurship more concrete, closer, and more feasible.

The improvement in EI can also be explained through the direct learning experiences provided by the sciencepreneurship model. The program did not only consist of general entrepreneurship counselling or training, but involved participants in the process of identifying village potential, understanding simple scientific principles, developing appropriate technology, and assessing the economic opportunities arising from that technology. This pattern is consistent with findings in the literature that entrepreneurship education and training can improve entrepreneurial intention, particularly when participants gain learning experiences that are relevant to business opportunities and capacity building (Fayolle & Gailly, 2015; Nabi et al., 2017; Zhang et al., 2022). In the context of this study, sciencepreneurship activities functioned as applied learning experiences that bridged knowledge, technical skills, and business orientation. Therefore, the increase in EI did not only reflect a change in attitude, but also a change in participants' perception of their ability to become involved in productive economic activities.

The findings also show a substantial shift in EI categories. Before the implementation of the model, participants generally did not show a high level of EI. After model implementation, most participants shifted to a better EI category. This shift indicates that the sciencepreneurship-based empowerment model was able to change participants' psychological position in viewing entrepreneurship. Participants who were previously hesitant or did not have a strong orientation toward business began to see entrepreneurial activities as something more possible to undertake. This finding strengthens the view of Liñán and Chen (2009) that entrepreneurial intention is a psychological construct that can be measured and influenced by attitudes, social norms, and perceived control over entrepreneurial behaviour.

The increase in EI in both groups was also related to participants' growing experience in using technology to solve local problems. In rural communities, entrepreneurial potential often remains underdeveloped because people do not yet have sufficient experience in transforming local problems and resources into business opportunities. Through the sciencepreneurship model, participants were encouraged to understand that village problems could become starting points for innovation. In Group A, the issue of reducing plastic use and the need for alternative products opened opportunities for developing tote bags made from spunbond fabric. In Group

B, the problem of clean water during the dry season and the need to support agricultural activities became the basis for developing a solar-powered water pump. This is consistent with the view that innovation and technology can support rural transformation when they are directed toward strengthening community capacity, improving livelihoods, and expanding economic opportunities inclusively (Lidder et al., 2025).

When viewed by EI dimension, all dimensions improved in both groups. In Group A, the most prominent improvement occurred in entrepreneurial orientation. This shows that the activity of producing tote bags made from spunbond fabric encouraged participants to become more interested in seeing village potential as a source of business opportunities. Tote bags are relatively easy to understand, can be produced through a process that is not too complex, and quickly result in a visible product whose economic value can be assessed. Such characteristics made it easier for participants to connect the training activity with possible real business opportunities. Thus, appropriate technology that is simple and close to local market needs tends to strengthen participants' entrepreneurial orientation more quickly.

In Group A, internal motivation also showed a strong increase. This indicates that the experience of producing a concrete product can strengthen participants' internal drive to learn, try, and develop a business. The experience of successfully producing an initial product gave participants the opportunity to feel that a business could begin with simple skills and available materials. In self-efficacy studies, early mastery experience is one important source of self-confidence development. Newman et al. (2019) emphasized that entrepreneurial self-efficacy is closely related to the formation of entrepreneurial behaviour and intention. Therefore, direct experience in producing appropriate technology can strengthen participants' perceived capability, which in turn supports increased EI.

In Group B, the most prominent improvement occurred in self-perception as a prospective entrepreneur. This finding shows that the development of a solar-powered water pump helped participants see themselves as part of the effort to solve village problems through technology. Unlike spunbond tote bags, which are closer to direct business products, the solar-powered water pump is a functional technology related to the needs for clean water and agriculture. Involvement in this appropriate technology appeared to strengthen participants' belief that they could learn, understand, and manage technology that benefits the community. However, risk-taking courage in Group B showed a more limited improvement compared with the other dimensions. This can be understood because solar-powered water pump technology requires costs, maintenance, technical mastery, and a more complex management scheme. This complexity may have made participants more cautious in imagining technology-based business opportunities.

The more limited improvement in the risk-taking courage dimension deserves careful attention. In rural contexts, entrepreneurial intention is often constrained by real economic risks, such as limited capital, market uncertainty, limited networks, and fear of failure. Studies on entrepreneurial intention in rural communities show that financial factors, education, social support, and perceived capability can influence community readiness to start a business (Ali et al., 2023; Banerjee et al., 2025). The interview data in this study also showed that participants still mentioned capital, fear of failure, competition, and the need for careful business calculation as barriers. Therefore, the improvement in EI needs to be interpreted cautiously. Entrepreneurial intention increased, but it did not completely remove participants' concerns about business risks.

The comparison between groups showed that Group A tended to demonstrate stronger EI improvement than Group B after participants' initial conditions were statistically controlled. This finding indicates that the type of appropriate technology developed can influence the level of EI improvement. Appropriate technology that is simpler, easier to practise, and faster to produce appears to more easily stimulate participants' entrepreneurial intention. In contrast, technology that is more technical and requires a more complex management scheme can still improve EI, but the improvement tends to be more cautious. This finding suggests that the effectiveness of a sciencepreneurship-based empowerment model is not determined only by the intervention design, but also by the characteristics of the technology selected. Technology that is aligned with participants' capacity, local needs, available resources, and market opportunities is more likely to encourage entrepreneurial intention.

The difference between Group A and Group B also highlights the importance of the principle of suitability in developing appropriate technology. Appropriate technology should not be seen merely as a technically useful tool, but also as technology that can be operated, maintained, understood, and developed by the user community. Technology that is too complex may still be beneficial, but it requires stronger technical and institutional support. Therefore, in a sciencepreneurship-based empowerment model, the selection of appropriate technology needs to consider ease of adoption, market potential, capital requirements, maintenance capacity, and possibilities for business development. In other words, appropriate technology is technology that is not only technically appropriate, but also socially, economically, and institutionally appropriate.

The observation results showed that the implementation of the model in both groups was in the good category. This indicates that the empowerment process became stronger over time. The most prominent aspect in both groups was support from facilitators, BUMDes, and the village government. This finding shows that the success of the model did not depend only on participants, but also on the quality of facilitation and local institutional support. In the context of rural entrepreneurship, social and institutional support is important because rural communities often need networks, legitimacy, market access, and resource support to start a business. Ali and Yousuf (2019) showed that social capital influences entrepreneurial intention through perceived desirability, perceived self-efficacy, and social norms.

The role of BUMDes is important in this study because BUMDes can function as a connector between appropriate technology innovation and village business opportunities. BUMDes can support marketing, joint production, financing, business management, and market network expansion. Kania et al. (2021) positioned BUMDes as an institutional approach to promoting rural entrepreneurship in Indonesia through the utilization of local resource potential. However, the role of BUMDes cannot be assumed to succeed automatically. Putra et al. (2025) showed that BUMDes still faces challenges in management, business opportunities, and institutional strategy. Therefore, BUMDes support in this study should be understood as important initial capital, but it still requires stronger governance, clearer roles, transparency, and business capability to sustain appropriate technology-based enterprises.

The observation data also showed that Group B had very good process quality, although Group A demonstrated stronger EI improvement. This finding is important because it shows that the quality of participation does not always directly produce the highest increase in EI. In Group B, participants appeared active, were able to recognize village problems, and received good institutional support, but the complexity of the solar-powered water pump may have made them more cautious in converting learning experiences into stronger business intention. Thus, a good empowerment process still needs to be supported by appropriate technology design and a clear business model. Without a clear business scheme, useful technology may increase interest and awareness, but it may not immediately produce high entrepreneurial readiness.

The interview results strengthened the quantitative and observation findings. Participants stated that the empowerment activities provided new experiences, encouraged creativity, and helped them see appropriate technology as a business opportunity. In Group A, participants associated the activity with producing goods that could reduce plastic use and had market potential. In Group B, participants associated the technology with the need for clean water and support for agricultural activities. These data show that sciencepreneurship can function as an empowerment approach because it connects local problems with simple scientific principles, adaptive technology, and economic opportunities. Communities are not merely asked to become entrepreneurs, but are guided to understand problems, try solutions, and assess their economic value.

Nevertheless, the interviews also showed that the increase in EI still faced weakening factors. The most prominent barriers were limited capital, fear of failure, competition, and the need for careful business calculations. This finding is consistent with the rural entrepreneurship literature, which shows that rural communities often face structural barriers related to financing access, limited skills, weak market networks, and insufficient support from the business environment (Ali et al., 2023; Banerjee et al., 2025). Therefore, the sciencepreneurship-based empowerment model needs to be complemented by post-training strategies. These strategies may include business mentoring, cost simulation, small-scale market testing, group financing, production support, and marketing strengthening through BUMDes.

The findings on capital barriers and fear of failure also indicate that the increase in EI should not be interpreted as a final success. In this study, EI increased significantly, but this increase only indicated initial psychological readiness. For this intention to develop into entrepreneurial action, participants need continued support. This is consistent with Nabi et al. (2017), who argued that the impact of entrepreneurship education needs to be viewed more broadly, including how learning can develop into behaviour, skills, and business creation. Therefore, sciencepreneurship programs should not stop at training and appropriate technology prototype development, but should continue with business model development, economic feasibility calculation, market access, and sustainability monitoring.

Conceptually, this study strengthens the argument that sciencepreneurship can be a relevant approach for rural community empowerment. This approach brings together three important elements: science as a basis for understanding problems, technology as a means of producing solutions, and entrepreneurship as a mechanism for creating economic value. When these three elements are integrated into a participatory process, participants gain learning experiences that are more meaningful than entrepreneurship training that focuses only on motivation. Sciencepreneurship enables participants to see that innovation does not always have to begin with high technology, but can begin with local problems, available materials, and the economic needs of the community.

However, sciencepreneurship cannot be treated as a single solution. Its effectiveness depends on technology suitability, participant capacity, institutional support, mentoring sustainability, and access to economic resources. If appropriate technology is too complex, requires high costs, or lacks a clear business scheme, EI improvement may remain at the level of interest and initial confidence. Conversely, if appropriate technology is simple, easy to practise, and has clear market opportunities, EI improvement can be stronger. Therefore, the development of a sciencepreneurship-based empowerment model needs to consider adaptive, participatory, and contextual principles.

Methodologically, the use of a mixed-methods approach helped provide a more complete understanding. Quantitative data showed that EI increased significantly. Observation data showed that the implementation process ran well. Interview data explained why the increase occurred and what factors still inhibited it. Without qualitative data, the increase in EI scores could be interpreted too simply as full program success. In fact, the interviews showed that participants still had concerns about capital, risk, competition, and business sustainability. Thus, the integration of quantitative and qualitative data produced a more balanced interpretation: the model was effective in improving EI, but it still needs to be strengthened so that intention can develop into actual entrepreneurial action.

The practical implication of this study is that rural community empowerment needs to be designed as a staged process. The initial stage can focus on mapping village problems, village potential, and simple scientific literacy. The next stage can be directed toward developing and testing appropriate technology. After that, participants need assistance in conducting business feasibility analysis, cost calculation, pricing, and market testing. In the follow-up stage, BUMDes and the village government can play roles in supporting production, marketing, financing, and business management. This pattern is important because increased EI will only have real impact if there is an ecosystem that supports participants in moving from intention to action.

Another implication is the need to differentiate mentoring strategies based on the type of appropriate technology. For simple technologies such as spunbond tote bags, mentoring can focus on product design, material quality, branding, marketing, and production management. For more technical technologies such as solar-powered water pumps, mentoring needs to include tool maintenance, investment cost estimation, service models, initial financing, and institutional cooperation. The same strategy is not always suitable for all types of appropriate technology. Therefore, the sciencepreneurship-based empowerment model needs to be flexible and adjusted to the characteristics of the technology and the capacity of the user community.

Theoretically, this study contributes to understanding the relationship among sciencepreneurship, appropriate technology, and entrepreneurial intention in rural communities. This study shows that EI can be improved through direct experience in developing appropriate technology based on local potential. This improvement occurs because participants gain concrete experiences that influence entrepreneurial orientation, internal motivation, self-perception, and risk-taking courage. However, the strength of improvement in each dimension differs depending on the characteristics of the appropriate technology and the context of program implementation. Thus, the relationship between sciencepreneurship and EI is not automatic, but mediated by learning experiences, technology suitability, social support, and the structure of economic opportunities.

Ultimately, the findings of this study show that the sciencepreneurship-based community empowerment model is feasible to develop as a rural empowerment approach that connects scientific literacy, appropriate technology innovation, and local entrepreneurship. This model has the potential to strengthen rural communities' entrepreneurial intention because it makes business opportunities more concrete and closer to participants' experiences. However, for its impact to be more sustainable, the model needs to be followed by business mentoring, capital support, BUMDes strengthening, market network development, and post-program monitoring. In this way, the increase in entrepreneurial intention can be directed toward the formation of more concrete, productive, and sustainable appropriate technology-based business activities.

CONCLUSION

The sciencepreneurship-based community empowerment model was proven effective in improving the entrepreneurial intention of rural communities. This effectiveness was reflected in the increase in EI in both groups after the implementation of the model, both in the group that developed appropriate technology for producing tote bags made from spunbond fabric and in the group that developed a solar-powered water pump. The increase was also statistically significant. However, the effectiveness of the model cannot be separated from the characteristics of the appropriate technology developed. The group that developed the spunbond tote bag showed a stronger increase in EI than the group that developed the solar-powered water pump. This indicates that appropriate technology that is simpler, easier to practise, faster to produce, and closer to market opportunities tends to more easily encourage entrepreneurial intention among rural communities.

The increase in entrepreneurial intention occurred across all EI dimensions, namely entrepreneurial orientation, internal motivation, risk-taking courage, and self-perception as a prospective entrepreneur. In the spunbond tote bag group, the most prominent increase occurred in entrepreneurial orientation. This shows that participants became more interested in viewing village potential as a source of business opportunities. In the solar-powered water pump group, the most prominent increase occurred in self-perception as a prospective entrepreneur. This means that involvement in developing technology oriented toward solving village problems strengthened participants' belief that they could become entrepreneurs based on appropriate technology. Nevertheless, risk-taking courage remains a dimension that needs to be strengthened, especially in groups developing appropriate technology with a higher level of technical complexity.

The implementation of the sciencepreneurship-based empowerment model was in the good category. Participants showed activeness, involvement in making or testing appropriate technology, the ability to identify business opportunities, and group cooperation. Support from facilitators, BUMDes, and the village government became an important factor strengthening model implementation. The interview results also showed that participants viewed the program as a new experience that encouraged creativity, helped them understand village potential, and opened their perspective that appropriate technology could be developed into economic opportunities. Support from families, groups, BUMDes, and the village government also strengthened changes in participants' entrepreneurial intention.

Although this model was effective in improving entrepreneurial intention, this study also found that the increase in intention did not fully remove participants' hesitation to start a business. The remaining barriers included limited capital, fear of failure, competition, the need for careful business calculations, and the need for technical and marketing assistance. These barriers were more strongly felt in the more complex appropriate technology group because the technology required higher costs, technical skills, maintenance, and a stronger business scheme. Therefore, the increase in EI should be understood as an important initial stage, but not yet sufficient to guarantee the establishment of independent businesses without further support.

In general, the sciencepreneurship-based community empowerment model is feasible to use as a rural empowerment approach because it can integrate science, appropriate technology, and entrepreneurship in a participatory process. This model helps rural communities identify local problems, understand resource potential, develop technological solutions, and recognize economic opportunities from appropriate technology. To make its impact more sustainable, this model needs to be complemented by business mentoring, financing support, strengthening the role of BUMDes, market access, and post-program monitoring.

LIMITATIONS

This study was limited to 40 respondents divided into two appropriate technology groups, namely the production of tote bags made from spunbond fabric and the solar-powered water pump. This context means that the findings are more appropriately understood as an illustration of the model's effectiveness in two different forms of appropriate technology, rather than as a generalization to all rural communities or all types of appropriate technology. Participant characteristics, local potential, institutional support, and the level of technological complexity selected may influence the results of model implementation. In addition, this study did not involve a control group without treatment, so the effectiveness of the model was mainly interpreted from pretest-posttest changes and comparisons between two groups that both received the intervention.

The measurement of entrepreneurial intention in this study was based on a self-perception questionnaire, meaning that the results describe changes in participants' intention, beliefs, and psychological readiness, rather than actual entrepreneurial behaviour. This study also did not examine whether the increase in EI continued into business formation, sustainable production, increased income, or market expansion after the program ended. Observation and interview data strengthened the explanation of the EI change process, but they were not sufficient to describe the long-term sustainability of the impact. Therefore, the findings of this study are more appropriately positioned as initial evidence of the model's effectiveness in improving rural communities' entrepreneurial intention through appropriate technology.

RECOMMENDATIONS

The sciencepreneurship-based community empowerment model is recommended for development as a rural empowerment approach that integrates the identification of local problems, the use of simple scientific principles, the development of appropriate technology, and the strengthening of entrepreneurship. In its implementation, the type of appropriate technology should be carefully selected by considering community needs, ease of adoption, availability of materials or components, participants' technical capacity, market potential, and business sustainability opportunities. For simple appropriate technology, mentoring can focus on product design, production quality, branding, and marketing. For more complex appropriate technology, mentoring should be strengthened in technical aspects, maintenance, financing, business models, and the governance of business groups.

Future studies are recommended to involve a larger number of respondents, more diverse village contexts, and research designs that allow comparison with a control group. Measurement should also be expanded beyond entrepreneurial intention to include actual entrepreneurial behaviour, production sustainability, market access, income changes, and the contribution of appropriate technology to solving village problems. In addition, longitudinal studies are needed to determine whether the increase in EI can be sustained after the program ends and develop into real businesses. The involvement of BUMDes, village governments, universities, and market partners also needs further examination so that the sciencepreneurship model does not stop as a training program, but develops into a sustainable rural economic empowerment ecosystem.

ACKNOWLEDGMENT

The authors would like to express their gratitude to the Master's Program in Science Education, Faculty of Applied Science, Engineering, and Technology, Universitas Pendidikan Mandalika, as well as to the supervisors for their guidance and assistance during the preparation of this thesis. The authors also thank the Government of Krayan Jaya Village, Long Ikis District, Paser Regency, East Kalimantan Province, BUMDes, program facilitators, and all community participants who supported the implementation of the research, the development of appropriate technology, observations, interviews, and field data collection.

FUNDING INFORMATION

This research did not receive external funding.

AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Zulpan	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	
Saiful Prayogi		✓		✓	✓	✓			✓			✓		
Nova Kurnia		✓		✓			✓	✓		✓		✓	✓	

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

ETHICAL APPROVAL

The researchers meticulously followed ethical protocols throughout the research process, adhering to the principles outlined in the Declaration of Helsinki.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy considerations of research participants.

REFERENCES

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Al-Jubari, I., Hassan, A., & Liñán, F. (2019). Entrepreneurial intention among university students in Malaysia: Integrating self-determination theory and the theory of planned behavior. *International Entrepreneurship and Management Journal, 15*(4), 1323–1342. https://doi.org/10.1007/s11365-018-0529-0

Ali, A., & Yousuf, S. (2019). Social capital and entrepreneurial intention: Empirical evidence from rural community of Pakistan. *Journal of Global Entrepreneurship Research, 9*, Article 64. https://doi.org/10.1186/s40497-019-0193-z

Ali, J., Burhan, M., & Jabeen, Z. (2023). Factors affecting entrepreneurial intention among the rural population in India. *European Business Review, 35*(1), 74–91. https://doi.org/10.1108/EBR-05-2022-0082

Baldo, C., McCain, S., & Jouflas, G. (2023). An investigation on factors influencing university students' entrepreneurship orientations. *Entrepreneurship Education and Pedagogy, 7*(3), 264–288. https://doi.org/10.1177/25151274231184800

Banerjee, A., Mukherjee, D. N., Ghoshal, S., Priya, R., & Ruidas, S. (2025). Decoding rural entrepreneurship: Exploring the determinants of entrepreneurial intention in Jharkhand, India. *Journal of Innovation and Entrepreneurship, 14*, Article 106. https://doi.org/10.1186/s13731-025-00549-x

Bayona-Oré, S. (2023). The theory of planned behaviour and the entrepreneurial intention of university students. *Journal of Turkish Science Education*. https://doi.org/10.36681/tused.2023.008

Bhunia, A., & Shome, M. (2023). Interrelation between personality characteristics and social capital in formation of entrepreneurial intention: A conceptual framework. *International Journal of Professional Business Review, 8*(3), Article e01124. https://doi.org/10.26668/businessreview/2023.v8i3.1124

Caputo, A., Nguyen, V., & Delladio, S. (2024). Risk-taking, knowledge, and mindset: Unpacking the antecedents of entrepreneurial intention. *International Entrepreneurship and Management Journal, 21*(1). https://doi.org/10.1007/s11365-024-01064-3

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Sage.

Dahalan, N., Jaafar, M., & Rosdi, S. (2015). Attitude and entrepreneurial intention among rural community: The mediating role of entrepreneurial opportunity recognition. *SHS Web of Conferences, 18*, Article 01005. https://doi.org/10.1051/shsconf/20151801005

Ebewo, P., Rugimbana, R., & Shambare, R. (2017). Effects of entrepreneurship education on students' entrepreneurial intentions: A case of Botswana. *Management Studies, 5*(4). https://doi.org/10.17265/2328-2185/2017.04.002

Fayolle, A., & Gailly, B. (2015). The impact of entrepreneurship education on entrepreneurial attitudes and intention: Hysteresis and persistence. *Journal of Small Business Management, 53*(1), 75–93. https://doi.org/10.1111/jsbm.12065

Ferreira, V., & Lisboa, A. (2019). Innovation and entrepreneurship: From Schumpeter to Industry 4.0. *Applied Mechanics and Materials, 890*, 174–180. https://doi.org/10.4028/www.scientific.net/AMM.890.174

Ge, T., Abbas, J., Ullah, R., Abbas, A., Sadiq, I., & Zhang, R. (2022). Women's entrepreneurial contribution to family income: Innovative technologies promote females' entrepreneurship amid COVID-19 crisis. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.828040

Ghosh, S., Mahapatra, M., Tandon, N., & Tandon, D. (2023). Achieving sustainable development goal of women empowerment: A study among self-help groups in India. *FIIB Business Review, 13*(4), 477–491. https://doi.org/10.1177/23197145231169074

Ghouse, S., Durrah, O., & McElwee, G. (2021). Rural women entrepreneurs in Oman: Problems and opportunities. *International Journal of Entrepreneurial Behaviour & Research, 27*(7), 1674–1695. https://doi.org/10.1108/IJEBR-03-2021-0209

Ghouse, S., McElwee, G., Meaton, J., & Durrah, O. (2017). Barriers to rural women entrepreneurs in Oman. *International Journal of Entrepreneurial Behaviour & Research, 23*(6), 998–1016. https://doi.org/10.1108/IJEBR-02-2017-0070

Gujrati, R., Tyagi, V., & Lawan, L. (2019). Family financial status and students' entrepreneurial intention: The mediatory role of entrepreneurship education. *Journal of Management, 10*(3). https://doi.org/10.34218/jom.6.3.2019.003

Gulzar, F., & Fayaz, A. (2021). Youth entrepreneurial intentions: An integrated model of individual and contextual factors. *International Journal of Organizational Analysis, 31*(5), 1279–1303. https://doi.org/10.1108/IJOA-08-2021-2928

Harinurdin, E., Laksmono, B. S., Kusumastuti, R., & Safitri, K. A. (2025). Community empowerment utilizing open innovation as a sustainable village-owned enterprise strategy in Indonesia: A systematic literature review. *Sustainability, 17*, Article 3394. https://doi.org/10.3390/su17083394

Hoz-Rosales, B., Ballesta, J., & Tamayo-Torres, I. (2019). Effects of innovative entrepreneurship and the information society on social progress: An international analysis. *Journal of Entrepreneurship and Sustainability Issues, 7*(2), 782–813. https://doi.org/10.9770/jesi.2019.7.2(1)

Huang, L., Huang, Y., Huang, R., Xie, G., & Cai, W. (2022). Factors influencing returning migrants' entrepreneurship intentions for rural e-commerce: An empirical investigation in China. *Sustainability, 14*(6), Article 3682. https://doi.org/10.3390/su14063682

Hulyadi, H., Suryati, S., Azmi, I., Prayogi, S., & Verawati, N. N. S. P. (2025). Project-based teaching factory in the chemical cleaning industry to enhance students' soft skills and entrepreneurial intention. *Social Sciences & Humanities Open, 12*, Article 102221. https://doi.org/10.1016/j.ssaho.2025.102221

Ianioglo, A. (2022). Innovation and entrepreneurial ecosystems. In *Innovation ecosystems*. IntechOpen. https://doi.org/10.5772/intechopen.102344

Kania, I., Anggadwita, G., & Alamanda, D. T. (2021). A new approach to stimulate rural entrepreneurship through village-owned enterprises in Indonesia. *Journal of Enterprising Communities: People and Places in the Global Economy, 15*(3), 432–450. https://doi.org/10.1108/JEC-07-2020-0137

Khatani, S., Iraqi, K., Hamid, S., & Iqbal, A. (2021). Investigating entrepreneurial intention among the youth of Karachi: Evidence from partial least square-structural equation modelling. *International Journal of Management Research and Emerging Sciences, 11*(4). https://doi.org/10.56536/ijmres.v11i4.162

Lakmal, W., & Fernando, H. (2023). Evaluation on entrepreneurial intentions of Sri Lankan youth generation with special reference to Kurunegala District. *Sri Lankan Journal of Banking and Finance, 6*(2), 103–123. https://doi.org/10.4038/sljbf.v6i2.50

Li, J., Nair, S., & Wider, W. (2022). Effects of family background and entrepreneurship competition on students' entrepreneurial intention in China. *Humanities and Social Sciences Letters, 10*(4), 557–568. https://doi.org/10.18488/73.v10i4.3185

Lidder, P., Cattaneo, A., & Chaya, M. (2025). Innovation and technology for achieving resilient and inclusive rural transformation. *Global Food Security, 44*, Article 100827. https://doi.org/10.1016/j.gfs.2025.100827

Liñán, F., & Chen, Y. W. (2009). Development and cross-cultural application of a specific instrument to measure entrepreneurial intentions. *Entrepreneurship Theory and Practice, 33*(3), 593–617. https://doi.org/10.1111/j.1540-6520.2009.00318.x

Maayoufi, D., Péli, L., & Czabadai, L. (2023). Factors affecting entrepreneurial intention and entrepreneurial attitudes among rural Tunisian women. *Acta Carolus Robertus, 13*(2), 210–224. https://doi.org/10.33032/acr.4088

Mahn, D., Lecuna, A., Chávez, G., & Barros, S. (2022). Drivers of growth expectations in Latin American rural contexts. *Journal of Entrepreneurship in Emerging Economies, 15*(5), 1247–1276. https://doi.org/10.1108/JEEE-10-2021-0388

Makhdoom, H., Li, C., & Asim, S. (2019). Diffusion of innovation through individual and collective entrepreneurship. *Asia Pacific Journal of Innovation and Entrepreneurship, 13*(1), 89–107. https://doi.org/10.1108/APJIE-06-2018-0040

Malebana, M. (2014). Entrepreneurial intentions and entrepreneurial motivation of South African rural university students. *Journal of Economics and Behavioral Studies, 6*(9), 709–726. https://doi.org/10.22610/jebs.v6i9.531

Mawardi, M., Sujarwoto, S., & Sahputri, R. (2022). A multidimensional model of planned behavior theory and its prediction on entrepreneurial intention. *MIX: Jurnal Ilmiah Manajemen, 12*(2), 319. https://doi.org/10.22441/jurnal_mix.2022.v12i2.011

McGehee, N., & Kline, C. (2008). Entrepreneurship and the rural tourism industry: A primer. In *Entrepreneurship and rural tourism* (pp. 123–141). https://doi.org/10.1079/9781845934477.0123

Mohammadali, Z., & Abdulkhaliq, S. (2019). Prospects and challenges of entrepreneurship development in the Kurdistan region of Iraq: An overview. *International Journal of Entrepreneurial Knowledge, 7*(2). https://doi.org/10.37335/ijek.v7i2.89

Nabi, G., Liñán, F., Fayolle, A., Krueger, N., & Walmsley, A. (2017). The impact of entrepreneurship education in higher education: A systematic review and research agenda. *Academy of Management Learning & Education, 16*(2), 277–299. https://doi.org/10.5465/amle.2015.0026

Newman, A., Obschonka, M., Schwarz, S., Cohen, M., & Nielsen, I. (2019). Entrepreneurial self-efficacy: A systematic review of the literature on its theoretical foundations, measurement, antecedents, and outcomes, and an agenda for future research. *Journal of Vocational Behavior, 110*, 403–419. https://doi.org/10.1016/j.jvb.2018.05.012

Nyoko, A. E. L., & Hanafiah, M. H. (2024). A systematic literature review on entrepreneurial intention: PRISMA method. In *Proceedings of the 7th International Conference* (pp. 254–273). https://doi.org/10.2991/978-94-6463-411-2_21

Paço, A., Ferreira, J., Raposo, M., Rodrigues, R., & Dinis, A. (2011). Entrepreneurial intention among secondary students: Findings from Portugal. *International Journal of Entrepreneurship and Small Business, 13*(1), 92. https://doi.org/10.1504/IJESB.2011.040418

Pham-Ngoc-Huong, Q., Pham, T., Vu, T., Hung, P., & Phương, N. (2025). Factors affecting entrepreneurial intentions of women in rural areas of Vietnam. *Research on World Agricultural Economy, 6*(1), 395–407. https://doi.org/10.36956/rwae.v6i1.1442

Purusottama, A., Trilaksono, T., & Soehadi, A. (2018). Community-based entrepreneurship: A community development model to boost entrepreneurial commitment in rural micro enterprises. *MIX: Jurnal Ilmiah Manajemen, 8*(2), 429. https://doi.org/10.22441/mix.2018.v8i2.015

Putra, I. R. A. S., Wibowo, R. A., Purwadi, Andari, T., Asrori, Christy, N. N. A., Santoso, C. W. B., Harefa, H. Y., & Suryawardana, E. (2025). Village-owned enterprises perspectives towards challenges and opportunities in rural entrepreneurship: A qualitative study with MAXQDA tools. *Administrative Sciences, 15*(3), Article 74. https://doi.org/10.3390/admsci15030074

Runcan, R. (2020). Turning farmers into social farmer entrepreneurs for disadvantaged people. In *Proceedings of NORDSCI Conference* (Vol. 3, pp. 1–7). https://doi.org/10.32008/nordsci2020/b1/v3/31

Sedeh, A. A., Pezeshkan, A., & Caiazza, R. (2021). Innovative entrepreneurship in emerging and developing economies: The effects of entrepreneurial competencies and institutional voids. *The Journal of Technology Transfer, 47*(4), 1198–1223. https://doi.org/10.1007/s10961-021-09874-1

Silveyra-León, G., Rodríguez-Aceves, L., & Baños-Monroy, V. (2023). Do entrepreneurship challenges raise students' entrepreneurial competencies and intention? *Frontiers in Education, 8*. https://doi.org/10.3389/feduc.2023.1055453

Soria-Barreto, K., Zúñiga-Jara, S., & Campo, S. (2016). Educación e intención emprendedora en estudiantes universitarios: Un caso de estudio. *Formación Universitaria, 9*(1), 25–34. https://doi.org/10.4067/S0718-50062016000100004

Stoica, O., Roman, A., & Rusu, V. (2020). The nexus between entrepreneurship and economic growth: A comparative analysis on groups of countries. *Sustainability, 12*(3), Article 1186. https://doi.org/10.3390/su12031186

Yadav, R., Kumari, K., & Saini, C. (2023). COVID-19 and Indian women entrepreneurship. *Journal of Women's Entrepreneurship and Education, 1–2*, 72–88. https://doi.org/10.28934/jwee23.12.pp72-88

Yao, Z., & Lian, Z. (2022). Research on the influencing factors of the entrepreneurial intention of people returning from urban to rural areas: The views of new development concept. *SHS Web of Conferences, 151*, Article 01029. https://doi.org/10.1051/shsconf/202215101029

Yuan, C., Wang, D., Hong, L., Zou, Y., & Wen, J. (2022). Coming back home to start up a business? A comparison between youth from rural and urban backgrounds in China. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.962419

Zhang, W., Li, Y., Zeng, Q., Zhang, M., & Lu, X. (2022). Relationship between entrepreneurship education and entrepreneurial intention among college students: A meta-analysis. *International Journal of Environmental Research and Public Health, 19*(19), Article 12158. https://doi.org/10.3390/ijerph191912158