The Effect of Digital Literacy on the Entrepreneurial Performance of Smallholder Farmers in Tingloy, Batangas

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Abstract

This study examined the effect of digital literacy on the entrepreneurial performance of smallholder farmers in Tingloy, Batangas, Philippines. Specifically, it assessed their digital literacy levels, determined the direct effect of digital literacy on their entrepreneurial performance, and investigated the mediating roles of entrepreneurial bricolage and opportunity identification in this relationship. Data was collected from 107 smallholder farmers across 10 associations using questionnaires. Descriptive statistics and regression analyses revealed that these farmers possess an "acceptable" level of digital literacy, with notable strengths in digital communication and awareness, but moderate competence in evaluation and ethical use. Regression analysis confirmed a significant positive effect of digital literacy on entrepreneurial performance ($R2=0.766$, $p<0.001$). Furthermore, the study established that both entrepreneurial bricolage ($p=0.0004$) and opportunity identification ($p<0.001$) significantly mediate this relationship, demonstrating how digital competence fosters resourcefulness and the ability to identify and capitalize on entrepreneurial opportunities. Consequently, all null hypotheses were rejected, confirming the significant influence of digital literacy on entrepreneurial performance. These findings highlight the importance of integrated training programs that develop not only digital skills but also creativity, opportunity-seeking behavior, and entrepreneurial thinking to foster rural innovation and economic growth.

Keywords: Digital Literacy, Entrepreneurial Performance, Entrepreneurial Bricolage, Opportunity Identification, Agriculture

1. Introduction

1.1 Background of the Study

Globally, the agriculture sector is a vital contributor to socioeconomic progress. It plays a crucial role in achieving food security and eradicating poverty and hunger, aligning with Sustainable Development Goals 1 and 2. Additionally, agriculture significantly improves employment opportunities, income levels, and living standards for impoverished populations (FAO, 2014).

Developing regions prioritize food security, yet they remain vulnerable to various factors. Population growth worsens the impact of environmental events, such as floods and droughts. Concurrently, increasing food prices and income inequality further compound the challenges to food access and availability (Pawlak & Kołodziejczak, 2020). As stated by Gumbi et al. (2023), an estimated 70-80% of the world's food production comes from roughly 500 million smallholder farmers globally. Their significance for ensuring food security in developing nations is undeniable.

A smallholder farmer is an individual who engages in agricultural activities, such as livestock rearing, fish farming, or crop cultivation, on a limited scale. In developing countries, a smallholder farm is typically a family-owned operation depending on their farms for both sustenance and income generation. They occupy up to 10 hectares of land, with most farms being smaller, often less than 2 hectares. Smallholder farmers, particularly in developing countries, play a vital role in global food security (Gumbi et al., 2023).

In the context of the Philippine economy, particularly within the CALABARZON region, despite the large agricultural workforce, a concerning paradox persists, farmers and fishers experience disproportionately high poverty

rates. This trend is likely reflected in communities like Tingloy, Batangas, where farmers contend with a poverty rate of 19.1% (PSA, 2021). Recent data indicates a decline in national agricultural production, attributed to a combination of factors including shrinking farm sizes, low production due to outdated practices, limited access to financing, poor infrastructure, and the lack of technology awareness (PSA, 2020b).

Currently, smallholder farmers often rely on specific middlemen to sell their produce, limiting their income and control. Additionally, a lack of transparency in the system prevents farmers from obtaining the best prices for their products (Gomathy et al., 2021). This lack of market awareness further disadvantages them.

This proves the same with the municipality of Tingloy, the Special Area for Agricultural Development (SAAD) CALABARZON conducted needs assessments and participatory rural appraisals in 10 farming barangays in Tingloy. Participating farmers identified key challenges related to production and marketing. Production problems stemmed from a lack of knowledge regarding optimal practices, such as herd management, vaccination, cropping calendars, fertilizer application, and alternative feed usage. The island geography of Tingloy complicates produce marketing. These challenges could potentially be addressed through increased farmers' awareness and knowledge facilitated by digital literacy initiatives.

Farmers in Tingloy likely face numerous challenges that contribute to the high poverty incidence and hinder their economic growth. The research proposal suggests potential gaps in their digital literacy and entrepreneurial capabilities, both of which could limit farmers' ability to optimize production, access wider markets, and increase income. A reliance on less efficient traditional practices might negatively impact yields, resource management, and overall farm productivity. Moreover, limited access to essential resources like capital, improved infrastructure, and reliable market information could further exacerbate existing barriers.

Promoting digital literacy and the adoption of digital agricultural practices could present significant benefits for Tingloy farmers. Equipping them with digital skills would empower them to leverage ecommerce, precision farming, and other smart technologies – potentially revolutionizing their agricultural practices.

Farmers with high digital literacy are more likely to utilize e-commerce and digital payment platforms, enhancing their market participation and competitiveness. This breaks geographical restrictions and addresses product homogeneity, increasing farmers' income. Furthermore, high digital literacy empowers farmers to understand consumer needs and access valuable digital information. This facilitates effective communication with customers through instant messaging platforms, fostering stronger trading relationships. By tailoring product and service offerings to customer demands, digitally literate farmers can expand their business scale and gain a competitive edge, improving their entrepreneurial performance (Ji & Zhuang, 2023).

The rapid integration of digital technologies into agriculture holds significant advantages for smallholder farmers, enhancing their efficiency, productivity, and market access. To fully utilize these, farmers need digital literacy skills. Research by Chikaire et al. (2021) demonstrated the power of ICT platforms for accessing vital information on weather, markets, and best practices. However, Mehrabi et al. (2023) noted persistent barriers to digital adoption, including inadequate infrastructure and a lack of targeted training programs. Bridging this divide is necessary for inclusive development.

According to Magesa et. al. (2023), the growing adoption of digital technologies, including mobile services, remote sensing, and distributed computing, is already improving access to information, resources, markets, financing, and training for smallholder farmers. This integration strengthens their position within the agricultural food system. The rapid spread of mobile phones, with ownership increasing even among the poorest populations in developing countries (70% of the poorest 20% own mobile phones), underscores the potential of digital tools to accelerate progress towards ending poverty and hunger. This holds, especially in rural areas of developing countries where agriculture is the primary source of income for most people.

Farmers now have access to a wealth of data, including soil characteristics, weather patterns, and commodity pricing. This information, combined with the power of IoT devices and big data analytics, empowers them to make smarter decisions throughout the agricultural supply chain. Ultimately, this technological revolution aims to create a

more profitable and sustainable food production system. As highlighted in "Smart Farming Innovations for the Philippines" (Matero & Juwan-Matero, 2020), further advancements like e-commerce platforms, cloud computing, improved infrastructure, and advanced data analysis are crucial for the future of Philippine agriculture. These developments will not only enhance decision-making but also contribute to scaling up the industry.

Studies emphasized that digital literacy extends beyond mere technological access. Martin (2006) underscored the importance of critical analysis and problem-solving with digital tools in the agricultural context. Similarly, Bawden (2008) highlighted the multi-faceted nature of digital literacy, where farmers must not only master technical skills but also effectively locate, evaluate, and utilize online resources. Despite this growing recognition, a nuanced understanding of digital literacy levels and specific barriers within smallholder communities remains uneven (Ogutu et. al, 2020).

Magesa et. al., (2023), also emphasizes the complex nature of digital literacy. While farmers may have basic access and communication skills, they often struggle with information management, evaluation, and content creation. This suggests assessments must go beyond mere technological access. Importantly, the study connects ethical and safe online practices to digital literacy itself, a point reinforced by Sarbadhikari and Pradhan's (2023) work on misinformation risks.

This critical aspect deserves further investigation specifically within the Tingloy context. Additionally, the study highlights systemic barriers, including limited local content, language constraints, and a lack of targeted e-services. A localized assessment is essential to determine if similar barriers hinder digital literacy growth among Tingloy farmers, including factors like internet connectivity, the availability of resources in local languages, and the need for tailored agricultural e-services.

This underscores the need for both training initiatives and policy shifts to support digital literacy development among rural farmers. This highlights the importance of research, such as the proposed Tingloy study, that not only assesses digital literacy levels but also provides data-driven recommendations to inform effective support strategies. While existing research offers valuable insights, the specific challenges and needs of farmers in Tingloy, Batangas, require focused investigation to design practical interventions that will drive meaningful change within this unique context.

The Philippine government is tackling agricultural challenges head-on with innovative technological solutions. Techniques like drone monitoring, remote sensing, and satellite technology provide a clearer picture of farm activities. Farmers now benefit from real-time updates on infrastructure and machinery projects through ABEMIS, increasing transparency and efficiency. Remote sensing combined with data analysis is a game-changer, improving weather forecasting, predicting crop yields, and facilitating disaster assessment through PRiSM. Additionally, the RIICE project simplifies access to insurance schemes for farmers (Cordero & Park, 2023).

Technology extends beyond monitoring; drones are now used to precisely apply fertilizers, pesticides, and insecticides in orchards, optimizing resource usage and boosting efficiency. This integration of digital tools spans the entire agricultural process, from pre-production planning to postharvest activities. Furthermore, innovative solutions like urban farming initiatives with solar-powered smart greenhouses and indoor cultivation systems are being implemented to address food sustainability concerns. These advancements demonstrate the government's commitment to a more efficient and resilient agricultural sector.

According to high-level theory, individual entrepreneurial characteristics significantly influence how individuals perceive reality, impacting their decision-making and ultimately organizational performance. Entrepreneurship involves identifying opportunities, integrating resources, and creating value. Therefore, accurately identifying and evaluating entrepreneurial opportunities is crucial for farmers' success (Ji & Zhuang, 2023).

Smallholder Farmers' digital literacy can enhance their ability to identify and develop entrepreneurial opportunities, adapt their business strategies, and improve their overall entrepreneurial performance. Traditional farmers often have limited education and experience in modern agricultural practices, hindering their ability to recognize entrepreneurial opportunities. Digital technology disrupts traditional markets and creates new opportunities. Digitally literate farmers,

with strong digital awareness, knowledge, and skills, are more likely to utilize digital tools to acquire knowledge about modern business operations and management. This enhances their understanding and improves their ability to identify and capitalize on emerging entrepreneurial opportunities in these dynamic markets (Li et. al., 2022).

Digitally literate farmers can effectively utilize various online platforms to access timely and accurate market dynamics and policy information. Moreover, they can expand their social networks through online interactions, facilitating access to professional advice, diverse knowledge, and valuable tacit information. This not only improves access to high-quality market information but also reduces the cost of information acquisition, enabling farmers to effectively identify and evaluate entrepreneurial opportunities, ultimately enhancing their entrepreneurial performance (Wang et. al., 2022).

Due to limited access to quality education, smallholder farmers often hold low-skilled positions in employment, hindering their acquisition of management skills. Additionally, limited social networks restrict access to business-related information, further hindering the development of entrepreneurial skills among farmers. Studies have shown that knowledge, skills, and management abilities are critical for entrepreneurial success. Entrepreneurial learning, including learning from external sources, can significantly improve these abilities.

Digital literacy empowers farmers to leverage the benefits of digital technologies, such as expanded information access and broadened social networks that overcome knowledge barriers. High digital literacy facilitates "dry learning," that enhances human capital through digital means. This strengthens farmers' management skills, fosters social interaction, and ultimately boosts productivity and innovation. Furthermore, digital literacy enables farmers to effectively utilize fragmented resources through entrepreneurial bricolage. By expanding their social networks and connecting with diverse individuals, farmers can access a wider range of resources and perspectives. This allows them to creatively utilize these fragmented resources, mitigating resource constraints and generating valuable new assets (Wang et al., 2022).

Entrepreneurial bricolage involves continuous learning. Digitally literate farmers, with strong learning attitudes and digital skills, can effectively acquire complex knowledge and information from various online platforms (Zhang, 2023). This enables them to effectively analyze and utilize seemingly redundant resources that identify their unique advantages and potential connections. By creatively utilizing these resources, farmers can overcome resource limitations, generate innovative solutions, and ultimately improve their entrepreneurial performance (Yu et. al., 2020).

Considering the identified challenges facing smallholder farmers in Tingloy, Batangas, and the limited existing research on the effects of digital literacy to their entrepreneurial performance, this study utilized data collected from farmers in Tingloy. It examined the digital literacy of these farmers across three key dimensions: digital cognitive identification, digital evaluation and application, and digital communication and sharing.

Focusing on how digital literacy can enhance the entrepreneurial success of Tingloy farmers, this study incorporated entrepreneurial bricolage and opportunity identification into the research framework. The study investigated the mediating roles of these factors in the relationship between digital literacy and entrepreneurial performance. This aims to understand the specific pathways through which digital literacy affects the entrepreneurial outcomes of Tingloy farmers.

By contributing to the existing body of knowledge on the effect of digital literacy and enhancing the understanding of entrepreneurial performance among smallholder farmers in Tingloy, this research may provide valuable insights for policymakers and farmers alike. It underscores the importance of cultivating digital literacy among Tingloy farmers and offers practical recommendations for effectively leveraging digital technologies to enhance their entrepreneurial endeavors.

1.2 Research Frameworks

This study adapted the framework of Ji and Zhuang (2023) with the entrepreneurial performance as the dependent variable and the digital literacy of farmers being the independent variable. The study found that digital literacy significantly and positively affects the entrepreneurial performance of smallholder farmers. This positive effect is mediated through two key variables which are entrepreneurial bricolage and entrepreneurial opportunity identification.

Firstly, digital literacy empowers farmers to effectively utilize and combine existing resources, enhancing their entrepreneurial bricolage capabilities, which in turn leads to increased competitiveness and improved entrepreneurial performance. Secondly, high digital literacy enables farmers to determine and evaluate most opportunities, ultimately improving their performance.

Furthermore, the study revealed a mediation effect, demonstrating that digital literacy influences entrepreneurial performance by simultaneously influencing both entrepreneurial bricolage and entrepreneurial opportunity identification.

Based on these findings, the study emphasized the importance of enhancing digital literacy among smallholder farmers by investing in training programs that equip farmers with diverse digital skills, encouraging farmers to proactively improve their digital literacy by seeking out training opportunities and actively utilizing digital technologies, and emphasizing the importance of leveraging digital technologies to "make do with" and "reconstruct" existing resources to enhance competitiveness and improve entrepreneurial performance.

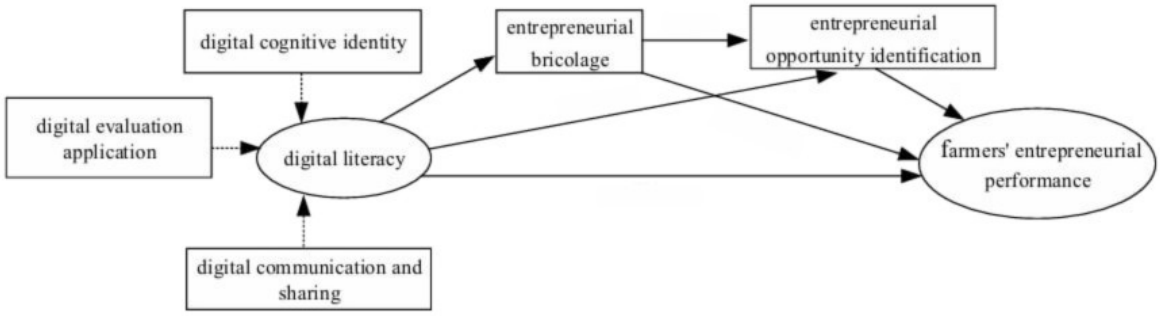

Figure 1. Conceptual Framework
Source: The Impact Path of Digital Literacy on Farmers' Entrepreneurial Performance: Based on Survey Data in Jiangsu Province (Ji and Zhuang, 2023)

While the study of Ji and Zhuang (2023) was conducted in the Jiangsu Province of China, this study was conducted in the Philippines, particularly the municipality of Tingloy in Batangas. Both studies were participated with smallholder farmers. This study was guided by the operational framework stated in the figure below.

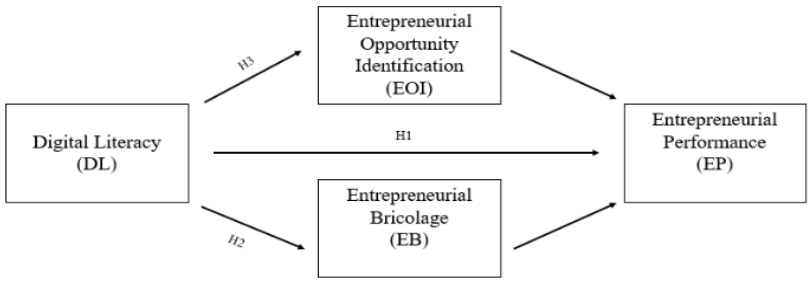

Figure 2. Operational Framework

As presented in the study of Ji and Zhuang (2023), the key variables are defined as follows: Digital Literacy (DL) encompasses the ability to effectively utilize digital technologies for accessing, understanding, evaluating, creating, and communicating information. This was operationalized through scores on a validated assessment tool. Digital Cognitive Identity refers to the individual's self-image constructed through online interactions. Digital Evaluation Application signifies the ability to critically evaluate and apply digital information for decision-making in agriculture.

Digital Communication and Sharing denote the ability to effectively communicate and share information using digital platforms.

Entrepreneurial Bricolage (EB) involves the creative utilization of available resources, including digital ones, to identify and exploit entrepreneurial opportunities. Entrepreneurial Opportunity Identification (EOI) refers to the ability to recognize and assess potential business opportunities in the agricultural sector. Lastly, Farmers' Entrepreneurial Performance (EP) measures the overall success and profitability of the farmer's entrepreneurial ventures.

Entrepreneurial Performance (EP) is assessed using an 8-item scale. Digital Literacy (DL) was measured with a 7-item scale, which is further broken down into three dimensions: digital cognitive identification, digital evaluation application, and digital communication sharing, all utilizing a 5-point Likert scale. Entrepreneurial Bricolage (EB) is evaluated using an 8-item scale also on a 5-point Likert scale. Entrepreneurial Opportunity Identification (EOI) is measured with a 4-item scale, similarly, employing a 5-point Likert scale. Control variables, including individual characteristics such as sex, age, education, and years in farming/business, along with family characteristics like annual household income and the number of labor force members, are measured using direct questions.

1.3 Objectives of the Study

In general, the study aims to determine the effect of digital literacy on the entrepreneurial capabilities of smallholder farmers in Tingloy, Batangas. Specifically, the study seeks to:

1. assess the level of digital literacy among smallholder farmers in Tingloy, Batangas;
2. determine the effect of digital literacy on the entrepreneurial performance of smallholder farmers;
3. investigate the mediating role of entrepreneurial bricolage between digital literacy and entrepreneurial performance among smallholder farmers in Tingloy, Batangas;
4. investigate the mediating role of entrepreneurial opportunity identification between digital literacy and entrepreneurial performance among smallholder farmers in Tingloy, Batangas; and
5. identify potential programs and initiatives that can enhance the digital literacy, entrepreneurial bricolage, opportunity identification, and entrepreneurial performance of smallholder farmers in Tingloy, Batangas.

1.4 Hypotheses

The hypotheses below are tested in this study:

H_{o1}: Digital Literacy does not have a significant effect on the Entrepreneurial Performance of Smallholder Farmers.

H_{o2}: Entrepreneurial Bricolage does not mediate the relationship between Digital Literacy and smallholder farmer's Entrepreneurial Performance.

H_{o3}: Entrepreneurial Opportunity Identification does not mediate the relationship between Digital Literacy and smallholder farmer's Entrepreneurial Performance.

2. Methods

2.1 Research Design

This study employed a descriptive, causal research design to examine the effect of DL on the EP of smallholder farmers in Tingloy, Batangas. It examined if EB and EOI have a mediating relationship between DL and EP. Primary quantitative data was collected through self-administered survey questionnaires using pen and paper to the participating farmers.

2.2 Locale of the Study

The study was conducted in Tingloy, Batangas, a lone island municipality wherein tourism was a significant contributor to the local economy. Tingloy boasts a diverse agricultural landscape, with key crops including bananas and coconuts, as well as livestock such as goats and swine. Vegetable cultivation for personal consumption is also prevalent. The primary market for agricultural products is the nearby town of Mabini, Batangas. Farming and fishing remain crucial sources of livelihood for most of the residents. Despite its natural and tourism-related assets, Tingloy remains classified as a 5th-class municipality, indicating its socio-economic challenges

2.3 Respondents of the Study

The respondents comprised of 337 registered farmers residing in Tingloy, Batangas. These farmers are members of various Farmers' Associations (FAs) formally recognized by the Department of Agriculture and registered with the Department of Labor and Employment. These FAs served as strata for sampling purposes, ensuring that the research sample adequately represented the diverse groups within the farming community in Tingloy.

To compute the required sample size, GPower was utilized. Within GPower, the "F tests" -> "Linear multiple regression: fixed model, R^2 increase" option was selected, followed by "A priori: compute required sample size - given α, power, and effect size." The following parameters were set as Effect size (f^2): 0.15, α err prob: 0.05 (significance level), Power (1-β err prob): 0.95, and number of predictors which is 2. Based on these parameters, G*Power analysis indicated a required sample size of 107 smallholder farmers to achieve a power of 0.95.

2.4 Sampling Design

The study employed a two-stage sampling method using proportionate stratified sampling. First, the population of farmers in Tingloy was stratified based on their membership in different Farmers' Associations (FAs). The number of farmers sampled from each FA is proportional to the FA's representation within the overall farming population of Tingloy.

This proportionate allocation ensured accurate representation of all distinct groups within the farming community. Second, simple random sampling was conducted within each stratum (FA) to select the final research participants. This combination of proportionate stratification and random sampling within strata ensured both representativeness and minimized bias.

TABLE 1. Number of Respondents per FA

Farmer Association (FA)	Number of Members	Number of Respondents
Farmer's Association 1	25	8
Farmer's Association 2	35	11
Farmer's Association 3	31	10
Farmer's Association 4	25	8
Farmer's Association 5	28	9
Farmer's Association 6	50	16
Farmer's Association 7	25	8
Farmer's Association 8	40	13
Farmer's Association 9	33	10
Farmer's Association 10	45	14

2.5 Research Tools and Instruments

The study used Ji and Zhuang's (2023) questionnaire in assessing the impact part of digital literacy on farmer's entrepreneurial performance. All items used a 5-point Likert scale. Individual (sex, age, education, farming experience) and family (income, labor force) characteristics were the control variables.

In terms of reliability testing, the previous study conducted by Ji and Zhuang (2023) demonstrated strong internal consistency for all variables (DL, EOI, EB, and EP). Cronbach's Alpha values exceeded 0.8, and Composite Reliability (CR) values were greater than or equal to 0.858, showing consistency and reliability. A pilot test was also performed, testing a total of 30 respondents. Like the previous study, the resulting Cronbach Alpha values exceeded 0.9, indicating consistency and reliability.

TABLE 2. Cronbach's Alpha per Variable based on Pilot Study

Variable	Number of Items	Cronbach Alpha
A. Digital Literacy (DL)	7	0.939
B. Entrepreneurial Opportunity Identification (EOI)	4	0.918
C. Entrepreneurial Bricolage (EB)	8	0.944
D. Entrepreneurial Performance (EP)	8	0.928

2.6 Data Analysis and Interpretation

Upon data collection, the results were analyzed and interpreted to address the specific objectives of the study. The scale interpretation ranges were outlined in Table 3.

TABLE 3. Response Category and Interpretation

Mean Range	Digital Literacy (DL)	Entrepreneurial Opportunity Identification (EOI)	Entrepreneurial Bricolage (EB)	Entrepreneurial Performance (EP)
4.20-5.00	Very High Level	Very High	Very High Level	High Performance
3.40-4.19	High Level	High	High Level	Good Performance
2.60-3.39	Acceptable Level	Moderate	Acceptable Level	Moderate Performance
1.80-2.59	Low Level	Low	Low Level	Poor Performance
1.00-1.79	Very Low Level	Very Low	Very Low Level	Very Poor Performance

The Data analysis started with the calculation of descriptive statistics, including means and standard deviations, for all control (age and key variables). Multiple regression analyses were conducted using Andrew Hayes' PROCESS macro in SPSS to examine the influence of digital literacy on the entrepreneurial performance of farmers, with entrepreneurial bricolage and entrepreneurial opportunity identification as mediators. This approach assessed both the direct and indirect effects of digital literacy on entrepreneurial performance through entrepreneurial bricolage and entrepreneurial opportunity identification.

The bootstrap method was also employed to enhance the accuracy of the mediation analysis by providing more precise estimates of the indirect effects and their 95% confidence intervals. This analysis provided insights into the effects of digital literacy on entrepreneurial performance among smallholder farmers in Tingloy, Batangas, and clarify the mediating roles of entrepreneurial bricolage and entrepreneurial opportunity identification. The table below presents the verbal interpretation of each variable, and the corresponding mean range obtained from the 5-point Likert scale used in the assessment.

2.7 Ethical Considerations

This study adhered to strict ethical guidelines, prioritizing the privacy and well-being of all participating smallholder farmers in Tingloy, Batangas. Prior to their involvement, informed consent was obtained from each participant. This process ensured that participants fully understand the study's objectives, procedures, and that they voluntarily agree to participate without any coercion. All data collected were treated with the utmost confidentiality, and anonymity was maintained throughout the process and in all published reports. Formal letters of approval were obtained from the relevant ethical organizations and departments and local authorities including the Municipal Agriculture's Office and the local government unit of Tingloy, Batangas, before commencing any activities. This ensured that the study followed all relevant ethical regulations and received necessary approval.

3. Results and Discussion

3.1 Descriptive Statistics and Respondent Profile

The study surveyed 107 smallholder farmers from 10 farmer associations in Tingloy, Batangas. The sample comprised slightly more of female farmers (53.3%) than male farmers (46.7%). This slight difference may be attributed to the timing of the interviews, as many male farmers were engaged in farm labor and other income-generating activities when the survey was conducted.

Regarding age distribution, most surveyed farmers were in the middle age brackets, with 41.1% aged 36-45 years and 30.8% aged 46-55 years. Younger farmers (21-35 years) constituted 17.8%, while the fewest respondents were above 56 years old (10.3%). The lower representation in the youngest group is likely due to individuals seeking employment outside the island, while some older individuals may have been less willing to participate in the survey.

In terms of educational attainment, the highest proportion of farmers completed high school (52.3%), followed closely by those who finished elementary education (43%). It was noted during data collection that many individuals with college degrees have migrated to nearby cities for better employment prospects outside of farming.

Analysis of farming and business experience shows a relatively even distribution across the defined categories: 37.38% had 1-5 years of experience, 36.45% had 6-15 years, and 26.17% had 15 years or more. This indicates a diverse range of experience levels among the surveyed farmers.

Regarding household size, the category of households with at least 2 or more individuals accounted for 45.8% of respondents. This large proportion is a characteristic of communities with strong family ties and suggests potential implications for labor availability and economic decision-making within the family unit.

Concerning annual income, the distribution shows that a significant percentage of smallholder farmers earn less than ₱30,000 (31.78%), with another large group earning between ₱30,000 and ₱59,999 (24.30%). Considering the identified average annual income of ₱60,000, these figures indicate that over half of the surveyed farmers earn below the average income level. Higher income brackets were less represented, with 23.36% earning between ₱60,000 and ₱89,999, and 20.56% earning above ₱90,000.

The table below presents the descriptive statistics for the key variables of the study: Digital Literacy (DL), Entrepreneurial Opportunity Identification (EOI), Entrepreneurial Bricolage (EB), and Entrepreneurial Performance (EP). These statistics provide an overview of the central tendency and variability of these four variables, offering insights into the characteristics of the respondents.

Table 4. Verbal Interpretation of Descriptive Statistics

Variable	Mean	Standard Deviation	Interpretation
Digital Literacy (DL)	3.26	0.88	Acceptable Level
Entrepreneurial Opportunity Identification (EOI)	3.45	0.97	High
Entrepreneurial Bricolage (EB)	3.42	0.89	High
Entrepreneurial Performance (EP)	3.09	0.94	Moderate Performance

Specifically, the mean for Digital Literacy is 3.26, with a standard deviation of 0.88, interpreted as an "Acceptable Level". This suggests that, on average, the smallholder farmers in Tingloy possess a moderate level of digital literacy; while it is considered "acceptable," it is not "high," indicating room for improvement. The standard deviation of 0.88 indicates a moderate spread in digital literacy levels among the farmers, meaning that while many farmers are close to the average, there is also some variation, with some farmers being less digitally literate than others.

The mean for Entrepreneurial Opportunity Identification is 3.45, with a standard deviation of 0.97, interpreted as "High". This shows that farmers, on average, demonstrate a good ability to identify entrepreneurial opportunities. However, the relatively high standard deviation of 0.97 suggests significant variability in opportunity identification skills, with some farmers being highly skilled at spotting opportunities and others less so.

Entrepreneurial Bricolage has a mean of 3.43 and a standard deviation of 0.89, interpreted as "High Level". This indicates that the farmers generally exhibit a strong tendency to engage in entrepreneurial bricolage, resourcefully creating something new from existing resources to overcome limitations. The standard deviation of 0.89 suggests a moderate degree of variability in bricolage behavior, with most farmers being resourceful but with some being more adept at it than others.

Finally, the mean for Entrepreneurial Performance is 3.09, with a standard deviation of 0.94, interpreted as "Moderate Performance". This suggests that the overall entrepreneurial performance of the farmers is at a moderate level. The standard deviation of 0.94 indicates a fair amount of variability in performance, with some farmers performing quite well and others struggling.

3.2 Assess the level of digital literacy among smallholder farmers in Tingloy, Batangas

The first objective of this study was to assess the digital literacy levels of 107 smallholder farmers from 10 farmer associations in Tingloy, Batangas. To measure this, seven items were used, capturing three core aspects of digital literacy: digital cognitive identity (DL1–DL2), digital evaluation application (DL3–DL5), and digital communication and sharing (DL6–DL7).

Table 5. *Digital Literacy Level of Smallholder Farmers*

Digital Literacy	Mean	Std. Deviation	Interpretation
Living in digital age (DL 1)	3.45	1.15	High Level
Awareness of digital tools (DL 2)	3.35	1.07	Acceptable
Understanding of theories and methods (DL 3)	2.98	0.90	Acceptable
Validation of obtained information (DL 4)	3.24	1.07	Acceptable
Use of digital tools in problem solving (DL 5)	3.10	0.90	Acceptable
Sharing of information (DL 6)	3.48	1.13	High Level
Follow ethical guidelines (DL 7)	3.24	0.88	Acceptable
Digital Literacy	**3.26**	**0.88**	**Acceptable**

The overall mean score for digital literacy was 3.26, interpreted as “Acceptable,” suggesting that, on average, the farmers possess a moderate level of digital competence. Within the digital cognitive identity category, DL1 recorded a mean of 3.45, which reflects a high level of awareness about the importance of digital technology. This is consistent with findings by Magesa et al. (2023), who observed that smallholder farmers in Tanzania were increasingly aware of

the potential of digital tools to improve agricultural outcomes. DL2, however, received a slightly lower mean of 3.35, indicating only an acceptable level of understanding of the theories and concepts underlying digital practices. This disparity implies that while farmers recognize the value of technology, their grasp of the foundational knowledge needed to apply it effectively is somewhat limited.

In the area of digital evaluation application, DL3, DL4, and DL5 all fell within the "Acceptable" range, with means of 2.98, 3.24, and 3.10, respectively. These results suggest that farmers exhibit a moderate ability to utilize digital tools for problem-solving, evaluation, and decision-making. However, the relatively lower mean for DL3 points to a weakness in using digital tools specifically for evaluating information. Similar patterns were reported by Zhang et al. (2023), who found that while farmers in Jiangsu Province, China, were familiar with digital applications, they often struggled with tasks that required deeper critical engagement, such as evaluating digital content and applying it to real-world decisions.

In terms of digital communication and sharing, DL6 achieved a high mean score of 3.48, indicating that farmers are generally confident in using digital platforms to share information. This finding aligns with Magesa et al. (2023), who reported that communication-related tasks were among the strongest aspects of digital literacy among rural farmers. DL7, on the other hand, had a mean of 3.24, falling into the "Acceptable" category. This suggests that while farmers are comfortable with digital communication, they may lack a consistent understanding of ethical guidelines surrounding digital information use, an issue also noted in broader discussions about digital literacy development in rural contexts.

Standard deviations for the seven indicators ranged from 0.88 to 1.15. DL1 exhibited the highest standard deviation (1.15), indicating considerable variability in how farmers perceive the importance of digital technology. Conversely, DL7 had the lowest standard deviation (0.88), implying a more uniform understanding of ethical behavior in digital environments, despite the overall moderate mean.

Taken together, these findings illustrated a digital literacy profile characterized by strong awareness and communication skills, paired with modest capabilities in evaluation and ethical application. This reinforces the need for targeted interventions that strengthen foundational digital knowledge and critical digital competencies. As digital technologies become more embedded in agriculture, particularly in areas like market access and farm management, addressing these gaps will be essential for empowering farmers to fully participate in the digital economy and agricultural innovation landscape (Zhang et al., 2023; Magesa et al., 2023).

3.3 Determine the effect of digital literacy on the entrepreneurial performance of smallholder farmers

Table 6. Effect of Digital Literacy on the Entrepreneurial Performance of Smallholder Farmers

	Unstandardized Coefficients		*Standardized Coefficients*			
Model	*B*	*Std. Error*	*Beta*	*t*	*p-value*	*Interpretation*
Constant	*.052*	*.169*		*.307*	*.759*	
Digital Literacy	*.930*	*.050*	*.875*	*18.540*	*.000*	*Significant*
Dependent Variable: Entrepreneurial Performance, R^2 = .766, F-value = 343.734						

The coefficient of determination (R^2) was found to be 0.766, suggesting that 76.6% of the variance in entrepreneurial performance can be attributed to differences in digital literacy levels. This substantial proportion underscores digital literacy as a robust predictor of entrepreneurial success among smallholder farmers. Further examination of the regression coefficients revealed that digital literacy has a positive and significant effect on entrepreneurial performance, with an unstandardized coefficient (β) of 0.930 and a standardized coefficient (β) of 0.875. The corresponding t-value of 18.540 reinforces the strength and reliability of this relationship.

These findings align with the research conducted by Ji and Zhuang (2023), who observed that digital literacy significantly enhances the entrepreneurial performance of rural farmers by facilitating better access to information,

improving decision-making processes, and enabling more effective resource utilization. Similarly, Liu and Liao (2024) demonstrated that improvements in digital literacy among farm households lead to tangible economic benefits, including increased income levels, by enabling farmers to leverage digital tools for market access and financial management.

3.4 Investigate the mediating role of entrepreneurial bricolage in the relationship between digital literacy and entrepreneurial performance of smallholder farmers in Tingloy, Batangas

Based on the figures, it showed that entrepreneurial bricolage significantly mediates the relationship between digital literacy and entrepreneurial performance (p = 0.0004). This suggests that entrepreneurial bricolage plays a crucial role in how digital literacy influences farmers' performance. This finding is consistent with the idea that digital literacy not only directly affects performance but also operates through the mechanism of bricolage, where farmers creatively utilize available resources.

Table 7. Mediating Effect of Entrepreneurial Bricolage on Digital Literacy and Entrepreneurial Performance

	coeff	se	t	p	LLCI	ULCI
Constant	-0.1329	0.1682	-0.7902	0.4312	-0.4663	0.2006
Digital Literacy	0.5814	0.1067	5.4500	0.0000	0.3699	0.7930
Entrepreneurial Bricolage	0.3858	0.1058	3.6477	0.0004	0.1760	0.5955
Model Summary: R: .8903, R-sq: .7925, MSE: .1848, F: 198.6623, df1: 2,000, df2: 104.0000						

The results indicate that digital literacy has a positive and significant effect on entrepreneurial performance, as evidenced by the coefficient for DL (coeff = 0.5814, p < 0.0001). Furthermore, entrepreneurial bricolage also has a positive and significant effect on entrepreneurial performance (coeff = 0.3858, p = 0.0004). The significant effect of entrepreneurial bricolage suggests that it acts as a pathway through which digital literacy enhances performance.

These findings suggest the need to consider the role of resourcefulness and creativity (bricolage) in understanding how digital skills translate into tangible entrepreneurial outcomes. Agricultural settings may require farmers to leverage their digital literacy to adapt and innovate with limited resources, and entrepreneurial bricolage captures this crucial aspect.

It aligns with the results of the study of Liu and Zhang (2024) explaining that entrepreneurial bricolage plays a crucial role for entrepreneurial ventures. It empowers them to identify and capitalize on new opportunities and thereby drive business innovation. Conversely, when the level of digital literacy is low, it can hinder the conduct of entrepreneurial bricolage activities, the business innovation of entrepreneurial ventures may not be realized, and the sustainable entrepreneurial performance may also find it difficult to significantly improve.

Moreover, entrepreneurial bricolage facilitates the development of content, structure, and governance mechanisms, thereby capturing new opportunities. It is found to have a beneficial impact on entrepreneurial performance, and it also exerts a favorable influence on business innovation. In turn, business innovation significantly and positively impacts sustainable entrepreneurial performance. The innovation of entrepreneurial ventures resulting from entrepreneurial bricolage can foster the enhancement of sustainable entrepreneurial performance, which is consistent with the research findings of Jenkinson et al (2024) and Guo (2016).

3.5 Investigate the mediating role of entrepreneurial opportunity identification in the relationship between digital literacy and entrepreneurial performance of smallholder farmers in Tingloy, Batangas

The regression model, with entrepreneurial performance (EP) as the outcome variable and digital literacy (DL) and entrepreneurial opportunity identification (EOI) as predictor variables, is statistically significant ($p = 0.0000$). This indicates that digital literacy and entrepreneurial opportunity identification, together, significantly predict entrepreneurial performance. The model explains a substantial portion of the variance in entrepreneurial performance, with an R-squared value of 0.8076, suggesting a strong model fit. Furthermore, the high multiple correlation coefficient ($R = 0.8987$) confirms a strong positive relationship between the predictor variables and the outcome variable.

These results suggest that entrepreneurial opportunity identification mediates the relationship between digital literacy and entrepreneurial performance. The significant coefficients for both digital literacy and entrepreneurial opportunity identification, in conjunction with the overall model significance, indicate that digital literacy influences performance not only directly but also indirectly through its impact on farmers' ability to identify and capitalize on entrepreneurial opportunities. In essence, higher digital literacy empowers farmers to better recognize and exploit opportunities, which subsequently leads to improved entrepreneurial performance.

Table 8. Mediating Effect of Entrepreneurial Opportunity Identification on Digital Literacy and Entrepreneurial Performance

	coeff	se	t	p	LLCI	ULCI	Interpretation
Constant	-0.0548	0.1560	-0.3515	0.7259	-0.3642	0.2546	
Digital Literacy	0.5069	0.1002	5.0589	0.0000	0.3082	0.7056	Significant
Entrepreneurial Opportunity Identification	0.4313	0.0909	4.7437	0.0000	0.2510	0.6115	Significant
R: .8987, R-sq: .8076, MSE: .1714, F: 218.3153, df1: 2,000, df2: 104.0000							

Likewise, Zhao et al. (2021) explained that digital literacy aids entrepreneurial opportunity identification by enabling individuals, such as smallholder farmers, to leverage digital tools and platforms. This includes using data analysis features to understand market trends and consumer needs, allowing for the prediction of in-demand products or services. Furthermore, digital skills facilitate conducting market experiments on platforms through tools like testing and feedback analysis, helping entrepreneurs pinpoint unmet market demands and refine their business approaches.

Similarly, Zhao et al. (2023) iterated that social interaction capabilities as part of digital literacy that allows entrepreneurs, such as smallholder farmers, to identify opportunities through engaging with social networks and online communities. Interactions on these platforms can reveal user needs and market potential, providing access to industry information and helping to uncover previously unnoticed market opportunities.

Finally, entrepreneurial opportunity identification is fundamental to achieving strong entrepreneurial performance, as it boosts market competitiveness and innovation. Entrepreneurs must not only spot opportunities but also leverage them effectively through innovative business models. Especially within the digital landscape, recognizing opportunities is significantly aided by digital capabilities, such as analyzing data, operating on platforms, creating content, and engaging socially, which together improve the precision and speed of opportunity identification. The research shows that there is a significant positive relationship between digital literacy and opportunity identification, with entrepreneurial opportunity identification serving as a direct pathway to improving entrepreneurial performance

(Xiong, 2025).

4. Conclusion

This study examined the relationship between digital literacy and entrepreneurial performance among smallholder farmers in Tingloy, Batangas. The findings revealed that while farmers widely acknowledge the importance of digital technology, their proficiency across different dimensions of digital literacy remains uneven. Consistent with Magesa et al. (2023), many smallholder farmers demonstrated a strong awareness of the relevance of digital tools yet often lack the deeper competencies necessary for their effective use. In particular, this study found high levels of recognition regarding the importance of digital technology (DL1), but only acceptable levels of understanding and application in areas such as theoretical concepts (DL2), practical use of tools for analysis and productivity (DL3–DL5), and ethical and responsible use (DL7).

The results further confirmed a significant positive relationship between digital literacy and entrepreneurial performance. In line with Zhang et al. (2023), the data indicated that higher levels of digital literacy were associated with improved entrepreneurial outcomes, including enhanced innovation, market access, and income generation. This aligns with the findings of Annan et al. (2024), who emphasized that digital competence plays a critical role in expanding access to agricultural knowledge and economic opportunities, particularly in rural areas where traditional resources are constrained.

Moreover, the study highlighted the crucial mediating role of entrepreneurial bricolage in this relationship. Echoing Zhang et al. (2023), the findings suggested that digitally literate farmers are better equipped to creatively and efficiently mobilize available resources to overcome constraints and pursue opportunities. This implied that digital literacy not only has a direct effect on entrepreneurial performance but also fosters adaptive and innovative behaviors that are essential for sustainable agricultural entrepreneurship.

Based on statistical evidence, the null hypotheses were all rejected. Specifically, the null hypothesis stating that digital literacy does not significantly affect entrepreneurial performance (Ho1) was rejected. Likewise, the hypothesis suggesting that entrepreneurial bricolage does not significantly mediate the relationship between digital literacy and entrepreneurial performance (Ho2) was rejected. Finally, the hypothesis proposing that entrepreneurial opportunity identification does not significantly mediate this relationship (Ho3) was also rejected.

These findings emphasized the importance of developing interventions that go beyond mere access to digital technologies. As Magesa et al. (2023) asserted, empowering farmers with digital tools must be coupled with efforts to enhance their digital competencies and entrepreneurial mindsets. A holistic, integrative approach—combining skill development with the cultivation of adaptive and opportunity-oriented thinking—can help unlock the full potential of digital literacy to drive sustainable growth and improve agricultural performance.

5. Recommendations

Based on the findings of this study, several key recommendations emerged to support the improvement of digital literacy and entrepreneurial performance among smallholder farmers in Tingloy, Batangas. Given that digital literacy was found to have a significant positive effect on entrepreneurial performance, it is imperative to design and implement comprehensive training programs that not only enhance technical know-how but also build confidence in the practical application of digital tools in agriculture. These should focus on strengthening foundational digital skills such as evaluating online information, applying digital tools in decision-making, and understanding ethical practices in digital communication. Equally important is the promotion of digital cognitive identity, where farmers are encouraged to view digital technology as a strategic enabler of growth rather than a peripheral tool.

The study also revealed that while farmers exhibit an acceptable overall level of digital literacy, their abilities vary significantly across different areas. This variability highlights the need for personalized, context-sensitive interventions. Collaborations between local government units, agricultural extension workers, educational institutions,

and non-government organizations should be strengthened to ensure that these initiatives are accessible, inclusive, and sustainable. Moreover, integrating digital education into existing agricultural programs will create a synergistic platform where farmers can immediately apply what they learn in real-life farming and entrepreneurial scenarios.

Since entrepreneurial bricolage plays a mediating role in enhancing the relationship between digital literacy and entrepreneurial performance, programs should also focus on cultivating resourcefulness and creative problem-solving among farmers. Encouraging a culture of innovation, where farmers are taught to creatively use available resources, repurpose materials, and develop low-cost solutions to local problems, will strengthen their ability to adapt and thrive when faced with problems. This can be reinforced through the establishment of community learning centers that serve as collaborative spaces for knowledge sharing and peer learning.

Additionally, since entrepreneurial opportunity identification was shown to mediate the link between digital literacy and performance, it is essential to foster a more proactive entrepreneurial mindset among farmers. Training programs should not only help them recognize emerging market trends and shifts in consumer preferences, but also guide them in exploring new business models, value-added product development, and diversified income opportunities. This can be effectively supported through existing initiatives such as the Department of Agriculture's Special Area for Agricultural Development (SAAD) program, which provides comprehensive training and assistance on entrepreneurial mindset development and other relevant topics. Furthermore, forming partnerships with seasoned agricultural practitioners can greatly enhance these efforts by offering practical insights, real-world experiences, and ongoing guidance. These collaborations create an environment where farmers can gain inspiration and practical knowledge, thereby strengthening their capacity to identify and act on entrepreneurial opportunities in a dynamic agricultural landscape.

Considering that more than half of the farmers earn below the average annual income, any digital and entrepreneurial development programs must also be aligned with economic support measures. These may include facilitating access to digital devices, affordable internet connectivity, government subsidies, and micro-financing opportunities tailored to the needs of smallholder farmers. Addressing the financial barriers to technology adoption will ensure broader participation and deeper impact.

Finally, because many young individuals in the 21–35 age group have migrated for work outside the island, there is a pressing need to make agriculture more attractive to younger generations. Empowering youth with digital and entrepreneurial competencies and showcasing successful farming ventures that leverage modern tools and business practices may encourage them to see agriculture not only as a livelihood but as a viable, forward-looking enterprise.

5.1 Limitations of the Study

This study has several limitations that should be considered when interpreting the findings. First, the research was confined to smallholder farmers from 10 farmer associations within Tingloy, Batangas. As such, the findings may not be fully generalizable to smallholder farmers in other geographic locations, especially those in more urbanized or technologically advanced areas. The island setting may present unique infrastructural and socio-economic factors not found elsewhere.

Secondly, while the constructs for digital literacy, entrepreneurial bricolage, and opportunity identification were adapted from established literature, the interpretation of these constructs might vary in local and rural contexts. Cultural nuances and varying levels of exposure to digital tools may have influenced how respondents understood and answered the survey items.

Lastly, the study focused on internal capabilities such as digital literacy and entrepreneurial mindset but did not extensively examine external factors (e.g., access to infrastructure, market conditions, government support) that may also significantly influence entrepreneurial performance. These contextual variables could provide a more holistic understanding of farmer success.

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