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Integration of Internet of Things (IoT) Based Technological Innovation and Product Branding in Strengthening the Student Entrepreneurship Ecosystem at the Unsulbar Farming Club

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Abstract: *This study aims to analyze the integration of Internet of Things (IoT)-based technological innovations and product branding strategies in strengthening the student entrepreneurship ecosystem at the Farming Club, University of West Sulawesi (Unsulbar). The research employs a mixed-methods approach, combining quantitative and qualitative methods. The quantitative approach is used to measure the increase in productivity and income from harvests after implementing the IoT system, while the qualitative approach explores students' perceptions and the impact of innovation implementation on entrepreneurial development. The results show that the implementation of an IoT-based automation system using an ESP32 microcontroller, ultrasonic sensors, and a digital monitoring application successfully increased watering efficiency by 40% and reduced water waste as well as labor requirements. Economically, the integration of IoT and product branding increased the income of the Unsulbar Farming Club by 57.4% per harvest cycle. The new packaging and logo design labeled "UFC Hydroponics Vegetables" with the slogan "Petani Milenial, Petani Keren" (Millennial Farmers, Cool Farmers) proved to enhance product appeal, strengthen brand image, and expand market reach. This study concludes that the combination of IoT technology implementation and product branding strategies plays a crucial role in strengthening the student entrepreneurship ecosystem. The integration not only contributes to higher productivity and income but also fosters innovative, creative, and competitive student character in the digital era.*

Keywords: *internet of things, product branding, hydroponics, student entrepreneurship, unsulbar farming club*

1. INTRODUCTION

The development of digital technology has had a significant impact on the world of entrepreneurship, including within higher education institutions. The integration of Internet of Things (IoT)-based technological innovation and product branding enhancement has become a crucial factor in building a sustainable student entrepreneurship ecosystem. At the University of West Sulawesi (Unsulbar), through the student organization Unsulbar Farming Club (UFC), the implementation of IoT in hydroponic farming systems has become a tangible form of technological innovation that supports entrepreneurship activities based on practical field experience. The Unsulbar Farming Club (UFC) is an agricultural student community actively operating in the Greenhouse of the Faculty of Agriculture, Forestry, and Animal Science (Fapertahut) at Unsulbar. The club focuses on producing environmentally friendly agricultural products. Within the club, students conduct hands-on practice in hydroponic cultivation and subsequently sell their harvested products to local communities and university lecturers. Based on observations, it was found that the club's business management, particularly in the operational aspect, had not yet utilized technological support.

The process of providing and monitoring nutrient water in the hydroponic reservoirs was still conducted manually. As a result, nutrient levels in the reservoirs often dropped below optimal levels, causing an inadequate water supply to the hydroponic plants. The water nutrient factor, however, plays a vital role in plant growth. One solution to address the manual monitoring process of nutrient water levels is the implementation of smart farming based on the Internet of Things (IoT). Through an ultrasonic sensor installed in the reservoir, students can monitor the nutrient water level, allowing the pump to automatically refill the tank via a mobile application installed on their smartphones. In addition, another challenge faced by the Unsulbar Farming Club (UFC) lies in limited product marketing. This issue arises because the club has not yet established a strong product brand or identity. The packaging method remains simple, using clear plastic and adhesive tape. In essence, product identity and attractive packaging play a crucial role in any business entity. Previous research has shown that effective product branding and appealing packaging can enhance product competitiveness, boost sales, and increase consumer purchase intention. Based on these findings, this study was designed to integrate IoT-based technological innovation with product branding enhancement within the context of student entrepreneurship at the Unsulbar Farming Club. The synergy between technological mastery and marketing strategy is expected to strengthen the position of students as innovative, adaptive, and highly competitive young entrepreneurs in the era of the digital economy.

2. LITERATURE REVIEW

Technological innovation in agriculture continues to advance, one of which is through the implementation of the Internet of Things (IoT), which enables automated control and monitoring of agricultural systems. Research conducted by Zulkifli, Wabula, and Taufik (2025) shows that the application of IoT-based smart farming can improve efficiency in hydroponic cultivation management through automated irrigation systems, pH measurement, and real-time monitoring of temperature and humidity. With this system, farmers or students can remotely control agricultural processes using mobile devices, thereby saving labor, time, and production costs. Such innovations support the principles of precision agriculture, which are adaptive to land and resource limitations. Furthermore, Juanto, Nugroho, and Nurfiana (2024) emphasize the importance of developing IoT-based smart farming applications integrated with mobile apps, as these systems provide users with high flexibility to monitor and control plant irrigation in real time while supporting data-driven decision-making.

This is relevant to the needs of the Unsulbar Farming Club, which focuses on modern and efficient agribusiness practices. From a marketing perspective, Nazhif and Nugraha (2023) explain

that branding plays an essential role in increasing the competitiveness of micro, small, and medium enterprises (MSMEs) and expanding the market reach of local products. Through packaging strategies, label design, and digital marketing, entrepreneurs can build a strong and attractive product identity in the market. A similar approach can be applied to the hydroponic products of the Unsulbar Farming Club to establish a distinctive brand recognized by the community. The integration of IoT innovation with product branding is also consistent with the findings of Ramadhan, Tibyani, and Farisi (2024), who assert that IoT technology in smart farming not only enhances productivity but also contributes to the overall digital transformation of agriculture through cloud-based monitoring systems and chatbots that facilitate communication between users and devices.

In other words, IoT-based agricultural technology opens opportunities for students to develop efficient and modern digital entrepreneurship. In addition, Indriani et al. (2024) report that digitalization-based mentoring and product branding for MSMEs by universities can improve digital literacy and strengthen brand identity through synergy among students, lecturers, and entrepreneurs. This approach can be adapted by the Unsulbar Farming Club to develop hydroponic product packaging and branding that reflect innovation and sustainability values. Finally, Sandra et al. (2025) emphasize that digital entrepreneurship training and technology adoption are essential elements in building an inclusive and sustainable business ecosystem within academic environments. Through the integration of IoT innovation and brand strengthening, students become not only technology users but also innovators capable of developing data- and technology-driven business models.

3. RESEARCH METHOD

This study employs a mixed methods approach, combining both quantitative and qualitative research methods. The quantitative approach is used to measure the increase in productivity and income resulting from the implementation of the IoT system and product branding strategies, while the qualitative approach serves to describe the implementation process, students' perceptions, and the impact of innovation on strengthening the entrepreneurial ecosystem at the University of West Sulawesi. The research was conducted at the Unsulbar Farming Club, a student activity unit under the Agrotechnology Study Program, Faculty of Agriculture, Forestry, and Environmental Science (Fapertahut), University of West Sulawesi, which focuses on hydroponic crop cultivation. The study was carried out over a period of four months, covering several stages: tool design, IoT system testing, branding strategy implementation, and evaluation of harvest and product sales results. The research subjects were students directly involved in cultivation and marketing activities, while the research objects included two main aspects—IoT-based technological innovation and product branding strategy. The technological innovation component involved the use of the ESP32 microcontroller, ultrasonic sensors, and an Android-based automated monitoring system, while the branding strategy included logo creation, packaging label design, and the application of digital branding to expand market reach.

This study includes two main variables: (1) independent variables, consisting of IoT-based technological innovation and product branding strategy, and (2) dependent variables, which include productivity improvement, management efficiency, and income from product sales. To measure the research outcomes, several instruments were employed, including IoT technical devices (ESP32, ultrasonic sensors, relay modules, water pumps, and solar panels) to test irrigation automation efficiency; observation sheets to record tool performance and plant conditions; and semi-structured interviews with students and buyers to explore their perceptions of innovation and branding. In addition, visual documentation and sales data were used to compare outcomes before and after the implementation of innovations. The research procedure consisted of several stages: (1) the preparation stage, including IoT device design and product packaging development; (2) the implementation stage, involving installation of the automated system at the cultivation site and

product branding application; (3) the data collection stage, involving direct observation and recording of sales results; (4) the data analysis stage, comparing quantitative and qualitative findings; and (5) the evaluation stage, drawing conclusions on the effectiveness of IoT and branding integration. In this study, the microcontroller and ultrasonic sensor system were developed by Mr. Andi Rosman N., S.Si., M.Si, from the Physics Education Department, Faculty of Teacher Training and Education (FKIP), University of West Sulawesi.

Data were collected through several techniques, including direct observation of the automation system and plant conditions, semi-structured interviews with students and buyers, documentation in the form of photos and sales reports, and income analysis based on sales data before and after the implementation of technology. Quantitative analysis was performed by calculating the percentage increase in income, while qualitative analysis employed a descriptive approach, interpreting observation and interview data to understand the impact of innovation on strengthening the student entrepreneurship ecosystem. To ensure data validity, triangulation of techniques and sources was applied by comparing observation results, interviews, and sales data. Technical validation was conducted through repeated testing of the IoT system during the cultivation period to ensure tool stability and accuracy. Through this method, the study is expected to produce an efficient and easily applicable IoT-based smart farming system model, an effective branding strategy to expand the student agricultural product market, and an increase in technological literacy and digital entrepreneurship at the University of West Sulawesi. The findings of this research are expected to serve as a strategic step toward building an independent, sustainable, and highly competitive campus business ecosystem in the era of digital agriculture.

4. RESULTS

The implementation of IoT-based technological innovation and product branding strategy at the Unsulbar Farming Club has significantly improved efficiency, productivity, and the market value of hydroponic crops. This program aims to integrate smart technologies into agricultural systems while simultaneously building a strong product identity to enhance the competitiveness of student products in the market. Before the introduction of innovation, hydroponic farming activities were carried out manually, with watering and nutrient tank refilling performed by human labor. This condition led to irregular maintenance, water wastage, and a potential decline in plant quality due to nutrient imbalance. After implementing the IoT-based automation system, farm management became more efficient as watering and water control were automatically performed based on signals from ultrasonic sensors connected to the ESP32 microcontroller. With this system, students could monitor and control farming operations using smartphones without being physically present at the site. The following table shows the results of water level monitoring in nutrient tanks for hydroponic plants:

Table 1. Water Level Monitoring Data (3–4 Weeks Old)

No.	Time	Water Level (cm)	Pump Status
1	08:00	50	Off
2	09:00	47	Off
3	10:00	44	Off
4	11:00	41	Off
5	12:00	37	Off
6	13:00	32	On
7	14:00	25	Off
8	15:00	15	On
9	15:30	50	Off
10	16:30	47	Off
11	17:30	45	Off

12	18:30	43	Off

Source: Data processing, 2025

The monitoring data show that the system can quickly respond to changes in water levels. When the water level drops below 35 cm, the automatic pump activates to refill the nutrient tank until it reaches the optimal level. Once the level reaches 50 cm, the pump automatically shuts off. This mechanism demonstrates that the system operates stably, efficiently, and with minimal energy consumption. The integration of the ultrasonic sensor, microcontroller, and relay ensures that nutrient circulation remains consistent with plant needs.

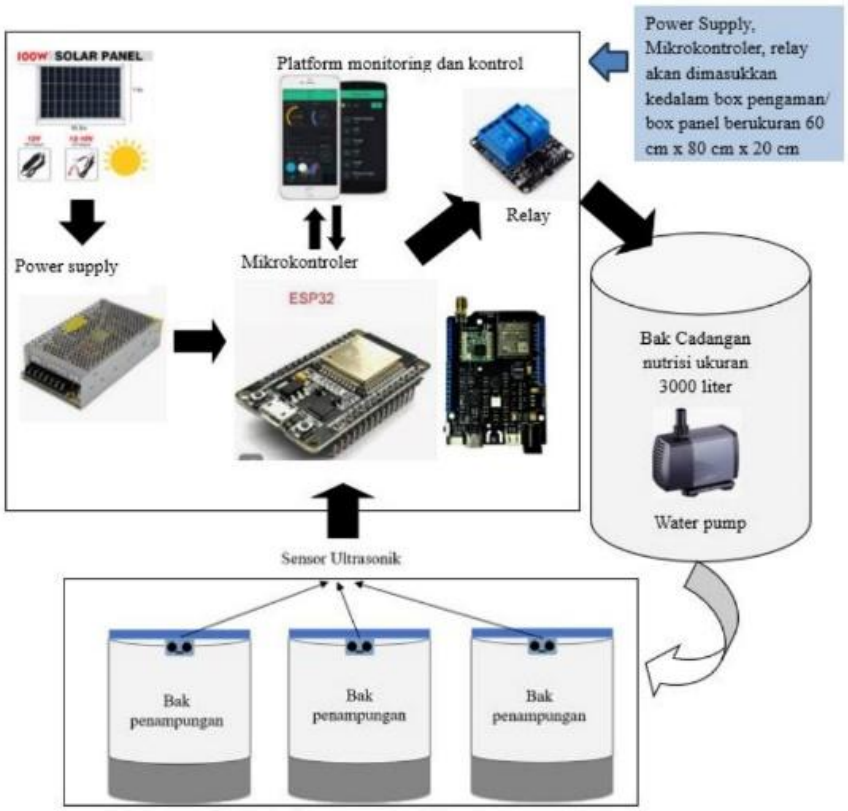

Figure 1. Design of IoT-Based Smart Farming Device
Source: Adapted from the Author(s), 2025

Figure 1 illustrates the integration between a 100W solar panel, ESP32 microcontroller, ultrasonic sensor, relay, and nutrient water tank. The IoT system is automatically controlled through an Android application accessible remotely. This smart farming system utilizes solar energy as the primary power source, making it an environmentally friendly and sustainable solution. Through IoT connectivity, students can monitor plant conditions, pump status, and water levels directly from their smartphones, enabling 24-hour supervision and reducing the risk of delays in plant maintenance. Additionally, the simple yet effective design facilitates maintenance and replication for other agricultural projects within the campus.

The following data present the sales performance of hydroponic products at Unsulbar Farming Club, comparing results before and after the implementation of IoT technology and product branding strategies. This table presents a comparison of sales performance for five types of vegetables (Pakcoy, Water Spinach, Lettuce, Mustard Greens, and Spinach) within one harvest cycle. The comparison is made between the "Before" and "After" phases of intervening with Internet of Things (IoT)

technology and Product Branding. The data proves that the implementation of IoT (likely for maintaining quality/freshness) and Branding (for marketing) successfully significantly increased market demand across all product lines. Consumers are more willing to purchase more products (volume up) after the introduction of technology and branding, indicating increased consumer confidence in product quality. Given that the increase occurred across all vegetable types without exception, this strategy appears to be effective overall and feasible for maintaining or scaling up. Here is the interpretation and analysis of the data based on Table 2:

Table 2. Sales Data Implementation of IoT Technology and Product Branding

Vegetable Type	Unit Price	Before IoT (Packs)	Total	After IoT (Packs)	Total
Pakcoy	Rp 10,000	50	Rp 500,000	80	Rp 800,000
Water Spinach	Rp 5,000	30	Rp 150,000	42	Rp 210,000
Lettuce	Rp 10,000	25	Rp 250,000	35	Rp 350,000
Mustard Greens	Rp 10,000	15	Rp 150,000	25	Rp 250,000
Spinach	Rp 10,000	10	Rp 100,000	20	Rp 200,000
Total per Harvest Cycle			Rp 1,150,000		Rp 1,810,000

Source: Data processing, 2025

From an economic perspective, the sales results indicate a substantial improvement. Before the implementation of technology and branding techniques, the total income per harvest cycle was Rp 1,150,000. After the innovation, income increased to Rp 1,810,000, a rise of 57.4%. This increase was not only due to higher yields but also the result of more effective marketing strategies supported by professional packaging and product labeling. The branding initiative made the products more recognizable, trustworthy, and appealing to consumers.

The logo features a green color scheme with a pakcoy leaf symbol and the slogan *"Petani Milenial, Petani Keren"* ("Millennial Farmers, Cool Farmers"). The label emphasizes key selling points such as *fresh*, *hygienic*, *pesticide-free*, and *100% halal*. The implementation of this branding design not only strengthens visual identity but also increases perceived product value. The green-dominant packaging, with plant imagery, conveys a natural, healthy, and eco-friendly impression. Highlighting attributes such as freshness and cleanliness has successfully built consumer trust, particularly among students and the local communities in Majene and Polewali Mandar who prioritize organic products.

Overall, the integration of IoT innovation and branding strategies has brought substantial transformation to student entrepreneurship activities at Unsulbar Farming Club. This innovation has turned students into young entrepreneurs capable of combining technology, creativity, and market orientation. Watering efficiency improved by up to 40%, plant failure rates decreased, and product competitiveness rose sharply. The program serves as a tangible model of digital-based smart agriculture that can be replicated by other universities to strengthen modern agricultural entrepreneurship ecosystems.

The results of interviews and pre-test–post-test questionnaires with Unsulbar Farming Club students participating in IoT and product branding training show a significant increase in knowledge and skills after the training program. The questionnaire consisted of five key questions covering understanding, technical skills, and the application of marketing and branding strategies. The table evaluates the effectiveness of an educational or training program provided to students of the Unsulbar Farming Club. It measures the change in knowledge and technical capability across five key indicators, comparing the percentage of students who understood the concepts before the training (Pre-Test) versus after the training (Post-Test). The results demonstrate a holistic improvement in student competency. They have evolved from having partial business knowledge and low technical

skills to becoming well-rounded individuals capable of both operating the technology (IoT) and marketing the product (Business) effectively. Here is the interpretation and analysis of Table 3 Pre-Test and Post-Test Questionnaire Results for Unsulbar Farming Club Students:

Table 3. Pre-Test and Post-Test Questionnaire Results for Unsulbar Farming Club Students

No.	Question	Pre-Test (%)	Post-Test (%)
1	Do you understand the use of IoT technology in hydroponic plant management?	28.1	87.5
2	Can you use IoT devices to monitor nutrient water levels in hydroponic systems?	25.0	75.0
3	Are you able to control the water pump using IoT via a smartphone?	25.0	100.0
4	Do you understand strategies to increase the sales scale of hydroponic vegetables?	68.9	93.3
5	Do you understand how to brand hydroponic vegetable products?	62.2	91.1

Source: Data processing, 2025

Based on Table 3, only 28.13% of participants initially understood the use of IoT in hydroponic management, but this figure rose to 87.5% after training. Similarly, the ability to use IoT tools to monitor nutrient levels increased from 25% to 75%, and the skill to control pumps via smartphones rose dramatically from 25% to 100%. These improvements indicate participants' success in mastering technical aspects of the automation system. The data in Table 3 strongly supports the hypothesis that the provided training program was highly effective. It not only introduced new technologies (IoT) with a 100% success rate in practical application (pump control) but also significantly strengthened the students' entrepreneurial capabilities in sales and branding. From a managerial and marketing perspective, students' understanding of strategies to increase hydroponic vegetable sales also showed a notable rise, from 68.89% to 93.34%. Likewise, their comprehension of product branding strategies improved from 62.22% to 91.11%, indicating that students not only understood the importance of brand identity but were also able to apply it practically through packaging, labeling, and logo design for *UFC Hydroponics Vegetables*. In general, the questionnaire and interview results reinforce previous findings that integrating IoT innovation with branding strategies enhances students' technological literacy and entrepreneurial skills. Students who were once mere farm operators have now evolved into innovators and digital-based business managers. The significant improvement in understanding and skills demonstrates that this training program successfully transferred technical knowledge while fostering an entrepreneurial mindset rooted in innovation and creativity. Therefore, the analysis of interviews and questionnaire results confirms that the implementation of IoT and product branding training programs made a substantial contribution to strengthening the student entrepreneurship ecosystem at the Unsulbar Farming Club. The marked improvement across all evaluated aspects suggests that hands-on and digital-based learning models are effective strategies to prepare students for entrepreneurial challenges in the era of Industry 4.0.

5. DISCUSSION

The integration of Internet of Things (IoT)-based technological innovation and product branding strategies within the Unsulbar Farming Club represents a tangible transformation of student entrepreneurship toward smart and market-oriented agriculture. The findings indicate that the implementation of an automated IoT-based hydroponic cultivation system improves efficiency, productivity, and crop quality, while simultaneously strengthening market positioning through effective branding strategies.

5.1. IoT-Based Technological Innovation in Hydroponic Farming

The hydroponic farming system employed utilizes an ESP32 microcontroller integrated with an ultrasonic sensor to monitor water levels, as well as relays and water pumps to automatically

regulate irrigation and nutrient circulation. Field data show that the system maintains water levels between 25 and 50 cm, and the pump operates only when necessary, demonstrating high energy efficiency.

These findings are consistent with those of Marisa et al. (2021) in Jurnal Teknologi Terpadu, who reported that automation of nutrient control systems using the NodeMCU ESP8266 significantly enhances the stability of hydroponic plant growth by maintaining ideal nutrient concentrations between 560 and 840 ppm. Similarly, Syafei Karim et al. (2021) in Buletin Poltanesa confirmed that the use of Arduino and sensors such as TDS, pH, and DHT-22 within IoT systems accelerates plant growth monitoring and maintains water quality. Furthermore, Sulmi (2022) emphasized that nutrient adequacy and environmental control in hydroponic systems determine productivity and market value. Digitally managed hydroponic products have been shown to achieve prices of IDR 40,000–50,000/kg for lettuce and IDR 20,000–25,000/kg for pakcoy, considerably higher than conventional crops. This demonstrates that IoT adoption not only enhances technical efficiency but also increases the economic value of agricultural products.

5.2. The Impact of IoT Implementation on Productivity and Income

Empirical data from the Unsulbar Farming Club reveal a 57.4% increase in income following the integration of IoT technology and product branding. Before the innovation, total income per harvest cycle was IDR 1,150,000; after automation implementation, it increased to IDR 1,810,000. This improvement was attributed to stable plant growth, minimal nutrient loss, and enhanced crop quality. The IoT system's performance aligns with the Deep Flow Technique (DFT) principles described by Marisa et al. (2021), in which the automated control of water levels and nutrient circulation accelerates photosynthesis and increases yield by up to 30%. Within the Unsulbar Farming Club context, this automation reduced students' manual workload and allowed them to focus on innovation, marketing, and product development research.

5.3. Product Branding Strategies and Their Impact on the Student Entrepreneurship Ecosystem

The second aspect of this innovation integration is the application of product branding strategies, which play a crucial role in expanding markets and enhancing product image. The design of the UFC Hydroponics Vegetables logo—green in color and accompanied by the slogan "Petani Milenial, Petani Keren" ("Millennial Farmers, Cool Farmers")—reflects a modern, healthy, and sustainable identity. The packaging labels containing claims such as Fresh, Hygienic, Pesticide-Free, and 100% Halal add value for health-conscious consumers. These results are consistent with the study by Dien Sefty Framita and Dian Maulita (2020), which demonstrated that packaging, labeling, and branding are key factors in increasing consumer purchase interest and MSME income in Sukaratu Village, Serang Regency. Likewise, Syauqi Alaik Muhammad et al. (2021) in Jurnal Graha Pengabdian asserted that creating appealing logos and informative labels can increase consumer interest by up to 20% and expand partnerships with cafés and souvenir shops. Similarly, Muljani et al. (2020) in Jurnal Abdimas PeKA highlighted that brands and packaging are not merely promotional tools but essential components in building consumer trust and enhancing product competitiveness. Therefore, the branding strategy implemented by the Unsulbar Farming Club is not merely aesthetic but forms an integral part of a value-based and innovation-driven entrepreneurial strategy.

5.4. IoT and Branding Integration as a Strengthening Factor for the Student Entrepreneurship Ecosystem

The integration of technological innovation and product branding has created a sustainable entrepreneurial ecosystem among students at the University of West Sulawesi. This approach strengthens not only technical competencies but also managerial and marketing skills. According to

Fadilah et al. (2021) in the Proceedings of UIN Sunan Gunung Djati Bandung, digital branding serves as a vital strategy in fostering economic independence among youth organizations and expanding market access through digital platforms. Within the Unsulbar Farming Club, IoT implementation provides students with hands-on experience in developing smart farming systems, while product branding trains them to think creatively and competitively in the market. The combination of these two aspects enhances students' understanding of the entire entrepreneurial value chain, from production to marketing.

The results of this study indicate that strengthening the student entrepreneurship ecosystem can be achieved through two synergistic approaches: (1) the adoption of IoT technology to enhance cultivation efficiency and productivity, and (2) the development of robust branding strategies to expand markets and build consumer loyalty. The integration of these aspects not only produces short-term economic benefits but also establishes a research- and innovation-based entrepreneurship learning model. Thus, the Unsulbar Farming Club has become a practical example of student-led smart farming that successfully combines the advantages of digital technology with creative branding strategies to build a sustainable and highly competitive agricultural business ecosystem.

6. CONCLUSIONS

This study concludes that the integration of Internet of Things (IoT)-based technological innovation with product branding strategies plays a crucial role in strengthening the entrepreneurial ecosystem of the Unsulbar Farming Club students. The implementation of IoT-based automation systems has improved irrigation efficiency and nutrient water management by up to 40%, while the enhancement of brand identity through the packaging and logo of "UFC Hydroponics Vegetables" has successfully increased income by 57.4% per cultivation cycle. The synergy between technology and branding not only boosts productivity and competitiveness but also fosters innovative, creative, and adaptive student character in response to the development of digital agriculture.

IMPLICATIONS FOR RESEARCH

This study enriches the literature on Technopreneurship and Smart Farming in higher education. The findings confirm that the success of the student entrepreneurship ecosystem does not depend solely on technology adoption, but rather on the integration of technological innovation (IoT) and commercialization strategies (Branding). This study proves that the mixed-methods approach is effective for measuring the dual impact of technological interventions on technical efficiency and marketing interventions on economic performance. This reinforces the theory that digital transformation in agriculture must be holistic, covering aspects from production (upstream) to marketing (downstream).

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