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Integrating Education, Technology, and Suistanable Practices for Community Empowerment in Siponjot Village

Zahedi[1], Dian Marisha Putri[2], Katrin Jenny Sirait[1], T. Irmansyah[3], Dolly Sojuangan Siregar[3], Miswar Budi Mulya[4], Benny Hidayat[3], Muhammadin Hamid[*5], M. Sabri[6], Badai Charamsar Nusantara[6], Meutia Nauly[7], Rahma Sahara[1], Kania Safa Puspita[1], Vikki Natalia Br Tarigan[1], Febe Veronika Situmeang[1], Marisa Venska[1], Cintya Deniati Sitorus[1], Afif Zulfa Nasution[1], Refina Julianti Sitohang[1], Dini Nurhaniah Harahap[1]

[1]*Mathematics Department, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan, 20155, North Sumatra, Indonesia*
[2]*Faculty of Cultural Sciences, Universitas Sumatera, Utara, Medan, 20155, North Sumatra, Indonesia*
[3]*Faculty of Agriculture, Universitas Sumatera, Utara, Medan, 20155, North Sumatra, Indonesia*
[4]*Biology Department, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan, 20155, North Sumatra, Indonesia*
[5]*Physics Department, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara, Medan, 20155, North Sumatra, Indonesia*
[6]*Mechanical Engineering Department, Faculty of Engineering, Universitas Sumatera Utara, Medan, 20155, North Sumatra, Indonesia*
[7]*Social Psychology Department, Faculty of Psychology, Universitas Sumatera Utara, Medan, 20155, North Sumatra, Indonesia*
[*]Corresponding Author: muhammadin.hamid@usu.ac.id

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ABSTRACT

This study explores the implementation of a holistic community service program in Siponjot Village, North Sumatra, aimed at enhancing nonformal education, economic sustainability, and environmental resilience. Through the "Marsiajar Manang Didia Pe" initiative, the program promotes a flexible learning system aligned with local cultural values, addressing gaps in formal education. Key components include training in agricultural practices focusing on coffee and mahogany cultivation alongside the introduction of data-driven decision making tools such as economic mathematical models and QR codes for improved information management. Results indicate improved community engagement, increased agricultural productivity, and enhanced digital literacy. The findings highlight the critical interplay between education, technology adoption, and sustainable practices in fostering community empowerment and resilience against environmental challenges.

Keyword: Non-formal Education, Suistanable Agriculture, Digital Literacy, Environmental Resilience

1. Introduction

Siponjot Village, Lintong Nihuta Subdistrict, Humbang Hasundutan Regency, North Sumatra Province, is an agricultural village with a population of 2,749 people from 538 households. The majority of the population are farmers who depend on approximately 632.88 hectares of land for their livelihood, with a community dominated by the Batak Toba ethnic group who still strongly adhere to customs and religious values [1]. Despite its rich culture and natural resources, the village faces challenges in access to formal education, limited infrastructure, and environmental vulnerability due to demographic pressures and hilly topography. In this context, non-formal education becomes strategic. In Siponjot, the "Marsiajar Manang Didia Pe", which means "learning anywhere" program reflect the Batak Toba philosophy that places learning as part of cultural identity [2]. This approach not only reduces school dropouts but also empowers the community through practical skills [3].

Empowerment efforts are also carried out through the planting of productive trees coffee and mahogany. Coffee was chosen because it's suitable for the highland climate and has the potential to increase income through management by the Village Owned Enterprise (BUMDes). Mahogany plays a role in mitigating erosion and landslides while also serving as a long-term ecological investment [4]. These two commodities address environmental sustainability challenges while strengthening the local demographic-based economy [5].

Microbusiness development in villages is often not based on rational analysis. Therefore, this activity introduces data-based decision-making methods through economic mathematical models such as Break-Even Point (BEP), Return on Investment (ROI), and cost income analysis so that communities can manage their businesses efficiently and sustainably [6]. In line with the village digitalization agenda, this activity also introduces QR Codes as a means of accessing transparent and inclusive public information [7]. In the livestock sector, training on Arduino-based automatic control systems is provided to improve the efficiency of laying hen house management through automatic temperature and humidity control [8].

By integrating local values, mathematical literacy, appropriate technology, and digitization, this activity aims to build the economic and environmental resilience of Siponjot Village in a holistic, inclusive, and sustainable manner.

Figure 1. The community service team with village officials at the Siponjot Village Hall

2. Methods

Community service in Siponjot Village is designed as a holistic empowerment effort that combines human resource strengthening, ecological sustainability, microeconomic improvement, and the use of appropriate technology within a data-driven and locally participatory framework.

Education is the foundation for strengthening human capacity. The MMDP system, adapted from the Kumon method, is implemented as a gradual, flexible, independent learning approach that is not bound by formal

Classrooms [9]. Participants begin learning at a level appropriate to their basic abilities, then progress gradually based on their mastery of the material. This approach supports the concept of "learning anywhere," which is particularly relevant in rural contexts with limited access to education. To ensure its effectiveness, comprehensive learning package has been developed that includes a tiered curriculum structure, guidance modules, an unlimited question bank, and pre-test and post-test tools to measure participants progress. The results of this evaluation form the basis for improvements and ensure that the learning process truly addresses literacy and numeracy gaps at the community level.

Figure 2. Implementation of MMDP at SMPN 4 Lintong Nihuta

Seedling planting began with the identification of strategic locations carried out together with the community, taking into account the ecological vulnerability and economic potential of the area. Given that Siponjot Village is located in a mountainous area with high rainfall, the risk of landslides and flash floods is a real threat. Ecologically, this village is vulnerable to erosion and landslides due to its mountainous topography and demographic pressure on land. Therefore, coffee plants are suitable for the cool mountain climate and have very high agro-ecosystem potential. In addition to coffee, mahogany planting has been proven effective in disaster mitigation and as a long-term ecological investment [10].

Figure 3. Seedling planting

In the field, service efficiency is a major concern. During seed distribution, a scheduled queue system is implemented, where each household receives a fixed allocation of time (20 minutes) based on their village, with two service teams working in parallel [11]. This approach successfully avoids crowding, overlap, and service time imbalances, ensuring that all citizens receive their rights fairly and on time. In the livestock sector, education on automatic control systems is provided through demonstrations of DHT22 sensor-based devices and Arduino microcontrollers that regulate the temperature and humidity of laying hen houses [12]. This technology is simple yet functional, designed to be replicated at an affordable cost by small scale farmers. To determine the priorities for community business development, which includes agriculture, livestock, trade, and home-based businesses, a multidimensional data-based decision-making method was applied. Each business alternative was evaluated based on objective criteria such as income, operational costs, and market potential, then ranked through a transparent calculation process using the TOPSIS method [13]. The entire calculation process was automated using the Python programming language with an efficient data structure, ensuring accuracy and ease of replication [14].

(a)

(b)

(c)

Figure 4. (a) Seed Distribution Queue (b) Population Survey (c) demonstrations of DHT22 sensor

A population survey was conducted to map the demographic characteristics of the village community directly. This survey is a data collection method that involves the use of questionnaires to gather information from respondents [15]. This survey was conducted to obtain a more comprehensive picture of the population structure. The questionnaire instrument contains basic demographic variables such as age, gender, last educational status, main occupation, marital status, number of family members, and others. Once the population data has been obtained, it is important to carry out activities such as socialization and training on the use of QR codes as part of the village digitization effort. These activities include creating QR codes through the QR code generator website https://me-qr.com/, providing materials on the functions and benefits of QR codes in supporting archive management and digital identity, and applying QR codes to the needs of BUMDes (Village Owned Enterprises), Farmer Groups, and village administration.

(a)

(b)

Figure 5. (a) Farmer Survey (b) QR Code Socialization

3. Result and Discussion

The community service program in Siponjot Village has successfully established a more organized and structured non-formal education system. The team created learning modules and evaluation tools to provide clear guidelines for the learning process. With these modules, the material taught is no longer random, and evaluations help to determine each student's abilities more accurately. This makes learning activities more focused and easier for mentors to implement.

In addition, students are placed according to their ability level, so they learn at a level that is neither too difficult nor too easy. All student progress is recorded, so mentors can see their progress over time. This documentation is also useful for continuing the program in the future. Overall, these achievements show that the learning system that has been created is working well and providing tangible benefits for the children in Siponjot Village.

MODUL PANDUAN TEKNIS
PEMBELAJARAN NON FORMAL

MARSIAJAR MANANG DIDIA PE
(MMDP)

DISUSUN OLEH :
TIM RBB

UNIVERSITAS SUMATERA UTARA
MEDAN
2025

(a)

Recap Nilai Pre-Test Kelas Sembilan Satu SMPN 4 LINTONG NIHUTA

No	Nama	Grade	Skor	Rank
1	Gracya Marbun	3	290	21
2	Wulan Hutarait	3	250	27
3	Marni Hutarait	3	200	29
4	Yabela Sitinjak	3	220	28
5	Teralanika Simamora	3	400	18
6	Fibel Sihambing	3	280	23
7	Dani Sirait	3	370	19
8	Mikha Sianipar	3	290	22
9	Jahan Silaban	3	260	26
10	Juliana Silaban	3	320	20
11	Pretty Aritanang	3	280	24
12	Kerya Silaban	3	270	25
13	Cairar Silaban	4	290	17
14	Surya Purba	4	380	15
15	Rafi Purba	4	310	16
16	Yehezkiel Silaban	4	400	14
17	Reza Silaban	4	420	13
18	Vicky Silaban	5	330	11
19	Janter Hutarait	5	240	12
20	Khazizah Silaban	5	360	10
21	Bryant Hutarait	5	380	9
22	Melki Sinaga	8	430	4
23	Dianni Silaban	8	430	5
24	Miracle Silaban	8	420	6
25	Lauren Aritanang	8	370	7
26	Adelima Silaban	8	360	8
27	Andriana Napitupulu	8	500	1
28	Seven Sianturi	8	450	2
29	Olivia Silaban	8	440	3

(b)

Figure 6. (a) MMDP Module (b) Pre Test Scores SMPN 4 Lintong Nihuta

After the tiered non-formal education system was successfully implemented, the community service program in Siponjot Village also strengthened the sustainability of the system through training for teachers. This training helped teachers improve their ability to design more adaptive learning, so that the material could be tailored to the abilities and needs of students at each level. Teachers are also equipped with tiered evaluation techniques so that they are able to assess student progress more regularly and accurately. With these skills, the learning process becomes more organized and easier to implement in the classroom. In addition, the program provides ongoing assistance to teachers so that the methods they have learned can be applied consistently. This assistance means that teachers do not work alone, but always receive guidance and support when applying new learning techniques. These efforts help maintain the quality of the non-formal education program that has been established and ensure that its benefits can be felt continuously by the students and community of Siponjot Village.

(a)

(b)

Figure 7. (a) and (b) MMDP Socialization

Population data for Siponjot village shows that the village has a population of 55 people with a very large proportion of productive age, namely 74.5%. The dependency ratio is only 34.15, which means that for every 100 working-age residents, there are only 34 non-productive residents. This figure is relatively low and indicates that the village is experiencing a demographic bonus that is very beneficial for the development of economic and non-formal education programs that have already been implemented.

In addition to describing the labor force, this demographic data also provides direction for future village planning. The productive age group is dominated by residents aged 35-44 years, making it ideal for skills training programs, business development, or other empowerment activities. Meanwhile, the low number of young children may be a consideration in planning long-term educational facilities. Overall, this demographic data helps the village understand its labor potential and ensure that programs already running well in the fields of education, environment, and economy can be directed according to the real needs of the community.

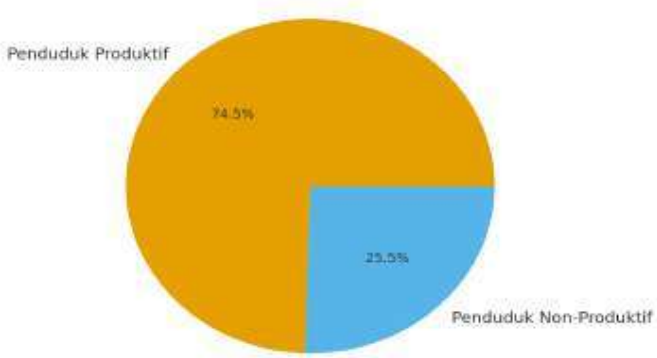

Figure 8. Pie chart ratio of the population of Siponjot village

The Siponjot Village area faces two interrelated challenges, namely the need to improve the community's economy and the threat of natural disasters in the form of floods and landslides due to its hilly geography and high rainfall. The community needs commodities that can provide long-term income, but at the same time, the village also needs strong vegetation to improve soil structure and reduce the risk of disasters. This imbalance requires solutions that are not only economically beneficial but also environmentally sustainable.

Figure 9. Flood damaged landscape in Siponjot Village

The selection of coffee seedlings as a productive commodity is based on the characteristics of the mountainous area of Siponjot Village, which is very suitable for coffee cultivation. Coffee has good economic prospects because its market value is stable, demand is high, and it is highly competitive as a plantation commodity. By planting coffee, the community has the opportunity to earn a sustainable long-term income. On the other hand, the selection of mahogany seedlings serves as an ecological solution to reduce the risk of disasters. Mahogany, with its deep roots, is able to strengthen soil structure, stabilize slopes, and reduce the potential for erosion and flash floods.

Figure 10. Coffee and mahogany seedlings

Through the distribution of 1,500 coffee and mahogany seedlings to the community, this activity provides an integrated solution that combines economic improvement and environment-based disaster mitigation. The distribution of seedlings was warmly welcomed and enthusiastically received by residents, who saw the direct benefits of planting these two types of trees.

Not only does this activity increase community participation, it also initiates the formation of strategic areas for productive tree planting and disaster mitigation, where the planting areas serve a dual purpose as a source of income and a natural barrier to maintain land stability. The integration of coffee and mahogany trees shows that village empowerment efforts can be designed holistically, providing long-term benefits for community welfare while strengthening environmental resilience.

In strengthening the capacity of rural communities, the use of simple technologies such as QR codes has had a clear impact. Before the outreach program, the community did not know that QR codes could be used for information management, data archiving, and group administration. After the explanation was given, there was strong interest from participants, including the head of the farmer group, who saw the opportunity to make it a digital archive center. The enthusiasm was evident from the many questions related to creating QR codes, uploading documents, and accessing shared data, which showed their readiness to adopt this technology. The socialization also increased the community's understanding of digital security risks and the importance of data protection. Overall, this activity encouraged increased digital literacy, awareness of information security, and the community's readiness to implement QR codes in their daily activities.

Figure 11. Socialization QR Code

Next, to determine the priorities for community business development in Siponjot Village, TOPSIS analysis was used to ensure a more objective assessment. By considering income, operational costs, number of workers,

constraints, and assistance needs, this method helps identify which businesses are most ready to be encouraged to grow.

The results show that the food trade/food stall business is the most promising option because it has the best combination of values across all criteria. The grocery business follows in the next position. Meanwhile, the agriculture and livestock businesses are ranked next because they still have several constraints that need to be addressed. These results help the village determine the most realistic and impactful business development focus for the community.

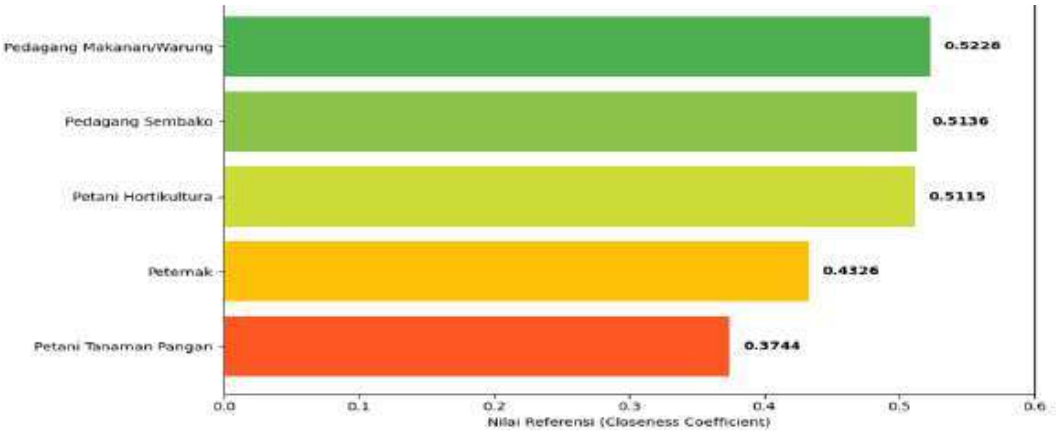

Figure 12. Priority ranking of business type development (TOPSIS method)

Figure 13. Discussion and survey with Siponjot residents

Next, after the business priorities were analyzed in the previous stage, the same data was reprocessed using Python to ensure faster and more accurate results. With the TOPSIS method calculated automatically, each type of business was assessed based on income, operational costs, number of workers, constraints, and assistance needs.

The Python processing results show the same priority order, where the food/food stall business remains the most potential option, followed by the basic foodstuff business, while the agriculture and livestock businesses are below them. This consistency shows that the decisions made are based on objective calculations and can be used as a strong basis for the village in determining the direction of community business development.

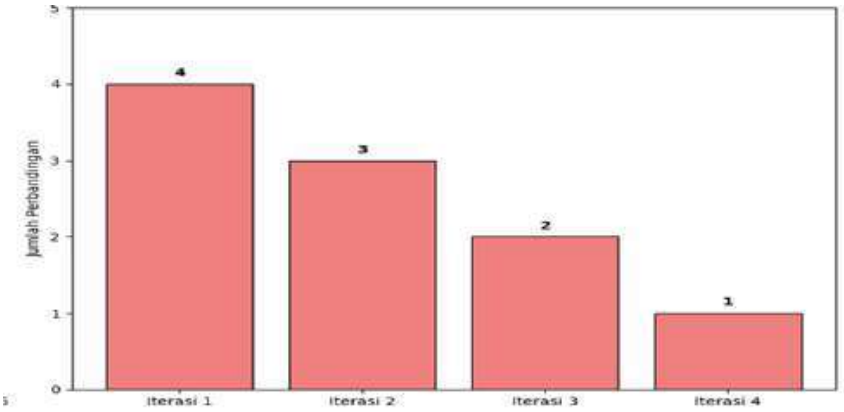

Figure 14. Complexity of sorting selection

In addition to the aspects of community empowerment and capacity building, economic analysis is also an important part of understanding how community businesses generate profits and capital efficiency. The results of the analysis show clear differences in performance among respondents, both in terms of profit and capital Efficiency.

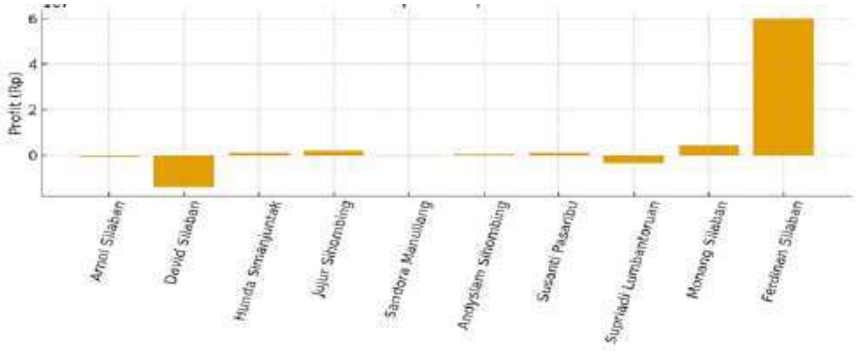

Figure 15. Profit Of Respondent

Six respondents made a profit and four suffered losses, with a significant difference between the highest and lowest profits. The ROI and profit margin values also indicate that only some respondents were able to manage capital and costs efficiently, while others recorded negative results. In addition, none of the respondents had reached the break-even point because the selling price was still lower than the production cost. These findings emphasize the need for improvements in cost structure, pricing strategy, and production management to make the business more efficient and sustainable.

As part of efforts to introduce technology relevant to the needs of residents, this activity also included dissemination of information on the application of simple control systems in chicken farms. In this session, the community was introduced to automated tools that help regulate coop temperature, feed distribution, and monitor environmental conditions more efficiently without the need for constant manual checks. The explanation was delivered through material presentations and supported by demonstration videos to make it easier for the community to understand how the devices work and their benefits.

Figure 16. Demonstration videos

During the event, the community appeared very enthusiastic, paying close attention to the material and showing interest in the application of this technology as a practical solution to increase productivity and facilitate chicken farming in their environment.

4. Conclusion

The community service program in Siponjot Village has successfully made significant contributions in the fields of education, economics, technology, and the environment. The implementation of non-formal education through the Marsiajar Manang Didia Pe (MMDP) program has created a more structured, tiered, and sustainable learning system through the development of modules, curriculum, evaluation, and training for teachers. This has encouraged the improvement of students' academic abilities while strengthening community involvement in village learning activities.

The planting of coffee and mahogany seedlings represents a strategic step to support environmental sustainability while improving long-term community welfare. Demographic analysis indicates a predominance of the productive age group, indicating significant potential for optimizing village empowerment programs. The use of digital technology through the implementation of QR Codes has increased community digital literacy and opened up opportunities for more effective, transparent, and efficient village information management. Furthermore, the process of analyzing business development priorities using the TOPSIS method and the use of Python has successfully provided a basis for objective decision-making regarding the most potential businesses to be developed in the village.

The economic analysis of the businesses indicates gaps in the efficiency of capital management, revenue, and pricing strategies. This underscores the need for further mentoring in business management. Meanwhile, education on the application of automated control systems in chicken farms introduces appropriate technology that has the potential to increase labor efficiency and livestock productivity. Overall, community service activities enhance the capacity of the Siponjot Village community through an integrated approach based on education, technology, environmental management, and economic empowerment.

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