

Bridging Rural Digital Gaps through IoT and AI Literacy Education: A Community-Based Approach for Supporting MSMEs in Katapang Hamlet

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Abstract

This study examines the implementation of community-based Internet of Things (IoT) and Artificial Intelligence (AI) education in enhancing digital literacy among rural senior high school students, identifying students' understanding of the relationship between digital technology and the transformation of Micro, Small, and Medium Enterprises (MSMEs), and evaluating the effectiveness of participatory approaches in supporting technology-based local economic development. The research was conducted at SMA Negeri 6 Seram Bagian Barat, Katapang Hamlet, Eastern Indonesia, involving 42 twelfth-grade students as participants. This study employed a descriptive qualitative method with a community-based participatory research (CBPR) approach. Data were collected through direct observation, interactive discussions, question-and-answer sessions, activity documentation, and participatory evaluation of students' responses during the educational program. Data analysis was conducted interactively through data reduction, data display, thematic interpretation, and conclusion drawing. The findings indicate that community-based technology education effectively improved students' initial understanding of IoT and AI concepts and their relevance to local MSME digital transformation. Contextual and participatory learning approaches also enhanced students' engagement, enthusiasm, and awareness of the importance of digital technology in rural economic development. The study contributes to the development of a sustainable community-based technology education model linking digital literacy, youth empowerment, and local economic transformation in rural areas.

Keywords: Artificial Intelligence, Community-Based Education, Digital Literacy, Internet of Things, MSMEs



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INTRODUCTION

The acceleration of digital transformation has fundamentally reshaped the structure of economic activities, educational systems, and social interaction across the globe. In developing countries, digital technology is increasingly positioned not merely as an instrument of communication, but also as a strategic driver of local economic development, social inclusion, and community resilience (Fianto et al., 2026; Nurniawan & Amalia, 2025). Within this broader transformation, Micro, Small, and Medium Enterprises (MSMEs) have

become one of the sectors most directly influenced by the expansion of digital ecosystems. Digital platforms, data-driven decision-making, artificial intelligence (AI), and Internet of Things (IoT) technologies are now widely integrated into production systems, marketing strategies, financial management, and consumer engagement (Paramarta, 2024; Rakhma et al., 2026; Susiang et al., 2026). Nevertheless, the benefits of digital transformation remain unevenly distributed, particularly between urban and rural communities. In many peripheral regions of Eastern Indonesia, limited technological infrastructure, low digital literacy, and unequal access to educational resources continue to reinforce structural digital inequalities.

The issue of rural digital inequality has become increasingly significant in contemporary development discourse because it directly affects community capacity to participate in emerging digital economies. Although Indonesia has experienced rapid internet expansion over the last decade, disparities in digital access and technological capability remain highly visible in rural and island regions (Hasbolah et al., 2021; Yudiastuti et al., 2021). These inequalities are not solely related to infrastructure availability but also concern the uneven distribution of technological knowledge, digital confidence, and adaptive capacity among local populations. In many rural communities, digital technology is still perceived as distant, abstract, or irrelevant to everyday economic activities. As a consequence, local MSMEs often struggle to adapt to evolving digital market systems, resulting in reduced competitiveness and limited opportunities for economic expansion.

This condition is particularly evident in Dusun Katapang, located in Seram Bagian Barat Regency, where local economic activities remain largely dependent on small-scale community-based enterprises. Despite possessing considerable local economic potential, the community continues to face challenges associated with limited technological literacy and inadequate exposure to emerging digital innovations. The rapid diffusion of AI and IoT technologies in urban industries has not been accompanied by equal educational dissemination in rural educational institutions. Many students in peripheral areas are familiar with digital devices only at the level of basic social media consumption, while their understanding of broader technological applications remains limited. This situation creates a growing gap between the accelerating pace of technological development and the preparedness of rural human resources to engage with future economic transformations.

The urgency of addressing this issue becomes even more critical when considering the strategic role of young people in shaping local digital ecosystems. Youth populations, particularly senior high school students, represent an important social group with strong adaptive potential toward technological change. Their position as digital natives provides opportunities for them to become mediators between technological innovation and community-based economic practices (Arie & Fikry, 2021; Cueto et al., 2022; Probohudono et al., 2025). However, in many rural contexts, educational institutions have not yet functioned as centers for community digital empowerment. Schools often remain disconnected from local economic transformation processes, while technology education tends to emphasize theoretical knowledge without contextual relevance to local livelihoods. Consequently, there

is a growing need for educational approaches capable of linking technological literacy with community-based economic realities.

Recent studies have highlighted the growing importance of digital literacy in supporting sustainable rural development. According to Supriatna et al. (2023) and Tambunan (2023), digital literacy extends beyond technical competence and includes the ability to critically understand, utilize, and adapt digital technologies within social and economic contexts. Similar findings were reported by Harahap et al. (2024) and Idris et al. (2025), who argued that digital inequality increasingly reflects differences in skills and meaningful usage rather than mere access to devices. In the context of rural communities, digital literacy plays an essential role in strengthening social participation, economic adaptability, and community resilience amid technological disruption. Research conducted by Ragnedda and Muschert (2018) further demonstrated that unequal digital competencies contribute to broader forms of social exclusion, particularly among marginalized populations in peripheral regions.

Several studies have specifically examined the relationship between digital transformation and MSME development. Kusumaningtyas et al. (2022) emphasized that MSMEs require adaptive digital capabilities to survive within increasingly competitive global markets. Digital platforms enable small enterprises to expand market reach, improve operational efficiency, and strengthen customer engagement. Similarly, research by Salim (2026) and Sunuantari et al. (2025) found that digital literacy significantly influences MSME innovation capacity and long-term business sustainability in developing countries. However, many MSMEs in rural areas continue to experience technological limitations due to inadequate training opportunities and low exposure to emerging technologies. In Indonesia, studies conducted by Haryati et al. (2023) and Rosepti & Niasari (2022) revealed that rural MSMEs frequently rely on informal knowledge-sharing mechanisms because formal digital training programs remain inaccessible or overly urban-centered.

The growing influence of AI and IoT technologies has also received increasing scholarly attention in recent years. AI technologies are widely recognized for their capacity to support predictive analysis, automated decision-making, and personalized digital services, while IoT systems facilitate real-time monitoring and interconnected data exchange across various sectors (Ilhadi et al., 2024; Putritamara et al., 2025). Research by Alfian et al. (2026) demonstrated that IoT applications can improve production efficiency and resource management in small-scale economic activities. Meanwhile, studies by Indani et al. (2024) and Zulkarnaini et al. (2023) highlighted the transformative role of AI in shaping future economic systems, including retail, agriculture, and local entrepreneurship. Despite these advancements, most existing research remains concentrated within urban industries, higher education institutions, or smart city initiatives, with limited attention given to rural educational contexts and community-based technological empowerment.

In parallel, community-based education has emerged as an important framework for strengthening participatory learning processes in marginalized communities. Fahrurrozi (2025) and Rahmawati et al. (2023) argued that transformative education should encourage

active participation and critical consciousness rather than passive knowledge transfer. This perspective has influenced contemporary community-based participatory research approaches, which emphasize collaborative engagement between researchers, communities, and local institutions. Studies by Dyah et al. (2025) and Qosim et al. (2025) demonstrated that participatory educational models can increase social ownership, strengthen local agency, and improve the sustainability of community development programs. Within rural settings, participatory education allows local knowledge, economic realities, and cultural experiences to become integral components of the learning process.

Existing literature has also explored the role of youth in digital transformation processes. Research conducted by Anggadwita et al. (2021) suggested that young people possess significant potential to become agents of technological adaptation within their communities. Similarly, studies by Prahara et al. (2023) emphasized that youth participation in digital culture contributes to innovation, collaborative learning, and social empowerment. In Indonesia, however, youth-centered digital empowerment initiatives remain predominantly urban-oriented, leaving rural students with limited opportunities to engage in advanced technological learning environments. As a result, the intersection between youth empowerment, emerging technologies, and local economic development remains insufficiently explored within rural island communities.

Although previous studies have provided valuable insights into digital literacy, participatory education, and MSME transformation, these discussions frequently remain fragmented. Research on rural digital literacy often focuses on basic computer usage or internet access, while studies concerning AI and IoT largely prioritize industrial, urban, or higher education settings. Likewise, investigations into MSME digitalization rarely position schools and young people as central actors within local transformation processes. Consequently, limited attention has been devoted to understanding how community-based technological education can simultaneously strengthen rural digital literacy, empower youth participation, and support sustainable MSME development in peripheral island regions.

Against this backdrop, the present study offers a broader perspective by connecting IoT and AI literacy education with community-based economic transformation in rural Eastern Indonesia. Rather than treating students merely as passive recipients of technological information, this study approaches young people as emerging actors capable of facilitating local digital transition processes. The educational activities were designed not only to introduce technological concepts but also to contextualize digital innovation within the realities of local MSMEs and village economic life. In doing so, the study contributes to expanding current discussions surrounding rural digital transformation by integrating participatory education, youth empowerment, and emerging technologies into a unified framework of community development.

This study therefore aims to analyze the implementation of community-based IoT and AI literacy education in improving digital understanding among senior high school students in rural areas, to identify students' perceptions regarding the relationship between digital

technology and local MSME transformation, and to examine the effectiveness of participatory educational approaches in strengthening community-based digital awareness. Furthermore, the study seeks to explain the potential role of rural youth as future agents of local digital transformation capable of supporting sustainable economic development within peripheral island communities.

RESEARCH METHOD

This study employed a qualitative descriptive approach within the framework of community-based participatory research (CBPR) to explore how Internet of Things (IoT) and Artificial Intelligence (AI) literacy education was implemented in a rural educational setting and how such activities contributed to students' understanding of local Micro, Small, and Medium Enterprise (MSME) transformation. The qualitative approach was selected because the study sought to understand social experiences, perceptions, interactions, and forms of participation that emerged during the educational process rather than measuring variables statistically. Qualitative inquiry allows researchers to capture contextual realities, interpret meanings constructed by participants, and examine how technological knowledge is socially understood within rural communities (Rose & Johnson, 2020; Salmiati et al., 2026; Santos-Villalba et al., 2023). In addition, the CBPR perspective was considered relevant because the study was not positioned merely as an observational activity but as a collaborative educational engagement involving students, teachers, and community contexts simultaneously. This participatory orientation enabled the research process to become more contextual, dialogical, and responsive to local realities, particularly in relation to the digital challenges faced by rural communities (Luetke Lanfer et al., 2024; Pyo et al., 2023).

The research was conducted at SMA Negeri 6 Seram Bagian Barat, located in Dusun Katapang, Huamual District, Seram Bagian Barat Regency, Eastern Indonesia. The selection of this location was based on several contextual considerations. First, Dusun Katapang represents a rural island community where access to advanced technological education remains relatively limited despite increasing exposure to digital media. Second, the area possesses considerable local economic potential through small-scale community enterprises, yet the integration of digital technology into local economic activities remains minimal. Third, the school functions as an important social institution within the village and has strategic potential to become a center for strengthening community digital literacy. The researchers viewed this setting as particularly significant because it reflects broader structural conditions experienced by many rural communities in Eastern Indonesia, where digital transformation is progressing unevenly.

The primary participants in this study consisted of 42 twelfth-grade students who participated directly in the IoT and AI literacy education activities. These students were selected because they represent a transitional youth group approaching higher education or workforce participation, making them socially important actors in future rural digital transformation processes. Their position as young community members with increasing

exposure to digital technology also provided valuable insights into how rural youth perceive emerging technological developments. In addition to students, the study involved three teachers and one school administrator as supporting informants. These participants were included because they possessed direct knowledge regarding the educational environment, student participation patterns, and institutional challenges related to digital learning implementation in rural schools.

Data collection was conducted through direct observation, interactive discussions, participatory educational activities, question-and-answer sessions, and documentation. Observation was carried out throughout the educational sessions to understand participant engagement, communication dynamics, and students' responses toward IoT and AI materials presented during the activities. This method allowed researchers to capture spontaneous interactions and contextual social behaviors that may not emerge through formal interviews alone (Santos et al., 2020; Vindrola-Padros & Johnson, 2020). Interactive discussions and question-and-answer sessions were conducted because participatory communication encourages participants to express opinions more openly and enables researchers to identify students' reflections regarding the relationship between technology and local MSME development. Documentation in the form of field notes, activity photographs, and participant reflections was also used to strengthen contextual interpretation and preserve the continuity of observational findings.

To ensure data credibility and analytical trustworthiness, the study applied triangulation techniques involving source triangulation, method triangulation, and contextual interpretation. Source triangulation was conducted by comparing information obtained from students, teachers, and school administrators to identify consistency in perceptions and experiences. Method triangulation involved comparing observational findings with discussion results and participant responses documented during the activities. Furthermore, interpretative triangulation was applied through continuous reflection among researchers during the analysis process to minimize subjective bias and strengthen thematic interpretation (Aspers & Corte, 2019; Sari et al., 2025). Data analysis followed an interactive model consisting of data reduction, data display, thematic categorization, and conclusion drawing. Through this process, the researchers sought to construct a comprehensive understanding of how community-based IoT and AI literacy education can contribute to strengthening rural digital awareness and supporting local MSME transformation in peripheral communities.

RESULTS AND DISCUSSION

Rural Digital Realities and Initial Technology Literacy among Students in Katapang Hamlet

The initial phase of the study revealed that students in Katapang Hamlet possessed relatively high familiarity with basic digital devices but demonstrated limited understanding of emerging technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI). Before the educational activities were conducted, most participants associated digital

technology primarily with social media platforms, online entertainment, messaging applications, and general internet browsing. Smartphones were widely used among students for communication and leisure activities; however, their interaction with technology rarely extended toward productive or innovation-oriented digital practices. This condition reflects a broader pattern frequently found in rural communities where digital exposure grows faster than digital capability itself (Bozkurt et al., 2025; Sharadgah & Sa'di, 2022). In many cases, access to devices does not automatically translate into the ability to critically understand or strategically utilize technology for social and economic transformation.

Field observations conducted during the early sessions showed that students tended to perceive IoT and AI as highly complex technologies associated exclusively with urban industries, robotics, or advanced scientific laboratories. During interactive discussions, several participants admitted that they had previously encountered the terms "AI" and "IoT" only through social media content or online videos without fully understanding their practical applications. One participant, identified as informant R.A., explained that technology was often viewed merely as "something modern used in big cities and large companies," while another participant, M.L., stated that discussions about AI had "never been part of classroom learning or village conversations." These responses indicate that the distance between rural youth and emerging digital discourse is not solely caused by infrastructural limitations but also by the absence of contextual educational exposure.

The social context of Dusun Katapang further shaped these conditions. As a rural island community located in Eastern Indonesia, the hamlet continues to experience uneven digital infrastructure development and limited access to technology-oriented educational resources. Internet connectivity is available but remains unstable in certain areas, while educational facilities related to digital experimentation and technological innovation are still minimal. Teachers involved in the study acknowledged that technology-related instruction in schools generally focuses on basic computer operations and standard internet usage rather than advanced digital literacy. According to one teacher informant, coded as H.S., "students are familiar with phones and applications, but they rarely understand how technology can support local economic activities or community development." This situation demonstrates how rural educational systems often struggle to keep pace with rapidly evolving digital transformation processes.

The findings also revealed that students had limited awareness regarding the relationship between technology and local economic development, particularly in the context of Micro, Small, and Medium Enterprises (MSMEs). Prior to the educational intervention, most participants did not associate digital innovation with village-based economic opportunities. Small businesses within the community were commonly understood through conventional economic practices, including direct selling, local market exchange, and informal promotion methods. Discussions concerning AI-assisted marketing, digital data management, or IoT-supported production systems were largely unfamiliar to participants. This condition illustrates that rural digital inequality involves not only unequal access to technological tools

but also unequal access to transformative digital imagination. As Ragnedda and Muschert (2018) argued, digital exclusion increasingly manifests through disparities in technological capability and participation rather than connectivity alone.

Another important finding concerns the absence of formal educational exposure to IoT and AI within the school environment. Most students reported that they had never received structured discussions related to emerging technologies in classroom learning activities. Existing digital education primarily emphasized operational skills such as word processing, presentation software, or internet browsing. While these competencies remain important, they do not necessarily prepare students to engage with contemporary digital economies increasingly shaped by automation, interconnected systems, and artificial intelligence. This educational gap is particularly significant in rural settings because schools often function as the primary institutional space through which students encounter new knowledge and technological perspectives.

The findings of this study strongly resonate with Gastélum-Chavira et al. (2024) and Wadipalapa et al. (2024), which emphasizes that digital inclusion should not be understood merely as physical access to internet infrastructure or digital devices. Rather, meaningful digital inclusion requires the development of interpretive, adaptive, and critical technological capabilities that enable individuals to participate actively within evolving socio-economic systems. In the context of Katapang Hamlet, students' limited understanding of IoT and AI demonstrates that the rural digital divide remains deeply rooted at the level of capability formation. The issue therefore extends beyond technological availability and enters the broader domain of educational inequality and knowledge accessibility.

At the same time, the initial conditions observed in this study also revealed important social potential. Although students lacked prior exposure to emerging technologies, they displayed strong curiosity and openness during preliminary discussions. Their enthusiasm toward understanding how digital technology could be connected to village life suggested that rural youth possess adaptive capacity that can be strengthened through contextual and participatory educational approaches. This finding becomes important because it challenges dominant assumptions that technological innovation is inherently urban-centered. Instead, the experiences from Katapang Hamlet suggest that rural communities are not resistant to technological transformation; rather, they often lack access to educational models capable of translating abstract digital concepts into socially meaningful and locally relevant knowledge.



Figure 1 Initial Digital Literacy Conditions of Students in Katapang Hamlet Prior to IoT and AI Education Activities

Source: Authors' documentation (2026)

The figure illustrates students' dominant use of digital technology for communication and entertainment, alongside limited understanding of emerging technologies and their relevance to local MSME transformation.

Community-Based IoT and AI Education as a Participatory Learning Process

The implementation of community-based IoT and AI education at SMA Negeri 6 Seram Bagian Barat was designed not merely as a technology dissemination activity, but as a participatory learning process that positioned students as active contributors in constructing digital understanding. Rather than relying on one-directional instructional methods, the educational sessions emphasized dialogue, interaction, contextual examples, and reflective discussion. This approach emerged from the recognition that technological literacy in rural settings cannot be effectively developed through abstract explanations alone. Students require learning environments capable of connecting digital concepts with the realities of their everyday social and economic experiences. Consequently, the educational activities were organized in a manner that encouraged students to relate technological innovation to local village life, family economic activities, and the broader transformation of rural communities.

Observations conducted during the learning sessions demonstrated that students became significantly more engaged when discussions moved beyond technical terminology and began incorporating examples directly associated with their surroundings. During early sessions, many participants appeared hesitant to respond to questions regarding AI and IoT because they perceived these technologies as distant from their lives. However, once facilitators introduced simple illustrations such as automated irrigation systems for agriculture, digital marketing for local products, or AI-assisted online promotion tools, students began participating more actively in discussions. One participant, identified as informant A.R., explained that "technology became easier to understand when the examples were connected to things we see every day." Similar responses emerged from other students

who noted that they had previously assumed AI and IoT were exclusively related to large industries or advanced urban infrastructure.

The participatory character of the educational process also became visible through the dialogical interactions established during group discussions and question-and-answer sessions. Students were encouraged not only to listen to explanations but also to express opinions, ask questions, and share personal experiences regarding technology usage within their communities. These interactions created a more inclusive learning atmosphere where participants felt comfortable engaging with unfamiliar concepts. Field observations indicated that students who were initially passive gradually became more confident in articulating their perspectives. Informant M.S., for example, reflected that the discussions “felt different from ordinary classroom learning because students could speak freely and connect the material with village problems.” Such responses suggest that participatory educational approaches can reduce psychological distance between learners and complex technological concepts.

The findings further indicate that contextual and community-oriented educational models were more effective in sustaining student attention compared to formal instructional approaches commonly experienced in schools. Throughout the activities, students demonstrated stronger enthusiasm when technological discussions involved local economic examples, including fisheries, small-scale trading, and household enterprises operating within Katapang Hamlet. This contextualization enabled students to perceive technology not as an abstract global phenomenon but as a practical instrument potentially relevant to their community’s future development. In this sense, the educational process functioned not only as knowledge transfer but also as social translation, transforming unfamiliar technological language into meaningful local understanding.

Another important aspect identified during the study was the emergence of collaborative learning dynamics among participants. Students frequently responded to each other’s questions, exchanged interpretations, and collectively explored how technology could support village-based economic activities. This collaborative atmosphere reflected the broader principles of community-based participatory education, where knowledge is socially constructed through interaction rather than passively received from instructors alone (Okunlaya et al., 2022; Syaidina et al., 2024). The participatory nature of the program also strengthened students’ sense of ownership toward the learning process. Several participants expressed that they felt “more involved” because discussions acknowledged their experiences and local realities instead of presenting technology solely from external perspectives.

The educational process additionally revealed the importance of emotional and social dimensions in rural digital literacy development. Students appeared more motivated when facilitators approached discussions informally and encouraged open dialogue rather than emphasizing technical correctness. In many instances, humor, storytelling, and village-based examples became effective mechanisms for reducing anxiety surrounding unfamiliar technological concepts. This finding is important because rural students often perceive

advanced digital topics as intimidating or inaccessible due to limited prior exposure. By creating a supportive and human-centered learning environment, the educational activities succeeded in fostering confidence and curiosity simultaneously.

These findings align closely with the concept of *participatory digital learning ecosystems* proposed by Clemente-Suárez et al. (2024), which emphasizes that digital education becomes more effective when technological learning is integrated with social participation, local contexts, and collaborative interaction. Within rural environments, technology education cannot rely solely on infrastructure provision or formal curriculum expansion. Instead, successful digital empowerment depends on the ability of educational programs to create socially meaningful learning experiences connected to everyday community realities. In Katapang Hamlet, the effectiveness of the educational activities emerged precisely because students were invited to interpret technology through the lens of local economic life, social relationships, and future village aspirations.

Furthermore, the findings reinforce broader discussions concerning participatory digital empowerment in marginalized communities. As argued by Heeks (2022) and Kolagar et al. (2022), meaningful digital inclusion requires educational strategies capable of strengthening critical understanding, adaptive skills, and community participation simultaneously. The educational process implemented in this study demonstrated that rural students possess considerable potential to engage with emerging technologies when learning approaches are designed inclusively and contextually. Rather than functioning as passive recipients of technological modernization, students became active participants in interpreting how digital transformation could contribute to local social and economic development.

Emerging Awareness of IoT and AI for Local MSME Transformation

One of the most significant findings emerging from the educational activities was the gradual transformation of students' understanding regarding the relationship between digital technology and local economic development. Prior to the implementation of the program, most participants viewed IoT and AI as technological concepts detached from village realities and relevant only to advanced industries or urban environments. However, as the discussions evolved through contextual explanations and participatory interaction, students began to recognize that digital technologies could also support everyday economic activities within their own communities. This shift in perception became increasingly visible during reflective discussions in which participants connected technological examples with local Micro, Small, and Medium Enterprises (MSMEs) operating in Katapang Hamlet.

The educational sessions intentionally introduced simple and locally relevant illustrations to bridge abstract technological concepts with familiar village experiences. Facilitators explained, for example, how IoT-based sensors could assist small-scale agricultural or fisheries production through monitoring systems, while AI-supported applications could help local entrepreneurs promote products more effectively through social media platforms and digital marketplaces. These examples proved particularly effective because they translated emerging technologies into understandable and practical possibilities rather than

distant technical abstractions. During one discussion session, informant D.L. explained that “before the activity, AI sounded very complicated, but after seeing examples related to online promotion and local products, it became easier to imagine how it could help village businesses.” Similar responses were expressed by other students who began associating technology with practical economic opportunities rather than solely entertainment or communication functions.

The findings also revealed that students gradually developed awareness regarding the importance of human resource capacity in supporting village economic transformation. Discussions concerning local MSMEs encouraged participants to reflect critically on the challenges faced by small businesses in rural areas, including limited marketing reach, dependence on conventional selling methods, and lack of technological adaptation. Through these reflections, students started to understand that digital transformation is not exclusively dependent on infrastructure availability but also on the ability of communities to learn and adapt to changing technological environments. Informant R.S., for instance, stated that “many small businesses in the village could grow faster if people understood how to use digital technology properly.” This emerging awareness indicates that students were beginning to position technology as a developmental tool capable of supporting broader community advancement.

Another important aspect identified during the study was the role of contextual examples in facilitating conceptual understanding. Rather than introducing highly technical discussions regarding machine learning systems or complex automation processes, the educational activities emphasized simple applications connected to students’ social realities. Examples involving digital product promotion, online customer communication, inventory management, and automated environmental monitoring systems allowed participants to imagine concrete forms of technological application within rural economic settings. Observational findings demonstrated that students became more responsive and engaged when facilitators discussed technologies that could potentially support local fisheries, small food businesses, or village-based handicraft production. This suggests that technological literacy in rural communities becomes more meaningful when educational content is grounded in local socio-economic contexts.

The educational process also stimulated reflective conversations regarding the future of village economies in the digital era. Several participants expressed concern that local MSMEs could face increasing challenges if rural communities remain disconnected from technological developments. At the same time, students demonstrated optimism that younger generations could contribute to helping local businesses adapt to digital transformation processes. Informant M.A. noted that “young people in villages should not only use phones for social media but also learn how technology can help local businesses.” Such reflections illustrate the emergence of a broader developmental consciousness in which digital literacy is understood not merely as personal competence but as part of collective community progress.

These findings reinforce the growing argument that digital literacy should be approached as an integral component of community-driven economic development rather than as a purely technical educational objective. According to Heeks (2022) and Kolagar et al. (2022), the sustainability of MSMEs in contemporary economies increasingly depends on adaptive digital capacities, including the ability to integrate technological innovation into production, communication, and market expansion processes. In rural settings, however, technological transformation often encounters structural barriers related to limited educational access and insufficient local digital ecosystems. The present study demonstrates that schools and youth communities can play an important intermediary role in addressing these limitations by fostering early technological awareness among future community actors.

The findings additionally contribute to expanding contemporary discussions surrounding digital MSME transformation in rural societies. Existing studies frequently focus on adult entrepreneurs or institutional business actors as primary subjects of digital adaptation (Handayani, 2022; Megawati et al., 2026). In contrast, this research indicates that the foundations of rural digital transformation may also emerge through educational interventions targeting young people within school environments. Students do not merely represent future labor resources but can become active agents in disseminating technological awareness and supporting local economic adaptation processes. This perspective broadens conventional understandings of community economic development by positioning technological education as a long-term social investment capable of strengthening rural resilience in the digital era.

Conceptually, the findings illustrate how technological literacy intersects with the formation of a community-driven digital economy. The educational activities conducted in Katapang Hamlet demonstrated that emerging technologies such as IoT and AI become more socially meaningful when linked directly to local economic aspirations and community realities. Rather than reinforcing the perception that technological innovation belongs exclusively to urban modernity, the study revealed that rural youth are capable of imagining alternative digital futures grounded in local economic potential. This process represents an important step toward narrowing the rural digital divide through socially embedded forms of technological empowerment.

Youth as Emerging Agents of Rural Digital Transformation

One of the most important transformations observed during the educational activities was the emergence of a new self-perception among students regarding their role within the digital future of their community. Prior to the implementation of the IoT and AI literacy program, most participants tended to view technological change as something external to village life, largely associated with urban societies, large industries, or highly educated professionals. However, throughout the participatory learning process, students gradually began to position themselves not merely as technology users but as potential contributors to local digital transformation. This shift became visible in discussions where participants started expressing ideas about how technology could be introduced within family businesses, village

economic activities, and everyday community practices.

The findings indicate that the educational process stimulated a growing sense of responsibility among students toward the future development of their village. During reflective discussions, several participants explained that digital knowledge should not remain limited to schools or urban populations but needed to be shared within the wider community. Informant A.L., for example, stated that “young people in the village should help parents and small businesses understand digital technology little by little.” Similar responses emerged from students who discussed the possibility of assisting local traders with social media promotion, online marketing, or digital communication with customers. These reflections suggest that the educational activities encouraged students to perceive technology not only as an individual skill but also as a collective social resource capable of supporting community advancement.

Another significant finding concerns the emergence of students’ confidence in imagining local economic opportunities through digital platforms. Prior to the activities, discussions about entrepreneurship were generally limited to conventional village economic practices. However, after participating in the program, several students began expressing interest in developing simple digital business ideas connected to local products and village potential. Informant R.M. explained that “local products from the village could become more widely known if promoted properly through digital platforms.” Others discussed possibilities such as online sales of fisheries products, promotion of traditional foods, or the use of digital storytelling to introduce village identity to broader audiences. Although these ideas remained at an early conceptual stage, they indicate an important cognitive shift in how rural youth interpret economic possibilities within the digital era.

The educational process also revealed how participatory learning environments can strengthen students’ social confidence in engaging with technological discussions. Observational findings demonstrated that students who were initially hesitant to speak gradually became more active in sharing opinions and asking questions. This change was particularly evident during collaborative discussions where participants exchanged ideas regarding how technology could support local livelihoods. Rather than positioning themselves as passive recipients of modernization, students increasingly saw themselves as capable of participating in village transformation processes. Informant S.K. noted that “technology no longer feels too far away because now we can imagine how it connects with things in the village.” Such statements reflect an important transformation in digital perception, where technology becomes socially approachable and locally meaningful.

Within the context of rural island communities, this finding carries broader significance because youth populations often represent the most adaptive social group in responding to technological change. Compared to older generations who may have limited exposure to digital systems, young people possess greater familiarity with mobile technology, online communication, and digital interaction. However, without contextual educational support, this familiarity frequently remains limited to consumption-oriented practices rather

than productive or developmental engagement. The present study demonstrates that when educational programs connect digital literacy with local social realities, rural youth are capable of repositioning themselves as intermediaries between technological innovation and community needs.

The role of schools also emerged as an important element within this transformation process. The findings suggest that schools in rural communities can function not only as formal educational institutions but also as social spaces for strengthening community digital capacity. Through participatory educational activities, schools became sites where students, teachers, and facilitators collectively discussed village economic challenges, technological opportunities, and future aspirations. This social role is particularly significant in peripheral regions where access to formal digital training institutions remains limited. A teacher informant, coded as H.T., explained that “schools should become places where students learn not only academic subjects but also how to face social changes happening around them.” Such perspectives reinforce the idea that educational institutions can contribute directly to local resilience in the face of accelerating digital transformation.

These findings resonate strongly with contemporary discussions surrounding *youth-centered digital transformation*, which emphasize the strategic role of young people in shaping sustainable digital futures within marginalized communities. According to Heeks (2022) and Kolagar et al. (2022), youth participation in digital transformation processes contributes not only to technological adaptation but also In rural contexts, this perspective becomes increasingly relevant because youth populations frequently possess the greatest potential to bridge generational and technological divides within local communities.

Schools as Community Nodes for Sustainable Rural Digital Ecosystems

The findings of this study demonstrate that schools in rural communities possess strategic potential to function not only as formal educational institutions but also as central nodes within emerging local digital ecosystems. In the context of Katapang Hamlet, SMA Negeri 6 Seram Bagian Barat became more than a place for classroom learning; it evolved into a social space where discussions concerning technology, village development, youth participation, and local economic transformation could intersect. Throughout the implementation of the IoT and AI literacy program, the school served as a meeting point connecting students, teachers, and broader community concerns regarding the future of rural digital adaptation. This dynamic is particularly important in peripheral island communities where access to technological training institutions, innovation centers, or digital development programs remains highly limited.

One of the most visible findings during the educational process was the strong social legitimacy attached to the school within the local community. Students participated actively not only because the program was educational in nature, but also because schools continue to hold symbolic authority as trusted institutions in village life. Several participants explained that discussions related to technology felt more approachable and acceptable when conducted within the school environment rather than through external or purely technical

training forums. Informant R.T. stated that “people in the village usually trust activities organized through schools because schools are seen as places for learning and community guidance.” This perception contributed significantly to the openness and enthusiasm observed throughout the program implementation.

The involvement of students also generated broader social effects extending beyond the classroom environment. During reflective discussions, several participants mentioned sharing newly acquired knowledge with parents, siblings, or friends after the educational sessions concluded. Some students discussed AI-assisted digital promotion with family members involved in small trading activities, while others spoke about introducing basic concepts of online marketing to relatives managing local products. Although these interactions remained informal, they indicate the emergence of what may be understood as a community ripple effect, where technological awareness gradually diffuses through everyday social relationships. In rural societies characterized by strong communal interaction, such informal dissemination processes are particularly significant because knowledge circulation often occurs through interpersonal trust and family networks rather than institutional channels alone.

The findings also reveal that the role of schools in strengthening rural digital ecosystems extends beyond educational instruction toward broader community empowerment functions. Teachers involved in the study recognized that digital literacy should increasingly become part of schools’ social responsibility within rapidly changing technological environments. One teacher informant, coded as M.H., explained that “students today are part of a digital generation, so schools cannot only teach conventional subjects without preparing them for technological realities outside the classroom.” This perspective reflects an emerging awareness among local educational actors that rural schools must adapt not only academically but also socially in order to remain relevant within contemporary transformation processes.

At the same time, the study identified several structural challenges that continue to constrain the development of sustainable rural digital ecosystems. Limited internet stability, inadequate technological infrastructure, and restricted access to advanced digital learning resources remain significant barriers within Katapang Hamlet. The school itself possessed limited facilities for practical technological experimentation, particularly concerning IoT applications or AI-based learning tools. Moreover, rural digital development programs in many peripheral regions still tend to prioritize infrastructure provision without adequately addressing long-term educational and human resource dimensions. These conditions suggest that sustainable digital transformation in rural communities cannot rely solely on short-term literacy programs but requires broader institutional support and policy integration.

Another important challenge concerns the limited collaboration between educational institutions, local governments, universities, and MSME actors in designing community-based digital empowerment initiatives. The findings indicate that students displayed strong curiosity and adaptive potential; however, without continuity mechanisms, these capacities risk

remaining underdeveloped. Informant A.S. noted that “students need more opportunities to continue learning technology after activities like this end.” This observation highlights the importance of building sustained partnerships capable of providing mentorship, technological access, and community innovation opportunities within rural environments. Collaborative approaches are particularly essential in island regions where resource limitations often restrict independent institutional development.

Conceptually, the findings reinforce the argument that rural digital transformation should be understood as an ecosystem-building process rather than a series of isolated technological interventions. According to Heeks (2022) and Kolagar et al. (2022), sustainable digital inclusion depends on the interaction between educational institutions, local governance, infrastructure systems, and community participation. In this study, the integration of IoT and AI literacy education with youth empowerment and MSME awareness demonstrates how schools can become catalysts for broader community adaptation processes.

The experiences from Katapang Hamlet also contribute to expanding current discussions regarding technology-based community engagement in rural and island settings. Rather than approaching rural communities as passive recipients of digital modernization, the study illustrates that local schools and youth populations possess significant potential to become active agents in shaping sustainable digital futures. The educational process showed that technological understanding becomes more meaningful when connected to local aspirations, village economies, and collective social experiences. In this sense, schools can serve as foundational institutions for nurturing locally grounded digital ecosystems capable of supporting long-term community resilience.

CONCLUSION

This study demonstrates that community-based IoT and AI literacy education can function as an effective social approach for strengthening digital understanding among rural youth while simultaneously fostering awareness of local economic transformation through MSMEs. The participatory and contextual learning process implemented at SMA Negeri 6 Seram Bagian Barat enabled students to move beyond a limited perception of technology as merely a communication and entertainment tool toward a broader understanding of its relevance for village development, small business innovation, and community empowerment. The findings indicate that the effectiveness of rural digital education is strongly influenced by the ability to connect technological concepts with local social realities, everyday economic experiences, and collaborative learning environments. In this context, students gradually emerged not only as recipients of digital knowledge but also as potential actors capable of supporting technological adaptation within their communities. The study further reveals that schools in rural and island regions possess strategic potential to become community nodes for strengthening sustainable digital ecosystems by linking education, youth participation, and local MSME development. Through this perspective, the research contributes to

expanding current discussions on rural digital transformation by integrating IoT and AI literacy, community-based education, and youth-centered empowerment within the context of Eastern Indonesian rural communities, where technological inclusion remains uneven and socially embedded approaches are increasingly necessary for sustainable local development.

ETHICAL STATEMENT AND DISCLOSURE

This study was conducted in accordance with established ethical principles, including informed consent, protection of informants' confidentiality, and respect for local cultural values. Special consideration was given to participants from vulnerable groups to ensure their safety, comfort, and equal rights to participate. No external funding was received, and the authors declare no conflict of interest. All data and information presented were collected through valid research methods and have been verified to ensure their accuracy and reliability. The use of artificial intelligence (AI) was limited to technical assistance for writing and language editing, without influencing the scientific substance of the work. The authors express their gratitude to the informants for their valuable insights, and to the anonymous reviewers for their constructive feedback on an earlier version of this manuscript. The authors take full responsibility for the content and conclusions of this article.

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