ARTICLE

Raspberry Pi-Based Offline Digital Library for Indonesian Villages Without Stable Power and Internet Access

A Case Study on Implementing Raspberry Pi-Based Offline Digital Library in Indonesia

Edward Evannov Santo Wiguna, Hendry Lie, Lorenzo Niro, Jimmy Linggarjati, Wiedjaja Atmadja, Daniel Patricko Hutabarat, Ivan Alexander, Rudy Susanto, Johan Yapson, John Reigton Hartono, Marincan Pardede, Wishnoebroto, and Rinda Hedwig

ABSTRACT

As one of the world's largest archipelagic nations, Indonesia faces a major challenge in distributing its wealth, including basic infrastructure such as electricity and internet, to some of its most remote islands. Due to its remote location, most people in this area live in poverty and have poor-quality education. To help solve this problem, an offline digital library was created based on a Raspberry Pi "minicomputer." With the ability to store more than 2,500 educational movies and e-books for offline viewing, the device has proven to be reliable even in areas with unpredictable power.

INTRODUCTION

Indonesia is an archipelago consisting of thousands of islands. Unfortunately, many of these islands and regions still live in poverty. Despite recent economic growth and development in Indonesia, poverty remains a major problem in many parts of the country. Papua, West Sulawesi, and Nusa Tenggara East are just a few examples of regions with high poverty rates. This persistent problem of poverty has a significant impact on the entire economy of the country as it limits access to education, health care, and economic opportunities. Additionally, many people in these regions lack access to information and technology, making it difficult for them to stay informed and stay connected. One consequence of this is a lack of interest in reading due to the lack of or

About the Authors

Edward Evannov Santo Wiguna (edward_sw97@yahoo.com) (corresponding author) is a graduate student, Computer Engineering Department, Bina Nusantara University. **Hendry Lie** (hendry_pl96@yahoo.co.id) is a graduate student, Computer Engineering Department, Bina Nusantara University. **Lorenzo Niro** (niro.lorenzo25@gmail.com) is R&D in Bank of Central Asia, Indonesia. **Jimmy-Linggarjati** (jimmyl@binus.edu) is Lecturer, Computer Engineering Department, Bina Nusantara University. **Wiedjaja Atmadja** (steff@binus.edu) is Lecturer, Computer Engineering Department Bina Nusantara University. **Daniel Patricko Hutabarat** (dhutabarat@binus.edu) is Lecturer, Computer Engineering Department, Bina Nusantara University. **Ivan Alexander** (ialexander@binus.edu) is Lecturer, Computer Engineering Department, Bina Nusantara University. **Rudy Susanto** (rudy.susanto@binus.ac.id) is Lecturer, Computer Engineering Department, Bina Nusantara University. **Johan Yapson** (johan.yapson@binus.edu) is a graduate student, Computer Engineering Department, Bina Nusantara University. **John Reigton Hartono** (john.hartono@binus.edu) is a graduate student, Computer Engineering Department, Bina Nusantara University. **Marincan Pardede** (marincan.pardede@gmail.com) is Lecturer, Pelita Harapan University. **Wishnoebroto** (wishnoebroto@gmail.com) is a student, Ohio University. **Rinda Hedwig** (rinda@binus.edu) is Researcher, Computer Engineering Department, Bina Nusantara University.

Submitted: 8 August 2023. Accepted for publication: 13 September 2024. Published: 16 December 2024.

https://doi.org/10.5860/ital.v43i4.16869

high cost of books and other reading materials. For Indonesia, it is important to continue to fight poverty and promote education and literacy in order to build a more just and prosperous society.

Research has found that many young people living in remote villages and regions in Indonesia are much less interested in reading than urban and rural youth who have access to libraries. Additionally, these measures have been cited in several studies on reading habits.[1] For this reason, an attempt was made to remedy the situation by establishing libraries in these regions by sending used books collected and distributed in other large cities. Due to the large number of islands and distant regions from the mainland, special transportation is often required. Even though land transportation costs to the destination are included, this results in extremely high logistical costs.

To illustrate the library establishment problem in remote areas, an attempt was made to transport a parcel of used books from Karawaci–Tangerang in West Java to the village of Onan Runggu–Sipahutar, more than 1,500 kilometers north of Sumatra. Shipping 50 kilograms of books costs US$130 (using the December 2023 exchange rate of US$1 = IDR 15,500), but the physical library needs more than 100 kg of books. For outlying islands such as Flores, East Nusa Tenggara (NTT), Papua, etc., shipping is even more expensive. Additionally, some of the donated books were not in "shelf ready" condition, requiring each book to be labeled, covered, and cataloged before it reaches readers. This made shipping books to remote locations inefficient, expensive, and time-consuming.

In this context, especially in remote areas with limited or intermittent power supply and no internet connection, the establishment of digital libraries is considered essential.[2] This is especially important for today's younger generation who need access to the latest information. From March through August 2018, research to find suitable formats for digital libraries led to the development of simple applications for viewing digital videos and textbooks for K-12 learners.[3] Research on finding suitable formats of digital libraries began by selecting the hardware and components that can meet the needs for building a simple application to display digital video and educational books for learners from kindergarten to high school.[4] The digital library is designed for offline use as internet connectivity is not available in this area. As a result, the digital objects obtained in the lab were selected from copyright-free material and inserted into the Raspberry Pi's integrated application.[5]

After some research, it was decided to use a Raspberry Pi to create an offline digital library. Each of these small computers consumes a maximum of 5W of power and is equipped with a power regulator that functions within the range of 110V to 220V. The device, which is smaller than the palm of an adult's hand, is fully usable via Wi-Fi networks. The system consists of a server, four clients, and solid-state storage that can hold up to 3,000 films and digital books. Including an LCD monitor, the whole system consumes on 110 watts. Each user is equipped with a headphone splitter capable of dividing audio for up to five headphones, facilitating simultaneous movie watching without causing disruptions among viewers. This offline digital library can work in conjunction with a solar power supply if it has a battery inside that is powered by DC solar technology.[6] Bina Nusantara University (UBiNus) and Pelita Harapan University (UPH) collaborated in early 2019 to explore the use of solar panels to power the offline digital library.

This library has two types of content: movies and digital books. The digital books are sourced from copyright-free books and movies are sourced from YouTube with the author's permission. Some movies are translated into Indonesian or have Indonesian subtitles. Experts carefully select content to eliminate inappropriate content such as bigotry, violence, and profanity. Digital movies have a maximum length of fifteen minutes, but digital books have no page limit. According to the

latest data (October 14, 2024), the system can store up to 6,000 video files and about 500 e-books. This amount will continue to grow as the content is compiled from the contributions of all UBiNus students who participate in community building activities. Some of these films are student originals. By the end of December 2024, the digital collection had grown to 7,000 items, 4,000 of them generously donated by an Australian YouTuber.

DESIGN AND PERFORMANCE TEST

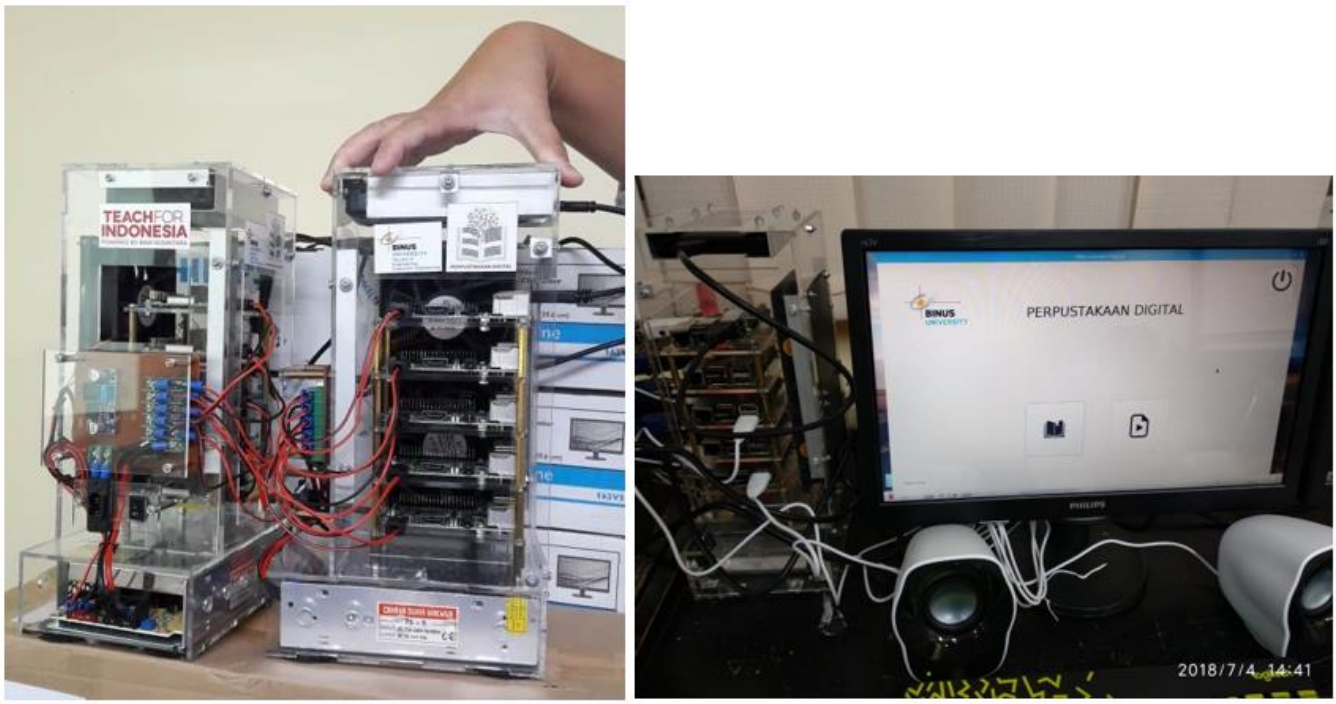
After analyzing various options for the most reliable and economical minicomputers for use as an offline digital library platform, the researchers finally settled on the Raspberry Pi, as shown in Table 1 and Figure 1. Raspberry Pi is a widely used single-board computer in the Indonesian market, and after 24 hours and 7 days testing, it showed the best performance compared to other similar products.

Table 1. The first and latest technology specification of offline digital library from 2018 to January 2024

First version in 2018–2022	
Computer	Raspberry Pi 3 Model B (single board computer)
Storage & memory	Micro SD 16GB (storage) & RAM 1GB (memory)
Hard disk capacity	external 1TB
Monitor	15.6" Phillips, non-HDMI, built-in power supply
Keyboard + mouse	Logitech (wireless)
Speaker	10 Headphones + 5 splitters
Cooling system	PC cooling fan installed in the Raspberry Pi compartment
The latest version in 2023–now	
Computer	DELL Chromebook 3100 touch
Server	Raspberry Pi 5 + case + heatsink
Memory	Sandisk MicroSD 128 GB
Power supply	Adapter + powerbank

Note: Number of clients can be adjusted according to the user's need. Additional equipment can be added as well.

Figure 1. (Left) Raspberry Pi's cabinets, which consisted of 5 minicomputers per cabinet. (Right) the system was fully set up.



The Raspberry Pi 3 Model B that is chosen in this project has a quad core 1.2GHz Broadcom, BCM2837 64bit CPU, 1GB RAM, BCM43438 wireless LAN and Bluetooth low energy on board. It has 100 baseT ethernet, 40-pin extended GPIO with 4 USB 2 ports. However, as the project was being developed, the technology that is used kept changing. Since the price of Raspberry Pi increased from $33 to $267 in 2020, we tried to change the technology several times. Currently, we use DELL chrome book as client with a Raspberry Pi server, and the total price is $904 (1 server, 5 clients).

Figure 2 shows the block diagram of the system built using five Raspberry Pi 3 computers. The system also included an Android-based client that allowed customers to browse the offline digital library using a mobile application. In some areas, a server built in Raspberry Pi is used and the clients are using tabs that can be located as far as ten meters from the server. Figure 3 shows a seven-page client application state diagram. Users can go to the main menu and select collections depending on whether they want to watch movies or read e-books. From the selection menu, the user can access another submenu containing the titles and images of collections organized by subject. They can choose to read a book or watch a movie on the other side. As shown in Figure 4, in addition to a page for customers, a page is also available for administrators with permission to add, remove, or edit material. Every year, the administrator can ask for updated books on a flash drive that can be sent via post.

Figure 2. The block diagram of the system.

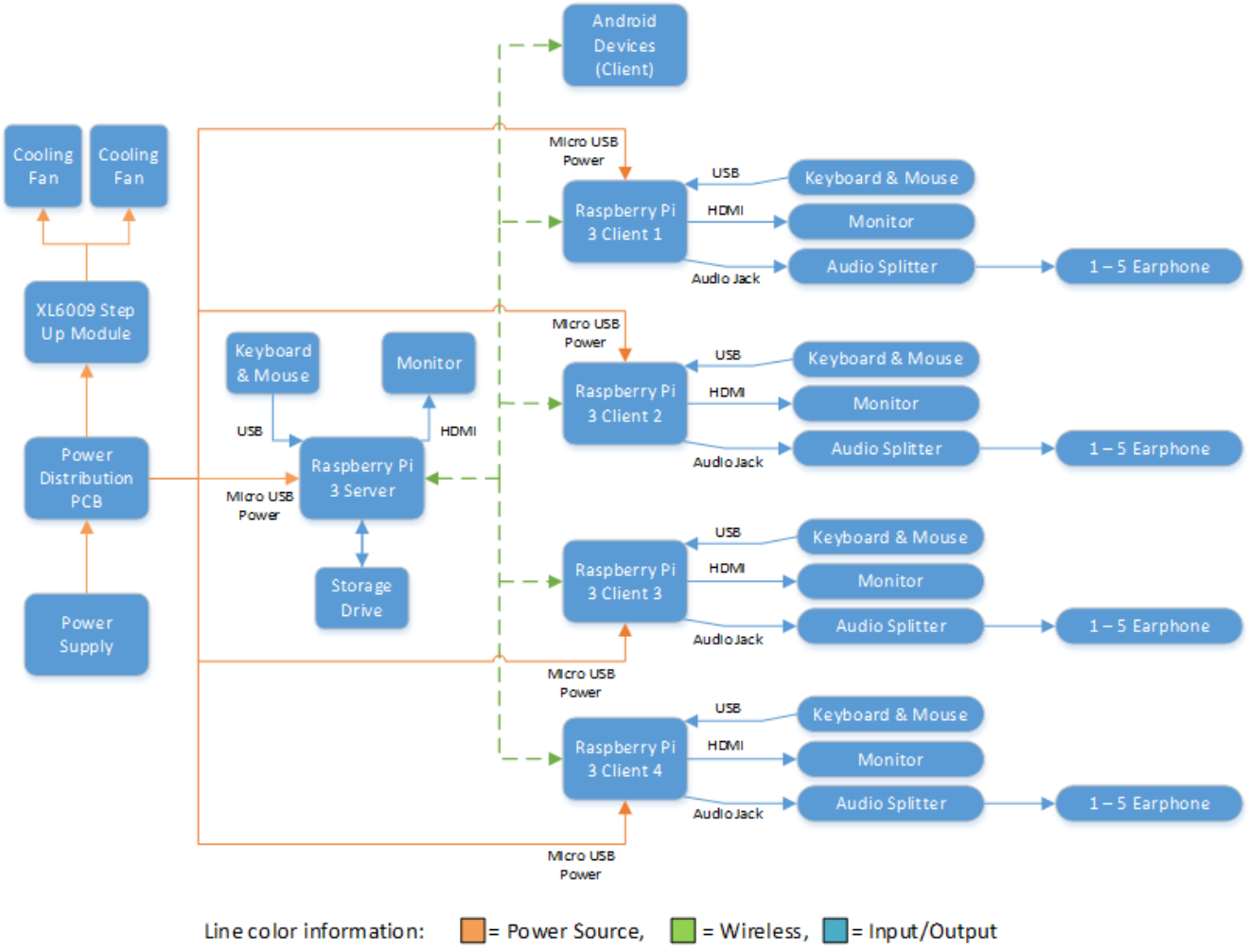


Figure 3. State diagram of the client.

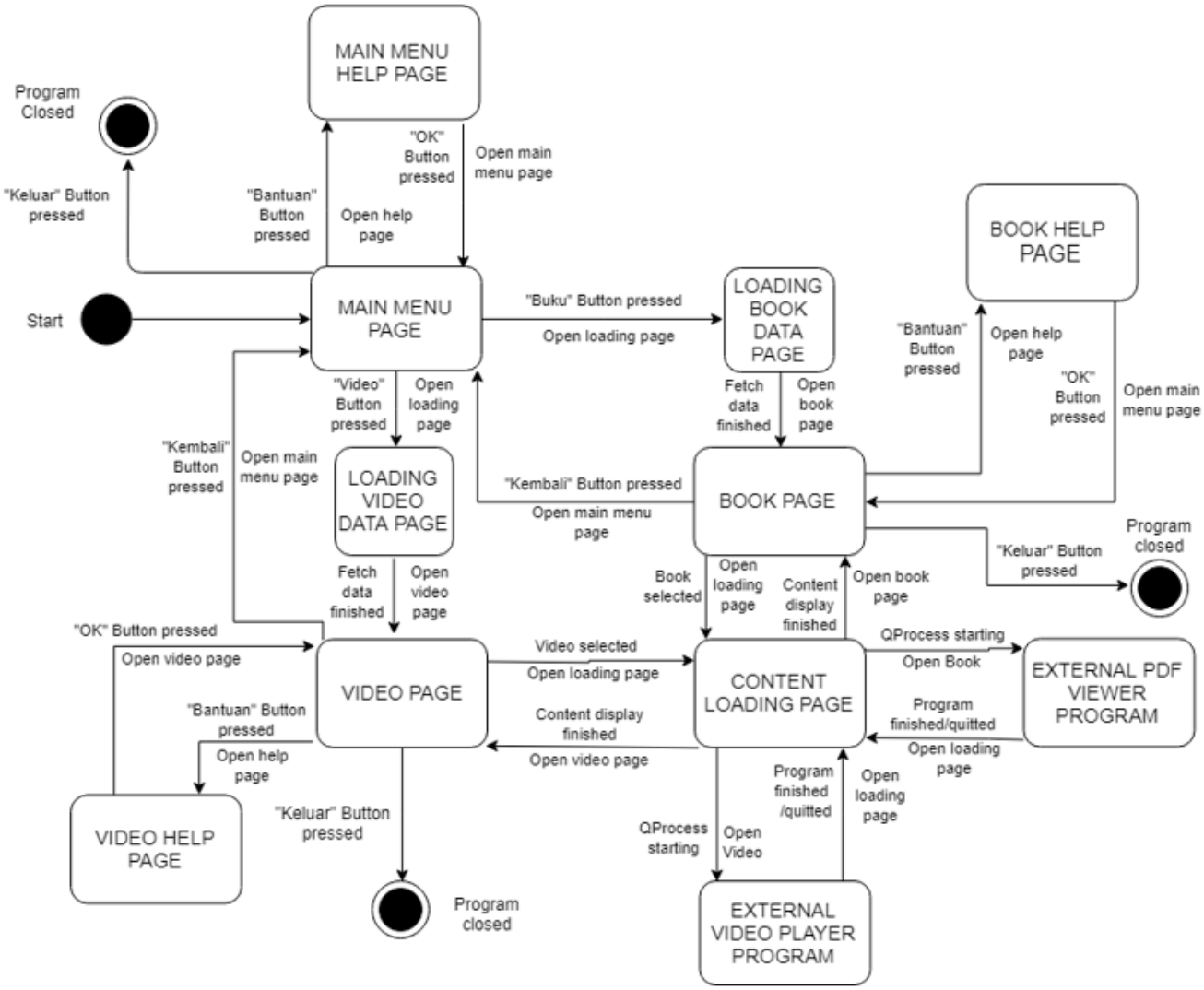
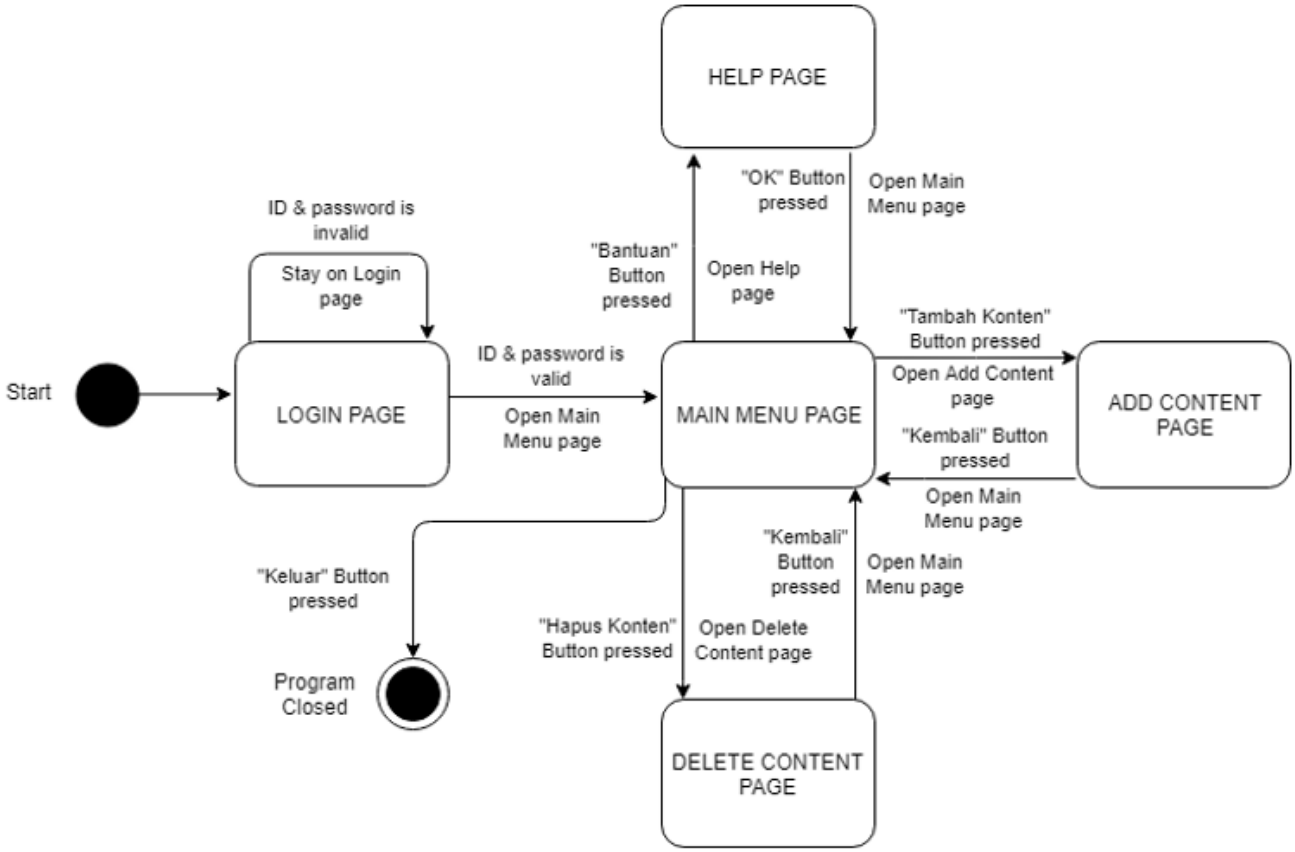


Figure 4. State diagram of the server.



The Raspberry Pi was tested in the lab for three months after the system was designed before it was deployed in the field. The system's dependability was tested in harsh weather conditions in Indonesia (humid, dry, and rain) as well as with inconsistent electricity provided into the system. Users accessed the system via the Raspberry Pi's Wi-Fi while the system performance was recorded. The first testing concentrated on the temperature of the system when it was running in both a humid and hot environment, as illustrated in Figure 5. The second test, as illustrated in Figure 6, measured the energy used during the operation. Both results demonstrated that the entire system is reliable enough to be used in an outdoor environment without air conditioning and with an unstable power supply.

Figure 5. Client's temperature during video playing.

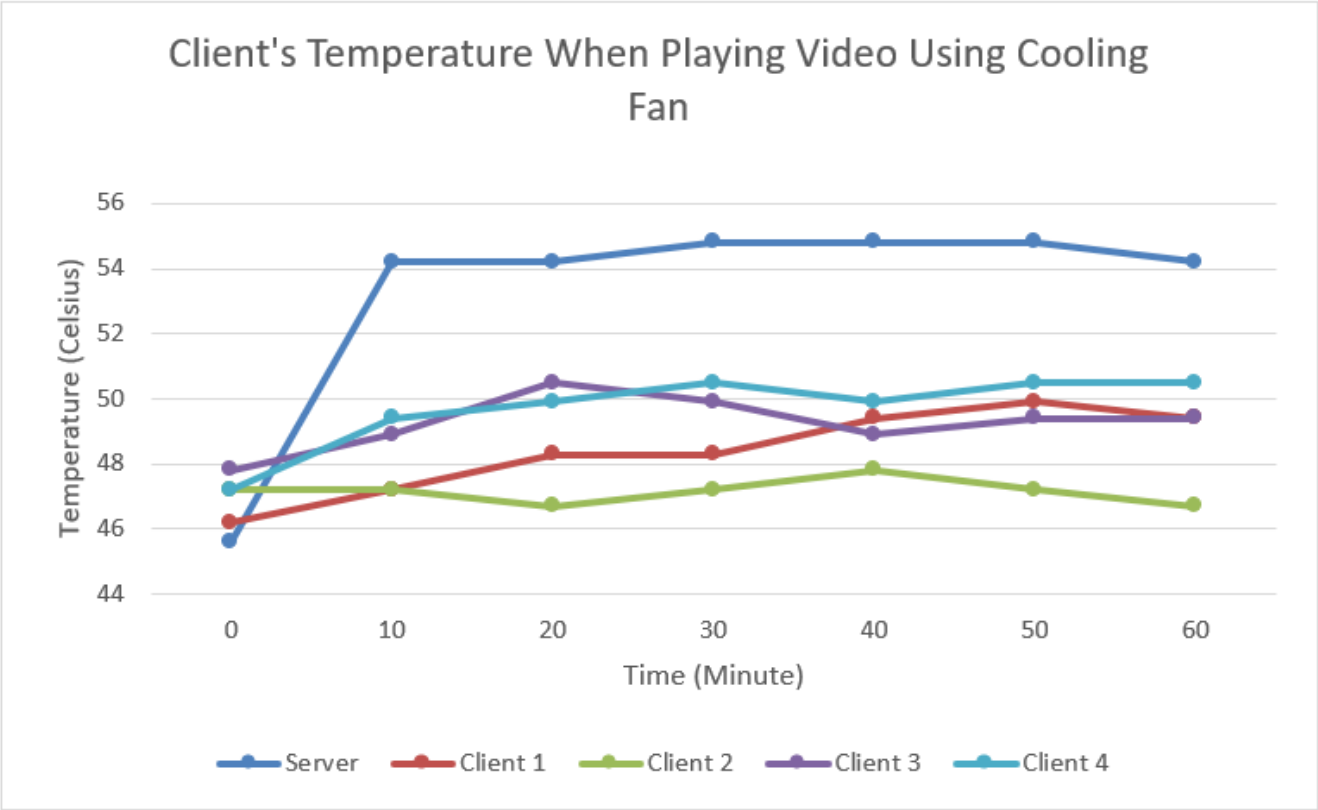
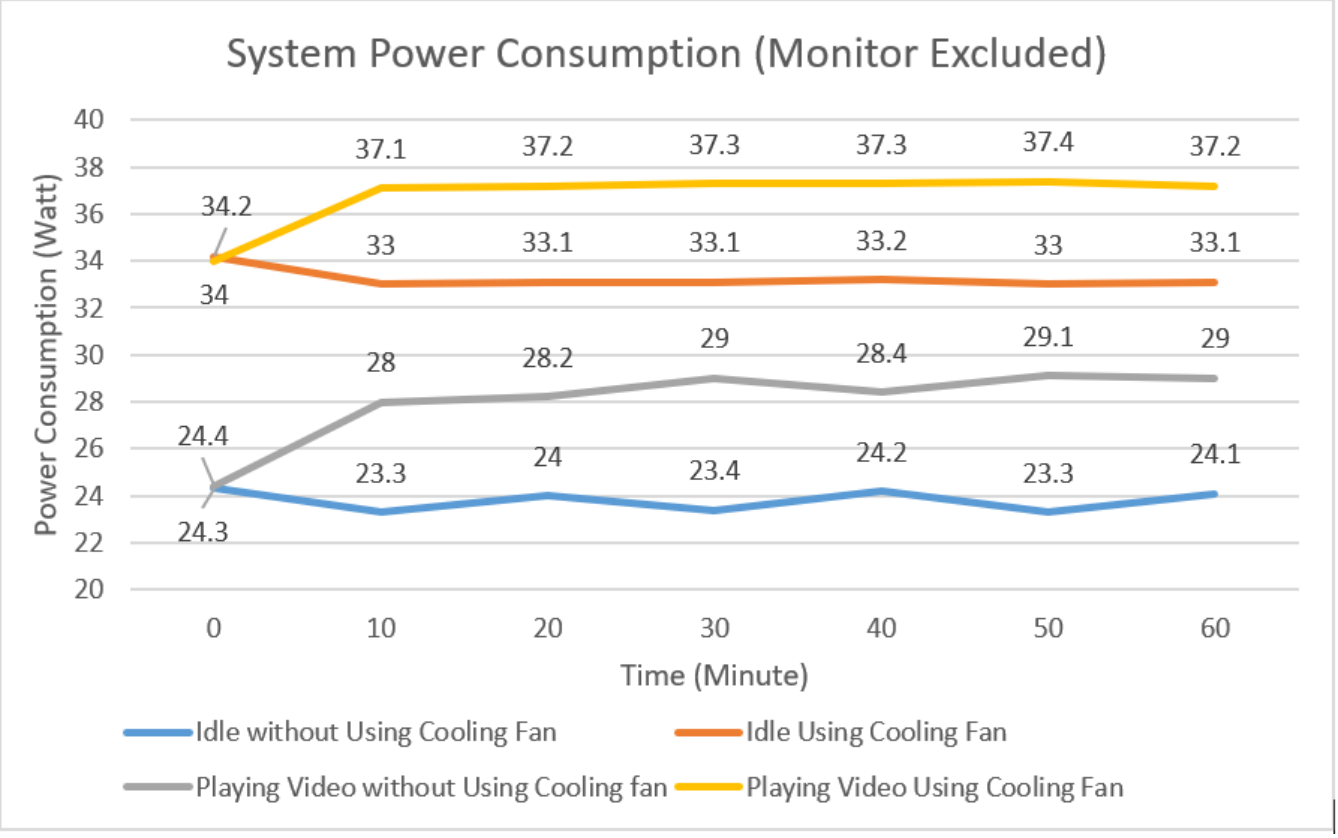


Figure 6. System power consumption during video playing.



IMPLEMENTATION RESULTS

In 2019, 500 students engaged in community service on the campus, contributing to a total collection of 2,500 e-books and videos. Remarkably, by January 2024, this content has expanded significantly, reaching a total of 7,000 items. The selected e-books are not copyrighted and provided directly by the writer while videos are mostly sourced from YouTube after receiving permission from content creators. Since all materials were delivered in Bahasa, Indonesia, some videos required translation or subtitles. The contents are regularly updated and sent by flash disk and via post to the remote areas.

As shown in Figure 7, the first system was installed on September 21, 2018, at "Onan Runggu Village"–North Tapanuli–North Sumatera. Onan Runggu is a community located on a barren mountain slope with no internet coverage and a dry, dusty environment. It is around 1,200 meters above sea level, and since the area is primarily composed of sand, the primary crop is pineapple.

Figure 7. (Left) The first implementation of Raspberry Pi–based offline digital library at Onan Runggu Village–North Tapanuli–North Sumatera where junior high school students are eager to use the System. (Right) A team shown during the assembling process.

In the first three months following the system's installation, surveys were distributed to collect user input: 78 percent of respondents prefer to watch videos, with children's animation videos being the most frequently accessed content. The system is still operational as of the most recent update on October 14, 2024.

The questionnaire comprised four primary questions: (1) Is the offline digital library simple to use? (2) What digital content do you enjoy the most? (3) Is all content suitable for your age? (4) Which content do you enjoy the best? Figure 8 shows the outcomes of the questionnaires.

Figure 8. The summary from the questionnaires that was taken each time the offline digital library installed.

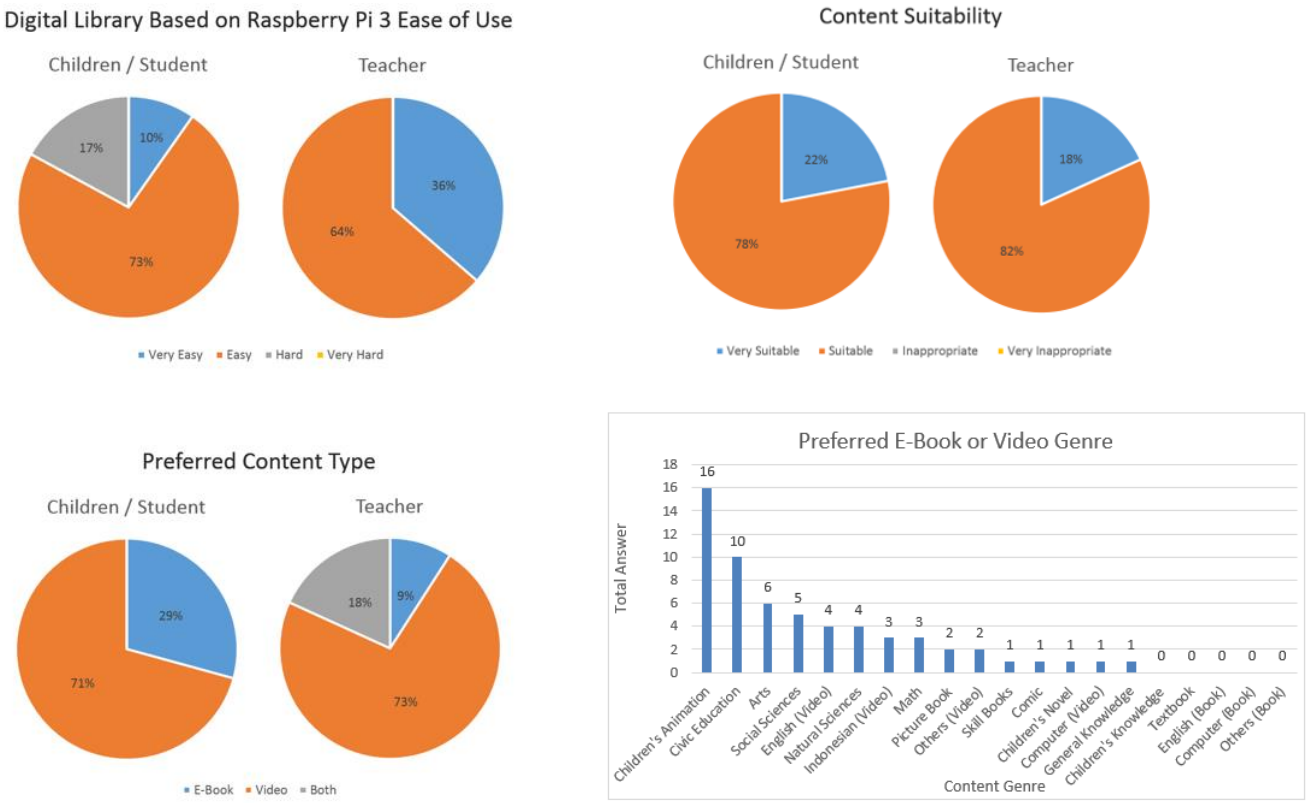


Figure 9. The second implementation at "Suka Maju" village (left) and "Suka Bangun" village–Bengkayang–West Kalimantan (right). The village is near the outer part of the jungle area, which is very humid and hot.

The second implementation took place on May 28, 2019, and was backed by Wahana Visi Indonesia (WVI), a Christian humanitarian social organization that promotes lasting change for the welfare of children, families, and communities.[7] As depicted in Figure 9, it was put in the

province of West Kalimantan, which consists primarily of jungle and has a very humid environment. There were two villages that benefited from the systems: "Suka Maju" Village and "Suka Bangun" Village in Bengkayang–West Kalimantan.

The third implementation took place on August 2, 2019, in the village of "Lumban Lobu"–North Tapanuli–North Sumatera, which was situated in a mountainous region that was extremely dry and dusty. Despite this extreme condition, both systems, which were a part of the second or third implementation as depicted in Figure 10, were still operating exceptionally well. Due to this excellent response, several locations in Indonesia sought the same system to replace the conventional library, which did not exist in these areas. WVI publicized the implementation in their media, and as a result, other regions, such as Papua, also requested an offline digital library, but without the Raspberry Pi, because a prominent Indonesian communications business had donated laptops.

This offline digital library was implemented again from August 19 to August 22, 2019, in the "Homfolo"–Sentani Lake, Papua and Wamena–Central Papua. A large telecommunications corporation, INDOSAT, supplied laptops to these villages, and the digital contents were replicated and distributed via the laptops, as seen in figure 11.[8] The digital contents were copied to secondhand laptops and desktop computers before being distributed to different schools for use as an offline digital library. Some areas had projectors set up so that multiple students could view the offline digital library's content at the same time. The area of Nabire–Papua also benefited from this offline digital library; however, the computers were supplied by Bank Mandiri, one of the largest state-owned banking organizations in the country. The user responses were generally good. However, to ensure optimal system performance, this system requires routine maintenance and communication between users and developers.

Figure 10. The third implementation of Raspberry Pi based offline digital library at "Lumban Lobu" Village–North Tapanuli–North Sumatera.

Figure 11. (Left) Children in Sentani Lake–Papua accessing the offline digital library contents in a reading house. (Right) A projector is used to watch the content together in Wamena–Papua.

In 2020 and 2021 the second version of the offline digital library was shared in North Maluku Island and Bali. This edition is designed to work seamlessly with an offline website, granting users access to the digital library even without an internet connection. This capability proves especially beneficial for locations equipped with computers but lacking internet access. With this version, users are not required to purchase the Raspberry Pi-based offline digital library system; instead, they can simply install the offline website program to access it directly from their existing computers. Other demands came from a company called IFT Group to install the system in Surabaya, Aceh, Singkawang, and Merauke in 2022 and 2023. With increased demand for this setup, it is projected that 95 units will be installed by the year 2025. The design has been changed but the function remains similar as shown in Figure 12.

After the system had been set up for a few months, it was evaluated in two ways: the first was with a questionnaire, and the second was with an interview through the online chat app WhatsApp. As shown in Figure 13, the results showed that the number of children who went to the reading house or library to engage in activities, like completing homework or watching educational movies, was on the rise. The parents were glad to hear that most children spent most of their time in the offline digital library to study or learn.

Figure 12. The new design where Raspberry Pi is directly attached to the monitor.

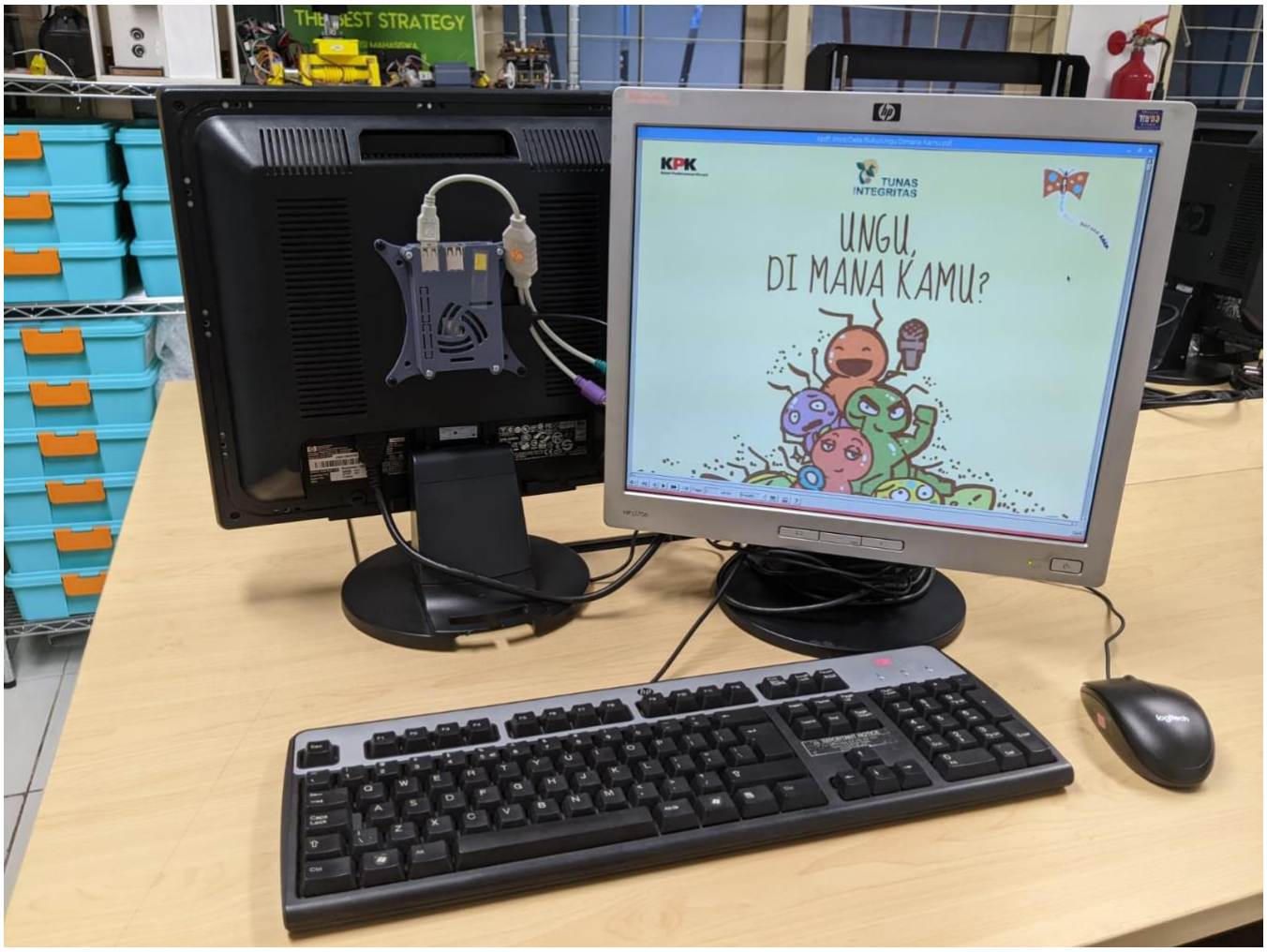


Table 2. Places that have received/will receive the offline digital library.

Name of place	Location	Province	Year
Desa Onan Rungu	North Tapanuli	North Sumatera	2018
Desa Suka Maju	Bengkayang	West Kalimantan	2019
Desa Suka Bangun	Bengkayang	West Kalimantan	2019
Desa Lumban Lobu	North Tapanuli	North Sumatera	2019
Distrik Homfolo	Sentani	Papua	2019
Distrik Wesaput	Wamena	Papua	2019
Nabire	Nabire	Papua	2019 & 2020
Kel. Takome	West Ternate	North Maluku	2020
Denpasar	Denpasar	Bali	2021
Kel. Togafo	West Ternate	North Maluku	2021
Kec. Genteng	Surabaya	East Jawa	2022
Manggarai	South Jakarta	DKI Jakarta	2022
Geulanggang Teungoh	Bireuen	Aceh	2022
Kec. Mataram	Lombok	NTB	2022
Gunung Bawakaraeng	Makassar	North Sulawesi	2022
Kel. Sijakung	Singkawang	West Kalimantan	2022
Kec. Tombatu	Manado	North Sulawesi	2023
Medan	Medan	North Sumatera	2023
Dusun Segenter	Lombok	NTB	2023
Air Tawar East	North Padang	West Sumatera	2023
Pulau Raam	Sorong	Northwest Papua	2023
Kec. Padang South	South Padang	West Sumatera	2023
Wae Kajong	Flores	NTT	2023
Kec. Sipora North	Kepulauan Mentawai	West Sumatera	2024
Sanggau Ledo	Bengkayang	West Kalimantan	2024
Sungai Pinyuh	Mempawah	West Kalimantan	2024
Pontianak	Pontianak	West Kalimantan	2024
Tana Toraja	Makassar	South Sulawesi	2024
Gido	Nias	North Sumatera	2024
Riangpuho–Larantuka	Flores East	NTT	2024
Lengkong Ajang	East Manggarai	NTT	2024
Mojokerto		East Jawa	2024
Ponorogo		East Jawa	2024
Kisar Island		Northwest Maluku	2024
Sabu Raijua Island		Near Kupang	2024

Certain places, such as Kisar Island and Sabu Raijua Island, are challenging to locate on maps. The sole means of reaching these islands is through a weekly flight using a small airplane or a day-and-night boat trip.

In the future, this offline digital library will be widely distributed throughout Indonesia, particularly in distant regions where internet access is unavailable and electrical supply is restricted or inconsistent. Even though this program is primarily supported by donations, the research group of the Computer Engineering Department at Bina Nusantara University will administer the program's sustainability. As for further development of the system, the offline digital library already comes with different versions and platforms. It can run under Linux,

Android, and web while some development is undergoing to improve its compatibility when running under Windows operating systems. The system is widely offered to many companies for corporate social responsibility activity as well as helping education in remote areas of Indonesia.

Figure 13 presents a testimony from a user in Kalimantan following the implementation of an offline digital library. The monitoring system for this initiative continues annually by gathering feedback from users, enabling necessary maintenance to be carried out. According to the testimony, local children are excited about the offline digital library and visit regularly to use the facility. Additionally, parents are pleased that the library helps enhance their children's reading skills. Similar feedback has been received from other regions where the offline digital library has been introduced. In one area of East Nusa Tenggara, it was reported that no children had been able to attend seminary school for many years. However, in 2024, two children from the village were able to enroll in seminary school, thanks to the practice gained from using the offline digital library. This positive outcome has motivated developers to expand the initiative and establish more offline digital libraries in remote areas of Indonesia.

Figure 13. Testimony from user in Kalimantan about offline digital library.

CONCLUSIONS

Transforming conventional libraries into offline digital libraries offers a solution to the lack of libraries in remote areas of Indonesia. Offline digital libraries allow for regular updates and maintenance, enhancing accessibility. The Raspberry Pi–based offline digital library is one of the alternative options for remote libraries due to its speed of access, system reliability, and reasonable price. With a cost of $904 (per January 2024) for a server and five clients, this design can be implemented in any nation with a problem comparable to that of Indonesia. Any nation can adopt this system after making the necessary modifications, most notably to the digital content's

language of instruction. The content of the offline digital library system is free, and interested parties can contact the author. Figure 14 illustrates several isolated places (currently 35 areas) that have previously benefited from this approach.

Figure 14. Colored dots mark the 35 areas where offline digital library was implemented.

ACKNOWLEDGMENTS

This work was partially supported by Wahana Visi Indonesia (WVI) under Memorandum of Agreement on October 10th, 2018, by IFT Group ($6,333 donation), and BINUS Initiative Project.

AUTHOR'S CONTRIBUTIONS

EESW, HL, LN, JL: prototyping from 1st version to 5th version, testing in the field, data gathering. WA, DPH, IA: funding, data analyzing, reviewing the product. RS, JY, JRH: content gathering up to 7000 e-contents, data classification, reviewing. MP, WW: writing and editing. RH: conceptualization, product design, methodology, writing, reviewing, editing, and manuscript finalization.

AVAILABILITY OF DATA AND MATERIALS

All data generated or analyzed during this study are included in this published article. Some documentations can be accessed at https://drive.google.com/drive/folders/1oRISPwEmaF8B-iP1kMcND9etqw5T0v5P?usp=drive_link.

CONFLICTS OF INTEREST

The authors affirm that they have no known financial interests or personal relationships that could be perceived as influencing the work presented in this paper.

ENDNOTES

[1] Linda B. Gambrell, "Getting Students Hooked on the Reading Habit," in *The Reading Teacher* 69, no. 3 (November/December 2015): 259–63, https://doi.org/10.1002/trtr.1423; Joseph

Sanacore, "Encouraging the Lifetime Reading Habit," *Journal of Reading* 35, no. 6 (1992): 474–77.

[2] Catherine C. Marshall, "Annotation: From Paper Books to the Offline Digital Library," in *Proceedings of the Second ACM International Conference on Digital Libraries* (1997): 131–40, https://doi.org/10.1145/263690.263806.

[3] Juan Pablo Hourcade et al., "The International Children's Digital Library: Viewing Digital Books Online. Interacting with Computers," *Interacting with Computers* 15, no. 2 (2003): 151–67, https://doi.org/10.1016/S0953-5438(03)00005-5.

[4] Hourcade et al., "International Children's Digital Library," https://firstmonday.org/ojs/index.php/fm/article/download/1050/970?inline=1

[5] Shawn Wallace, Matt Richardson, and Wolfram Donat, *Getting Started with Raspberry Pi (Make: Projects)* (Santa Rosa, CA: Maker Media, 2021).

[6] Prabhjot Kaur, Sudeep Jain, and Ashok Jhunjhunwala, "Solar-DC Deployment Experience in Off-Grid and Near Off-Grid Homes: Economics, Technology and Policy Analysis," in 2015 IEEE 1st International Conference on Direct Current Microgrids (ICDCM 2015), 26–31, https://doi.org/10.1109/ICDCM.2015.7152004.

[7] Wahana Visi Indonesia, accessed January 20, 2023, https://www.wahanavisi.org/id/tentang/tentang-kami.html.

[8] Indosat IM3 Oreedo, accessed February 15, 2023, https://indosatooredoo.com/en/personal.