Chapter 1
THE SCIENTIFIC PROBLEM

Introduction

Technology is an application of scientific knowledge to pragmatic goals or approaches. It applies scientific principles to improve the industry, other human creations, and the environment in which people live. All the world's technologies have been modified to improve human life, from basic inventions to advanced systems that operate independently of human experience. In the human environment, problems have always existed. Problems propel technological advancement; where adversity and strain exist, there is inventiveness. Technology results from this environment, improving the human experience by developing solutions to problems (Ford, Wood, & Cena, 2021).

Moreover, the importance of technology has a broad impact on making the world a better place to work. Technology is the application of human knowledge through tools, materials, and systems. If technology is used, it creates artifacts or products (Mohite, 2021). Technology's invention and development have various significant effects, but it becomes more effective when used with various devices. With the advancement of technology in television, people can now access various data and shows online rather than watching shows for entertainment. Heretofore, television handed us entertainment, news, education, culture, weather, sports, and even music. With the advancement of television, viewing options drastically increased, and people can now access both quality and a myriad of television programs (Caron, Caronia, Hwang, & Brummans, 2009).

In a highly technological world nowadays, televisions have large-scale benefits and have great contributions to every person’s life since the duty and purpose of televisions are to disseminate data, educate, spread

awareness, and entertain. Television (traditional or modern) plays a significant role in the modern world. It is considered one of the most crucial innovations in the history of information transformation. It may be a primary source of entertainment, information, and conversation. Many individuals have access to a wealth of knowledge because of television. Politics, science, history, geography, and culture may now be studied in ways never previously feasible (Sofar, 2015).

Furthermore, developing digital televisions that use digital signals to display media on the screen ameliorates technology. Woo Paik, an inventor, and engineer, concocted digital television in the *1990*s. Digital televisions use one value at a time for digital transmissions that are not in continuous mode. Digital televisions can be *80*p, commonly known as SD (Standard Definition), *780*p or *1080*i/p, or HD (High Definition). At the same time, it is now possible to increase the size of televisions without compromising the screen's visual quality—the ratio of *16:9* results in a larger screen size of digital televisions than the precedent televisions (Ben, 2011). Digital television is four times vertically and three times horizontally. The average screen size of digital television is *50-60* inches, and its excellent visual quality avoids photophobia (Yadav, 2022).

However, with the advancement of technology, televisions are now using the internet. Technology has changed how people watch television using different features. Android television is a television that uses Android as its operating system. The operating system has been optimized for large-screen viewing. This operating system includes apps such as the Google Play Store, which allows a person to download apps and games and access services such as Google Assistant. One of the operating system's primary goals is to make streaming services available and allow the person to organize all his local media files. Moreover, Android televisions have the

same features as smart televisions, they can connect to the Internet, and many come with built-in apps (TCL, 2020).

Nevertheless, due to the high cost of smart televisions, Android phones, and computers, the average Filipino's budget can only provide a limited number of items (Philippine Statistics Authority, 2015). The prices of Android television and personal computers are a real problem for those who need more cash and want to save money. To solve this problem, the researchers created a casting device that allows the digital TV to function as smart TV by reusing Orange Pi One Chip as the main material.

Orange Pi One Chip is an open-source operating system with a single-board computer. It is highly compact with a *69* x *48* millimeters dimension and weighs *36* grams. Orange Pi One Chip utilizes the All Winner H2SoC, with Quad-core *32*-bit Cortex-A*7* and *256* Megabits/*512* Megabits DRR*3* (shared with GPU), incorporates USB *2.0* port, TF card slot, *26*-pin header, and others. Orange Pi One Chip is a tool for creating practical and functional research about technology innovation. It also helps to run various applications and uses various operating systems and functions like Android. This allows users to experiment with different projects in the system (Pedamkar, 2022).

Furthermore, any social media network, including YouTube, Facebook, Gmail, and even online gaming, can be accessed using Orange Pi One Chip. The Android Operating System dubbed KitKat version *4.4*, Ubuntu, Debian, Raspberry Pi image, and Banana Pi image are all supported by the Orange Pi One chip. It has *512*MB DDR*3* SDRAM and is powered by the All Winner H*3* SoC. CSI or Camera Serial Interface input connector, *8*-bit YUV*422* Complementary Metal-Oxide Semiconductor (CMOS) sensor interface, CCIR*656* protocol for National Television Standards Committee (NTSC) and Phase Alternating Line (PAL). Tiny screen and video capture solutions of *1080*p at *30* frames per second are all video inputs of an Orange Pi One

Chip. Its visual output supports simultaneous High-Definition Multimedia Interface (HDMI) output and its thirty *(30)* features (e-Gizmo Mechatronix Central Inc, 2019).

Additionally, electronics have shrunk and grown more portable and powerful, allowing them to be taken anywhere and anytime. As a result, end customers carry phones and tablets (essentially mini-computers) everywhere they go. They prefer devices that cannot take up too much space and are portable to carry anywhere (KPCS, n.d.). The success of this study benefits many people. Not only are the parts of this device cheap or economical, but also these are recyclable materials. Mostly, the parts of this project could be found in broken *Piso* Wi-Fi, which makes it a recyclable material that can be harnessed for effective reuse.

Seeing the need in the locality where some of the residents do have digital television but aspire to own a smart television where they can get access to the latest application, this capstone project helps them meet their want to function their digital TV into a smart TV by offering them the reused Orange Pi One Chip (OPOC) as a casting device. In this manner, the study established a better idea of reusing materials from a PISO WIFI to create an innovation useful to the community instead of adding to the pressing problem of pollution brought by excessive waste and improper waste disposal.

Moreover, the reused Orange Pi One Chip (OPOC) was subjected to a series of effectiveness, durability, and functionality testing to ensure its success as a casting device for digital TV to function as smart TV.

Objectives of the Study

This project reused Orange Pi One Chip (OPOC) as a casting device for digital television to function as an Android or smart television.

Specifically, this study did the following tasks:

1. Applied the adopted but modified protocol from Chambers (2022) in reusing Orange Pi One Chip (OPOC) as a casting device for digital television to function as an Android or smart television.
2. Tested the reused Orange Pi One Chip as a casting device in terms of its:
   2.1 Effectiveness;
   2.2 Durability; and
   2.3 Functionality.

Research Questions

Guided by this study's objectives, the researchers answered the following scientific questions:

1. What is the applied protocol in reusing Orange Pi One Chip (OPOC) as a casting device for digital television to function as an Android or smart television?
2. What are the results of the testing undergone by the reused Orange Pi One Chip as a casting device in terms of its:
   2.1 Effectiveness;
   2.2 Durability; and
   2.3 Functionality?

Significance of the Study

The researchers believe that this study will be beneficial to the following individuals and aspects:

To Technology, this research will be a breakthrough by expanding the application of technology to produce new features and knowledge using microcomputers, also known as single-board computers. One of the microcomputers is the Orange Pi One Chip, the latest innovative technological development that can be used to upgrade digital televisions to

Android or smart television. Hence, the outcomes of this study present the efficiency of Orange Pi One Chip as a casting device in functioning digital televisions as an Android or smart television through a series of testing applied to test its effectiveness, durability, and functionality.

To the Environment, numerous ecosystems and species are directly impacted by poor waste management, contributing to climate change and air pollution. There are various ways rubbish influences our well-being and prosperity, both straightforwardly and roundabout: methane gases add to environmental change, air contamination is delivered into the climate, etc. (European Environment Agency, 2014). This study reused recyclable material as its main material, the Orange Pi One Chip, and other parts taken from a broken *Piso* WIFI Net to allow digital television to function as an Android or smart television. In this simple way, the researchers may help control waste production by adapting recyclable materials as much as possible.

To the Community, this research involves reusing recyclable materials convenient with an internet connection and available electricity. Having an Android or smart television in a family may greatly benefit their daily lives. Instead of buying an overpriced Android television worth twenty thousand pesos or more, they can save money using the Orange Pi One Chip to make any digital television function as an Android or smart television. With this recycled chip, families with digital televisions with an internet connection can now enjoy the features of an Android phone since this installed Android television can perform like an Android phone.

To the STEM Students, this study may help them apply their scientific knowledge and skills by developing more technological innovations, such as reusing the Orange Pi One Chip. Through this study, the students can showcase their capabilities and expertise in manipulating microcomputers, such as an Orange Pi One Chip used in this study.

Moreover, this study develops the scientific research skills of the students through being able to design a study by adopting the protocol to allow digital television to function as an Android or smart television. The students may also develop their critical thinking skills in answering and providing solutions found while conducting the study.

To Future Researchers, in this study, the researchers did not explore other operating systems that the recycled Orange Pi One Chip could also run due to the researchers' limited resources and the applicability of these systems: Linux Operating System and Mac Operating System. Only the latest version of the H*3*Droid from *h3droid.com*, an Android operating system named KitKat version *4.4,* was available for use. Thus, this study may be their basis for further studies regarding the recycled Orange Pi One Chip by installing the other operating system they prefer to utilize. In addition, distinct relevant literature and studies found and discussed here can be used as references to help future researchers discover important areas that still need to be explored.

Scope and Delimitations of the Study

This study reused the Orange Pi One Chip (OPOC) as a casting device to allow digital television to function as an Android or smart television. This was achieved by performing different procedures that answered the questions posed in this study. It began with gathering recyclable materials used in making this casting device. The researchers asked an owner of a broken Piso WIFI net the materials they reused in creating the casting device. When the owner approved, the researchers assembled the OPOC and its parts.

Meanwhile, the Orange Pi One Chip underpins a wide extent of working frameworks; this study supported only the most recent adoption of the H*3*Droid from h*3*droid.com, an Android operating system version *4.4*

named KitKat that made OPOC a successful casting device that allows digital television to function as an Android or smart television. However, the OPOC as a casting device was delimited only to households with an internet connection since it requires internet access before this device could be installed.

Moreover, in making this OPOC a successful casting device, the researchers applied the adopted but modified protocol. First, downloading the latest H*3*ii SD card image on *h3droid.com* and second, decompressing the downloaded image using a decompression tool named WinRAR that needed around *260* megabits free. Third, the researchers wrote the image using the writing tool Win*32*DiskImager and fourth, booting the H*3* device after inserting the Micro SD card, which underwent an automated installation process for five *(5)* minutes and restarted automatically. Fifth, a set of choices was flashed on the screen. The researchers chose by typing *21,* which indicated switch uboot.

After that, the screen displayed different types of OPOC, and the researchers chose *14* (uboots/u-boot-sunxi-with-spl.bin-orangepi_one), and they pressed enter. Once done, the next response of the OPOC was that it immediately went back to the main menu, where the installation process started. The researchers chose type *22* (*switch fex*) and pressed enter, and then they typed *10* (*H3/orangepione.bin*), and pressed enter. These actions led the researchers to the main menu, where they typed *99*, selected OS, and rebooted. After that, they chose and typed *1* (*h3droid*), and it rebooted for *10* seconds. Sixth, the cat icon appeared that lasted for about *3* minutes, signifying the successful installation of the casting device, OPOC.

Furthermore, this OPOC casting device underwent a series of effectiveness testing to ensure its usability in allowing digital TV to function as an Android or smart TV. This was achieved by subjecting the OPOC as a casting device to trial-and-error schemes to detect possible issues like

lagging and visual display. Next is its durability; there were heating issues with the Orange Pi One Chip, and the system could shut down if all the cores were used or when the system was used to its maximum capacity. Cores may become locked if the system is not shut down when the heating occurs (Pedamkar, 2022).

To impede these durability issues from possibly occurring, the researchers tested the OPOC. They detected and examined its heating issues by observing the performance of the system hour by hour and spotted possible problems regarding heating issues like the system shutting down and lagging. Lastly, regarding its functionality, the researchers tested the Orange Pi One Chip as a casting device to see if errors might occur while programming and also to confirm if the Orange Pi One Chip as a casting device had successfully performed its intended purpose of functioning the digital TV as an Android or smart TV like connecting to the internet to download applications, accessing any social media platforms, listening to music, watching shows, and launching camera setup for video-related communications. This was done by doing the casting process with the selected IT experts, who observed the procedures and evaluated the casting device-OPOC. After that, a survey questionnaire was handed to them for their final evaluation. This study was conducted in *2022-2023*.

Definition of Terms

As this study contains vague terminologies and unfamiliar terms to the readers, the researchers operationally clarified the following concepts to understand this study better:

Android refers to the operating system used in this study.

Android Television is a television that functions like smart television operated by the Android operating system.

Casting Device refers to the electronic equipment, i.e., OPOC, created by the researchers and used in this study to allow digital television to function as an Android or smart television.

Casting of Digital Television (TV) to Android or Smart Television (TV) refers to the programming process of an Orange Pi One Chip (OPOC) using the adopted but modified protocol from Chambers (2022) that allows digital television to function as Android or smart television.

Colon National High School refers to the locale of this study.

Community refers to the municipality of Maasim, Sarangani Province, and other places and municipalities that have wired internet connection and available electricity.

Digital Television refers to the transmission of television signals using a digital broadcast and was an experimental subject to determine the success of Orange Pi Once Chip (OPOC) as a casting device.

Durability of Orange Pi One Chip (OPOC) refers to the duration of the installed Android television using OPOC as a casting device, with a minimum of two hours and a maximum of four hours, proven through testing and observations.

Effectiveness of Orange Pi One Chip (OPOC) refers to the results shown, such as without lagging, visual output problems, and fast internet connectivity of the installed Android program to a digital television proven during the testing and observations.

Functionality of Orange Pi One Chip (OPOC) refers to the function of OPOC by successfully installing Android television, showing the features of an Android or smart television based on the testing and observations.

Orange Pi One Chip (OPOC) refers to the reused and programmed material as a casting device that allows digital television to function as an Android or smart television.

Reusing refers to recycling the OPOC and other usable parts of Piso WIFI net to be created as a casting device that allows digital television to function as an Android or smart television.

Chapter 2
THE SCIENTIFIC LITERATURE AND STUDIES

This chapter includes the related literature and studies utilized to support the premise and outcomes of this research. This discussion aims to set the research report and review concerning the Orange Pi One Chip and its use. Further, this chapter also discusses the conceptual framework of the study.

Microcomputers

Single-Board Computers, or SBCs, are used in several applications such as control, automation, and signal processing. Thanks to powerful processors and huge amounts of memory, these systems can run several systems simultaneously, be programmed for several platforms, and even run an operating system that has been in our lives for a long time. It has been around for a long time, starting with the first calculators and progressing to minicomputers connected to televisions and game consoles. Many applications today prefer single boards. As a result of the recent development process of computer systems accessible to all (Güven, Coşgun, Kocaoğlu, Gezici, & ve Yılmazlar, 2017).

Figure 2.1 Single-Board Computers

	CPU	GHz	RAM	ROM	USB	GPIO	Internet	Görüntü
Raspberry Pi 3	ARMv8	1.2	1GB	SD	4	40	Wifi+Eth	Hdmi+DSI
Raspberry Pi 2	Cortex-A7	0,9	1GB	SD	4	40	Ethernet	Hdmi+DSI
Raspberry Pi 1	ARM1176	0,75	512MB	SD	2	26	Ethernet	Hdmi+DSI
Raspberry Pi 0	ARM1176	1	512MB	SD	2	40	-	Hdmi
CHIP	ARMv7	1	512MB	4GB+SD	2	80	Wifi	-
Orange Pi 0	ARM	1.2	256MB	SD	2	13	Wifi+Eth	-
Orange Pi 1	Cortex-A7	1.2	512MB	SD	2	40	Ethernet	Hdmi
Orange Pi PC		1.6	1GB	SD	2	40	Ethernet	Hdmi+cvbs
Orange Pi +		1.6	1GB	8GB+SD	4	40	Wifi+Eth	Hdmi+cvbs
HummingBoard	Cortex-A9	1.2	2GB	SD	4	30	Ethernet	Hdmi
BeagleBone	ARM	0.7	256MB	SD	2	80	Ethernet	Hdmi
Black	Cortex-A8	1	512MB	4GB+SD	2	80	Ethernet	-
Green		1	512MB	4GB+SD	2	80	Ethernet	-
Enhanced		1	1GB	4GB+SD	4	80	Ethernet	Hdmi
Gelileo	İntel Quark	0,4	256MB	8MB+SD	2	40	Ethernet	PCI-ex
Edison	İntel Atom	0,5	1GB	4GB+SD	1	40	Wifi+Eth	-
Joule	İntel Atom	1,7	3GB	8GB+SD	4	48	Wifi	Hdmi
Banana Pi M1	ARM	1	1GB	SD	2	40	Ethernet	Hdmi+cvbs
Banana Pi M2	Cortex-A7	1,2	1GB	SD	4	40	Wifi+Eth	Hdmi+rgb
Banana Pi M3		1,8	2GB	8GB+SD	2	40	Wifi+Eth	Hdmi+DSI

Figure 2.2 Popular Single-Board Computers and General Features

Single-chip microcomputers, which have a wide range of applications due to their different CPU and memory sizes and interfaces (Ethernet, HDMI, DSI, CVBS, PCI-ex, etc.), are also used in general-purpose electronic applications. inputs and outputs (GPIO). These boards are embedded systems that have both a control system and a control system. They can be

internally wired or wireless, have wireless capabilities such as Bluetooth, and support industry communication standards. Due to its low price and extensive software support, it is very easy to use for educational purposes. Also, in the future, large-volume desktop computers will be programmed to achieve specific goals to ensure their more efficient use (Güven, Coşgun, et al., 2017).

Characteristics of Orange Pi One Chip

The Orange Pi is one of those PCs but is much smaller and consumes much less power. Orange Pi can be arranged parallel, forming a parallel cluster to improve computing performance. The Beowulf parallel cluster system, where all devices are on the same network and can cooperate to solve a problem, can be used to design Orange Pi parallelization. However, the Beowulf cluster method's limited bandwidth client is one of its drawbacks. When parallel processing is performed, the node and main devices communicate. Communication between nodes and the main that occurs often burdens the bandwidth on the available network. This limited bandwidth often reduces parallel computing performance. Therefore, a test is carried out using a multilevel network, where one Beowulf cluster will be further divided into Sub-clusters using one router for each sub-cluster (BadiaChristian, 2017).

Multilevel network configuration clients are expected to increase bandwidth during parallel processing, increasing overall computing speed. In this study, *17* Orange Pi were divided into four sub-clusters. Each sub-cluster consists of *4* Orange Pis, and *1* Orange Pi works as the main. Each sub-cluster is connected to a different router. The parallel computing process is implemented using OpenMPI. The test was carried out two times on the same parallel and multilevel parallel systems. Speed testing is done by

running the matrix multiplication program in both parallel systems. Tests were also conducted on two cases (BadiaChristian, 2017).

In the first case, the test was carried out with the same initial conditions, where all devices were in a new condition. The second test is to compare processing speed with different program sizes. Tests were also carried out using four different amounts of processing, namely *17, 34, 51,* and *68*. The results of this study indicate that an increase in speed is obtained in the case of parallel processing with new initial conditions turned on in the number of processes *17, 51,* and *68*. Increased speed is also obtained in tests with *34* processes and program sizes *100, 200, 600,* and *700,* and faster on all program sizes with *51* and *68* process counts (BadiaChristian, 2017).

Furthermore, Orange Pi One Chip upholds a few systems software: Android, Ubuntu, Debian, ArchLinux, Gentoo, OpenSUSE, Kali, Fedora, and Raspberry Pi Picture. Orange Pi One Chip is viable with parts of different PCs from the Orange series, for example, the more impressive Orange Pi PC and Orange Pi Light, which have a Wi-Fi module rather than an Ethernet connector. The Orange Pi One uses *10* watts of power and needs a power supply with a *2*A current and a *5*V output voltage. The board cannot be powered using USB-OTG. You can connect an HDMI display or CSI camera with a maximum resolution of *5* megapixels. *40* programmable general-purpose input/output (GPIO) pins are available on the Orange Pi One (Brown, 2021).

Uses of Orange Pi One Chip

Electric Actuators are widely used in modern industrial control as an important device in industrial automation systems. It must produce a specific torque to meet the demands of specific working conditions. The control box currently calibrates the factory torque calibration of Electric Actuators. This

paper describes a visual interface solution based on the Orange Pi. This scheme is based on the simulated resistance of the powder brake, the torque sensor's sensed torque, and the encoder's sensed speed. The Orange Pi acts as the control core, and the output current of the KTC*800*A voltage regulator controls the resistance. The HMI interface is based on a simple and intuitive lightweight display framework. The scheme detects detailed operating parameters of electric actuators, such as current, voltage, speed, and torque, and uploads them to the Alibaba Cloud IoT platform. The website allows users to view data remotely. The bare metal torque test and the electric actuator machine have been completed (Xue, Hao, Zhuo, & Yang, 2022).

In particularly dry areas, a water system is the manufactured application of water to the soil to develop crops. Different soil irrigation methods are used in different regions depending on the plants grown there. A smart irrigation system primarily takes care of these needs. A remote monitoring system based on an Arduino module accurately monitors soil moisture and temperature. The Arduino module remotely gathers information and sends it to the focal server of the Orange Pi, which then cumulates and sends it to the client's cell phone (Meduri, Diwan, & Meduri, 2020).

Furthermore, the framework has a detached water level sensor that identifies the presence of water in the tank and enacts actuators that consequently fill the tank with groundwater. Since this system runs on solar energy, no power is required. Taking pH sensors from the soil, the system automatically mixes fertilizers and chemicals at the right time and sprays crops at the right time for each crop of the season. The effectiveness of complexity was illustrated by diagrams showing fertilizer, water, and benefit mapping analysis (Meduri, Diwan, & Meduri, 2020).

Durability of Orange Pi One Chip

An Allwinner H*3* quad-core CPU powers Orange Pi One Chip. At the same time, utilizing this board without a CPU heat sink will result in overheating and may cause the board to fail totally. Use a *15*x*15*mm heat sink made of aluminum or copper. Another issue is that the CPU frequency and voltage settings in most operating systems available for the Orange Pi One are set to the highest feasible values, which can be deemed overclocked (Orangepione, 2016). Table *2.1* shows the Orange Pi One CPU frequency and voltage settings.

Table 2.1 Orange Pi One CPU Frequency and Voltage Settings

Level 1 frequency	1.54 GHz
Level 1 voltage	1.5 V
Level 2 frequency	1.2 GHz
Level 2 voltage	1.3 V

Allwinner processor frequency and voltage, GPIO, memory, display, and many other settings used at system startup are controlled by a specific script.bin configuration file. The Sunxi.fex files are required to compile the script.bin file. On Github, Thomas Kaiser improved the Orange Pi One, which changes the frequency and voltage settings so that we can tell the normal values of the Allwinner H*3* processor (Orangepione, 2016). Table *2.2* shows Thomas Kaiser for Orange Pi One frequency and voltage settings.

Table 2.2 Thomas Kaiser for Orange Pi One Frequency and Voltage Settings

Level 1 frequency	1.2 GHz
Level 1 voltage	1.3 V
Level 2 frequency	648 MHz
Level 2 voltage	1.1 V

Abridgment of the Android Operating System

The platform was created by Android Inc. Google later acquired the company and published the software as the AOSP (Android Open-Source Project) in *2007*. The Open Handset Alliance consortium was then formed to help promote and support Android. Android development and distribution are the focus of this site. The Apache License, a free, open-source license, governs the use of the program. An updated major version of Android is released every few months due to its rapid development. The Android operating system is the centerpiece of the OHA, a group of hardware, software, and telecom businesses that includes Google, Intel, NVIDIA, Qualcomm, Motorola, HTC, and T-Mobile. His primary objective is to create technology to speed up and lower the cost of developing and deploying mobile services and devices. The Google platform is made up of software, such as Volume. The initial step on this journey is the underlying operating system, the middleware, and the mobile applications. Android is a recently launched platform that is expanding quickly. Each major version is given an alphabetically arranged candy-related name. Figures *2.3* and *2.4* illustrate the percentage of active Android devices accessing Google Play.

Version	Name	Distribution[%]
2.2	Froyo	0.8
2.3	Gingerbread	14.9
4.0	Ice Cream Sandwich	12.3
4.1-4.3	Jelly Bean	58.4
4.4	KitKat	13.6

Figure 2.3 Active Android Devices with Access to Google Play

(Google collected data over seven days ending on June *4*, *2014*. Out of all the data, a very small percentage was found to be less than *0.1%.)*

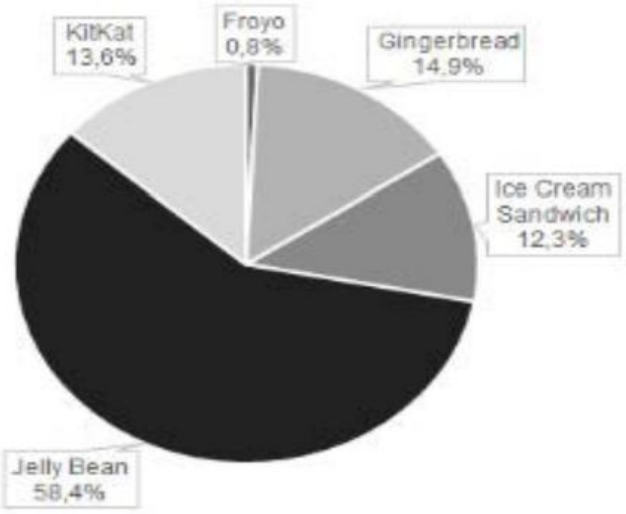


Figure 2.4 Placement of Android OS

Google Play was known as Android Market. It is a smartphone distribution platform, and an online store improved and vindicated by Google. It allows customers to find and download music, books, magazine articles, and applications that Google has approved. Jellybean is the most popular Android version, with over *58%* distribution, while KitKat is available in more than *13%* of portable devices (Wayback Machine, 2020). The Android release history is depicted in Figure *2.5*.

Version	Name	Release Date
1.5	Cupcake	April 2009
1.6	Donut	September 2009
2.0-2.1	Éclair	October 2009
2.2-2.2.3	Froyo	May 2010
2.3-2.3.7	Gingerbread	December 2010
3.0-3.2.6	Honeycomb	February 2011
4.0-4.0.4	Ice Cream Sandwich	October 2011
4.1-4.3.1	Jelly Bean	June 2012
4.4-4.4.4	KitKat	October 2013
5.0-5.0.2	Lollipop	November 2014

Figure 2.5 Android Release History

Significant advancements in each release include:

- Cupcake – this update includes upgrades to all core User Interface (UI) components, accelerometer-based application rotations, on-screen soft keyboard, Bluetooth, and video stereo support.
- Donut's quick search box, support for *802.1*x, and VPN (Virtual Private Network); battery level indication.
- Éclair – has customer service, a ton of emails, new camera modes, and support for Bluetooth *2.1*.
- Froyo – WLAN hotspot and tethering capabilities, JIT (Just in Time), and support for Adobe Flash.
- Gingerbread – Near Field Communications or NFC and extra sensor support (rotation vector, linear acceleration, gravity, and barometer) and support for many Google Talk, tablets with huge screens, and camera support.
- Honeycomb – a high-performance Wi-Fi lock, an Android upgrade for tablets that only support USB (universal serial bus) accessories.

- Ice Cream Sandwich –several modifications (stability, optimization, screen rotation, graphics), Wi-Fi Direct, and Face Unlock.
- Jellybean – Google Wallet, Google Now, USB Audio, Photo Sphere panorama photos, multiple user accounts, and Miracast wireless display are all supported.
- KitKat – supports Bluetooth MAP (Message Access Profile), a new runtime experimental virtual machine, and NFC host card emulation.
- Lollipop – project Volta (increased battery life), audio input/output through USB devices, support for *6*-bit CPUs, replacement of Dalvik with ART with AOT (Ahead-Of-Time) compilation, support for OpenGL ES *3.1*, recent activity screen displaying tasks rather than programs. (Gilski & Stenfanski, 2015).

Streaming Device

Over-the-top ("OTT") streaming devices like Roku TV and Amazon Fire TV that offer multi-channel options have seen a considerable increase in Internet-connected TV sets in recent years. A TV subscription service is often monetized through behavioral advertising. The researchers have developed a system capable of best-effort TLS interception, network traffic interception, and automatic download and interaction with OTT applications (also known as channels) to uncover the privacy policies of such platforms. In recent years, there has been considerable growth in the number of internet-connected TV devices. Over *2,000* channels on two well-known OTT platforms, Roku, and Amazon Fire TV, were examined using the smart crawler. The results demonstrate that tracking is pervasive on both platforms, with traffic to known trackers occurring on *69%* of Roku channels and *89%* of Amazon Fire TV channels (Moghaddam, Acar, Burgess, Mathur, Huang, Feamster, Felten, Mittal, & Narayanan, 2019).

Additionally, it is customary to record and send unencrypted network traffic carrying device IDs, serial numbers, Wi-Fi MAC addresses, and SSIDs. Finally, the researchers show that the myriad fixes offered on these devices, like limiting ad tracking options and ad blocking, are essentially useless. Furthermore, the current method of distributing and viewing video content over the internet using different website platforms is known as video streaming. Online video viewing has emerged as a brand-new entertainment and information-sharing platform. Due to the popularity of this medium, traditional media like television are becoming less and less prevalent in modern society. Thousands of video productions are added to the internet within one minute, some of which millions view. These issues have been generally discussed globally (Moghaddam et al., 2019).

However, since no such study has been conducted, it is worthwhile to investigate the best practices for using online video content in the Sri Lankan context. Due to a lack of research, the implications of streaming media use nationally have yet to be investigated. The study aims to ascertain how university students use streaming media daily to close the gap (Podduwage, Ratnayake, & Manuratne, 2021).

Casting Device Market

During the projection period (*2021-2026*), the casting device is expected to rise at a compound annual growth rate (CAGR) of *16.4%.* Extent consumption of video-on-demand (VoD) services, increasing demand for applicable and cost-effective styles to pierce entertainment content with a toned experience, and shifts in consumer habits are some of the significant factors driving the growth of the casting equipment market. At the same time, the availability of native smart television apps is likely to impede overall growth (MordorIntelligent, 2022).

Casting devices are unmanaged, network-connected devices that receive and display on-demand video from the internet on a screen. Since streaming services and devices are proliferating, the Smart TV industry is anticipated to hold a consequential market share over the forecast period. Smart TVs combine standard television features with computer functions, allowing viewers to surf the internet and download apps while viewing their favorite shows. The increasing usage of smart TVs in emerging markets and the development of new technologies such as *4*K resolution have emerged as key developments in the casting devices business. According to the Consumer Technology Association, global smart TV penetration will reach *32%* by *2019* (MordorIntelligent, 2022).

Additionally, the entertainment industry has made significant strides thanks to the introduction of cutting-edge technology like gesture and speech recognition features in smart televisions. Some advantages of streaming on a smart TV include a larger selection of internet TV services, additional navigation options, and replay possibilities. These advantages include playing games and watching favorite movies and television shows with a stable connection to the TV. Smart Televisions are increasingly used in advertising, allowing advertisers to reach a larger audience. According to digital advertising technology company RhythmOne, the number of smart TVs used in the US increased from *62* million units in *2016* to *94.8* million units in *2018* (MordorIntelligent, 2022).

Figure 2.6 Unit Sales of Smart TVs, Global, 2015 – 2020 (Millions)

Nonetheless, the casting device industry is highly competitive, with a few players who are experts in current domination streaming technology. To increase market share and profitability, major industry players will likely focus on expanding their business and customer base overseas in a joint strategic effort. Google Inc., Roku Inc., Apple Inc., Anycast, Mirascreen, Microsoft Corporation, and Hisense Co are participating. Major players in the current market include EZCast, NVIDIA Corporation, LG Electronics Inc., Samsung Electronics Co., Ltd., Airtame ApS, and Amazon.com, Inc (MordorIntelligent, 2022).

- July *2019* – With the ACT Stream TVK gadget, broadband internet service provider ACT Fibernet enters the streaming device industry. This unit supports streaming entertainment services such as Netflix, Hooq, Sony LIV, and Hungama Play.
- March *2019* – Customers may now move PC games to Xbox One thanks to new software that Microsoft has released for the gaming console. The program may be used to mirror Android phones as well (MordorIntelligent, 2022).

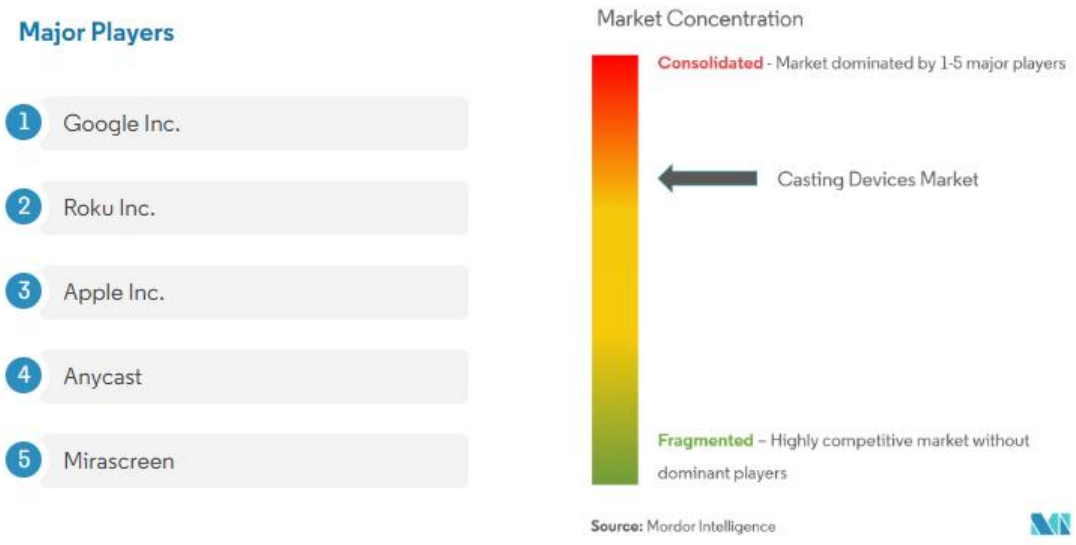


Figure 2.7 Competitive Landscape

Chromecast

Casting, also known as Google Cast or Chromecast, is one of the most significant advances in recent consumer technology. Streaming content from a phone or mobile device to a large-screen TV and controlling it with your hand is simple but effective. That is why the Chromecast is such a game changer and needs to be understood: it has no dedicated remote, no user interface, and casts content to your TV. It is the simplicity that many people miss because it accomplishes so much with so little effort, which causes people to panic (Hall, 2019).

Furthermore, Google's Chromecast is a gadget that allows customers to broadcast data from their computer, mobile device, or tablet to their television. The Chromecast lacks a user interface and is controlled by the device they are streaming their video. The Chromecast costs $*35*, which is around one-third the price of the comparable Apple TV, and it is tested for accessibility on a variety of operating systems, including a Windows PC, an iOS device running iOS *7*, and an Android smartphone running *4.4* KitKat (Preece, 2014).

Moreover, the Chromecast with Google TV is a hockey puck-sized device that plugs into an HDMI port on your television. It comes with a short HDMI cable that is built in. A USB-C-C power port is located on the other side of the puck. Unlike other media devices, the Chromecast requires you to plug it into the wall because it does not draw power from your TV. The necessary adapter, remote, and two AAA batteries are included (Meddaugh, 2021). The Chromecast is a basic device. It resembles a large USB flash drive with a round end that tapers to a rectangular end. The HDMI male connector (which looks like a USB connector) is at the rectangular end. A micro-USB female connection connects the power source at the round end. Next to the micro-USB connector is a reset button. The fundamental function

of Chromecast is to stream video from various mobile apps to your TV while utilizing your mobile device as a control (Preece, 2014).

Furthermore, the Chromecast Ultra is a simple and logical step up from the standard Chromecast. The ability to cast in *4*K Ultra HD with luscious High Dynamic Range has been added (HDR). Chromecast Ultra is a simple and predictable upgrade for Google and a device that makes perfect sense by supporting the most recent video streaming formats to your TV. However, unlike the previous two Chromecast devices, which filled a gap in your TV's capabilities, the Chromecast Ultra will likely infringe on features your TV already provides. And for many, this will render it obsolete (Hall, 2019).

Introduction to Plug and Play

A desktop system may readily adapt to hardware changes with the help of Windows Plug and Play (PnP) functionality. A user can add and remove devices without having to physically configure them or have any prior knowledge of computer hardware. For instance, without manually adjusting the settings, users may dock a computer device and use the mooring station's keyboard, pointing device, and supervisory features. PnP requires hardware, system software, and driver support. Standardizing hardware initiatives helps quickly identify boards and system pieces contributing to the Windows Driver Kit (WDK). This documentary evidence supports the Windows Driver Kit (WDK) focus on PnP support in system software and how drivers leverage that support to implement PnP (2021, Microsoft).

PnP manager detects and assigns resources to devices installed on the computer. This includes resources like ports on the computer, which is used to connect devices, and memory locations, which are used to store data. The PnP manager defines and allocates hardware resources for each device, such as I/O ports, block requests, direct memory access channels, and

memory addresses. PnP management redefines resource settings when a new device is added to the system that requires the resources currently in use. PnP device controllers do not show resources. instead, the requested resources are detected by device enumeration. PnP management looks for the needs of each device when allocating resources. Because the resources of legacy devices are not dynamically modifiable, PnP management prefers legacy devices for resource allocation (Microsoft, 2021).

- Appropriate driver loading
- A programming interface that allows drivers to communicate with the PnP system.
- The interface provides registry information, minor Plug and Play IRPs, procedures to ensure high-quality drivers, and I/O management functions.
- Means for drivers and programs to monitor and respond to changes in the hardware environment.
- With PnP, certain hardware events can be registered for and communicated with by drivers and user-mode codes.
- A driver must adhere to PnP guidelines, manage the necessary PnP IRPs, and provide the necessary PnP entry points to be considered PnP.

History of Plug and Play

The term "Plug and Play" was coined in the early *1990*s when manufacturers ambushed one other and discovered that peripherals could be inserted into a computer without further effort. The roots of plug and play, on the other hand, are more interesting because he highlights two distinct histories: the evolution of language and the evolution of technology. At long last, they agreed to tell a story. The computer's path to widespread use should be used to emphasize the immediate nature of plug-and-play games.

The initial title was "Plug in and Play." Because the electrical system was frequently linked, it is not surprising that the phrase became popular during the Great Depression because many rural Americans lacked access to electricity (Smith, 2021).

The phrase gradually developed into something more akin to its current form. Dynamic Instrument Corporation has developed a transistor radio battery charger that allows the radio to be used for years after conventional batteries would have to be thrown away. According to the United States Patent and Trademark Office, the Plug 'N Play is the first device patented under that name or direct derivatives. United States Patent and Trademark Office (USPTO). The term was rarely used in the *1960*s and *1970*s, in one case referring to televisions with a built-in shut-off function before it became popular. It had a resurgence in the *1980*s when tech companies started using it in their product lines. The Japanese company Okidata, whose printer lines are among the first to use the term in printing technology, was among the first to use it in the computer industry. The company introduced its Microline *92* and Microline *93* printer suite, which allowed the automatic alignment of IBM machines without additional programming. At the time, getting a non-IBM printer with a computer line was incredibly difficult, but Okidata succeeded with this addition (Smith, 2021).

Plug and Play Components

The PnP manager is divided into user-mode PnP manager and kernel-mode PnP manager. The kernel-mode PnP manager works with drivers and other operating system components to configure, manage, and maintain devices. The user-mode PnP manager manages device configuration and installation by interacting with user-mode setup elements like Class Installers. The user-mode PnP manager also interacts with programs by notifying them when a device event occurs and registering them for device change

notifications. PnP drivers support physical, logical, and virtual devices on a system. Any driver for Windows that supports the interfaces specified in this section is called a "PnP driver." Most PnP drivers are also WDM drivers and thus source compatible with Windows platforms. All drivers should support power management and PnP. The inability of a single driver to perform PnP and power management limits the system's overall capacity to implement these functions (Microsoft, 2021).

Figure *2.8* below shows the elements that cooperate to support PnP.

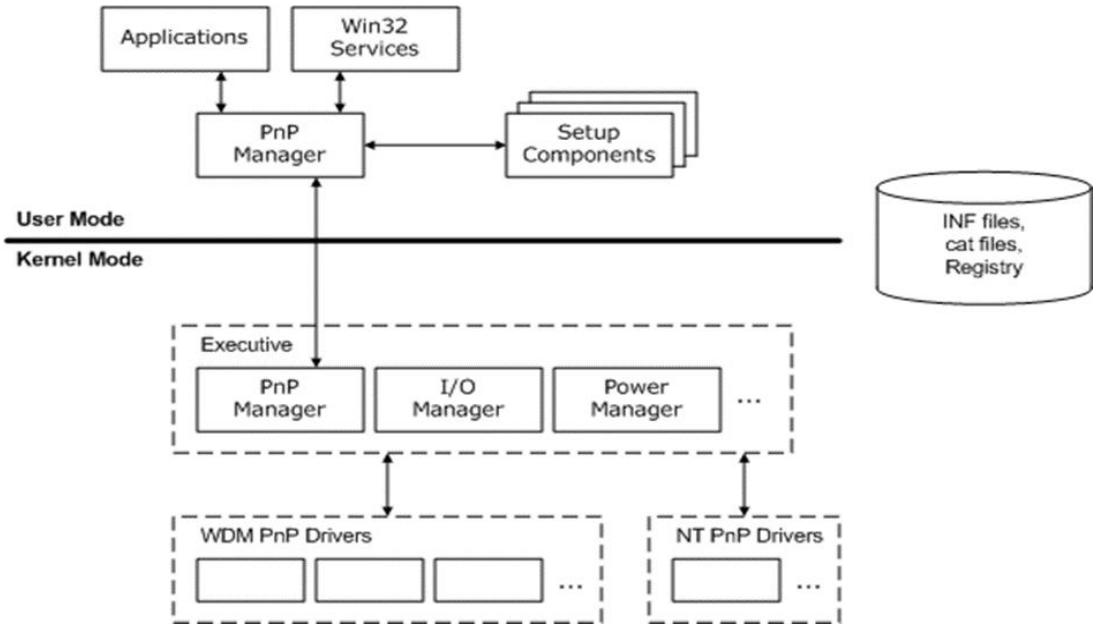


Figure 2.8 The components that collectively facilitate Plug and Play (PnP)

Plug and Play Devices

Plug and Play (PnP) refers to devices that work or are immediately recognized when connected to a computer. A fundamental advantage of PnP devices is that the computer automatically manages the device without requiring the user to install drivers manually. When you plug in your device, your computer will recognize it automatically and immediately load new drivers for your hardware. Let us assume you connect a plug-and-play device to a USB port on your computer. As a result, your device can be ready to use when you plug it in. Also, when comparing Plug and Play devices to non-Plug and Play devices, you may notice that setting up the device on your computer takes time. Plug and Play devices were possibly introduced in Windows *95* and have been preserved in all subsequent Windows-based computer versions. Plug-and-play gadgets are becoming increasingly popular as consumers want instant device access. USB devices, either internal or external hard drives, graphics cards, monitors, and various other devices are examples of plug-and-play devices (Remosoftware, n.d.).

If your system cannot detect and load PnP devices, you can use Device Manager and DOS drivers with CONFIG.SYS and AUTOEXEC.BAT configuration files, and DOS and the operating system. After performing the above steps, the device may remain unconfigured due to the complex operating system environment or lack of computer security. A USB device, for example, may encounter software or hardware incompatibility and cease functioning. This error can lead to device damage and data loss. If you find yourself in this situation, you can easily recover data after Windows or Mac cannot detect the USB drive using Remo Recover (Windows/Mac) tool (Remosoftware, n.d.).

Plug and Play (Windows *2000*)

Just plug and play. In Windows *2000*, your computer's main input/output system (BIOS), hardware devices, operating system, device drivers, and system resources work together to manage additional hardware devices added to Windows *2000*. Your computer system detects and installs—no need to understand and know the technical nuances of doing this. Plug and play automatically allocates the necessary system resources for the new device and detects and installs the essential driver software. Once you have installed and set up your new device in Plug and Play, you can turn it on and use your computer. This technique avoids manual gadget arrangement and drivers by making it simpler for non-specialized PC clients to update their PC frameworks. The objective was to make adding parts like printers and scanners as simple as embedding a toaster oven. Once associated, you can utilize it (Pittsley, 2001).

Additionally, Plug and Play service offers three levels of operation: BIOS, operating system, and devices. All three levels of operation require manual configuration. This level of operation requires users to be familiar with and understand the details of installing new components on the system. B. The allocation of IRQs, memory locations, and other system resources can be done using a Plug and Play operating system such as Windows *95* on non-Plug and Play legacy hardware. This results in the Plug and Play ladder rungs: A user can install new hardware in a computer system by using Device Assistant to detect and configure the new hardware and then using Device Manager to configure the hardware manually. Users can install new hardware into their computer systems by using Device Assistant to find and configure modern hardware and then Device Manager to manually set the system resources required by the components (Pittsley, 2001).

A client can put new equipment in a PC framework by first utilizing Gadget Partner to recognize and design the new equipment and afterward utilizing Gadget Chief to arrange the equipment physically. Clients can put

new equipment into their PC frameworks by utilizing Gadget Associate to find and design present-day equipment and afterward utilizing Gadget Chief to set the framework assets expected by the parts physically. can be introduced (Pittsley, 2001).

Plug-and-Play Distributed Intelligence for Smart Cities

In European and Japanese cities, citizens' quality of life is already improved by BIGCLOUT project solutions. A new global non-profit organization, the Urban Technology Alliance, is also expanding its international community of end users. City governments, local businesses, and citizens can develop their own developing applications, innovation ecosystems, and business models in addition to the BIGCLOUT tool, which provides a scalable, extensible, and cost-effective method for integrating the numerous technologies required to make cities "smart." Smartphones and Internet of Things devices like smart traffic lights, air quality sensors, and street cameras are examples of Plug-in-Play components. There are options for cloud and edge computing as well as powerful big data processing and analytic technologies. Based on the results of a previous EU-funded project called CLOUT, decentralized intelligence is getting smarter as more devices and services are added. The whole thing is better than the sum of its parts—arrangement to urban communities (European Commission, 2020).

Urban Innovation Ecosystems

The latter method is considered less expensive, more effective, and extensible due to its scalable and modular results, comparable to BIGCLOUT. Open-source deployment encourages the creation of invention ecosystems, business models, and, ultimately, unique businesses and jobs. In contrast, bottom-up strategies also have the advantage of promoting public participation and engagement. Increased citizen satisfaction, which

translates to improved quality of life, is why civil neighborhoods participate in smart mega-city systems. We must address environmental problems as well as social and economic difficulties. As a result, smart city technologies will play a key role in the transition to a low-carbon future (European Commission, 2020).

Through the Urban Technology Alliance, BIGCLOUT partners share ideas and solutions worldwide to help build smart cities and an international community of citizens who want to build a better and greener future. A key component of smart cities would extend the success of international cooperation between the EU and Japan by making their results available to people worldwide. Mutually supported by the European Commission and Japan's Public Establishment of Data and Correspondences Innovation, BIGCLOUT addresses areas of strength for an EU-Japan collaboration in the cloud, IoT, enormous information, and security innovations. This collaboration will address future economic and social issues by coordinating technology practices and standardization efforts, such as smart cities, e-government, and e-health. It has created unique applications in the field (European Commission, 2020).

Development of Operations Management Games Using a Plug-and-Play Approach

Numerous studies have argued that games (and simulations) can help students learn better. According to the study, students must be involved in their actions to comprehend the content better. Unfortunately, the classroom has few interactive games, especially in administration. The study suggests creating plug-and-play, interactive game paths to improve student learning. By making knowledge more accessible, making thinking more visible, making learning more enjoyable, and encouraging self-directed learning, the proposed game method makes learning easier. Future games can be added

to a plug-and-play (PnP) platform to meet the needs of students of various levels, which is an advantage (Tan, Tse, & Chung, 2010).

Android Television Operating System

Android TV is a version of the Android operating system intended for TV usage. It has been around since mid-*2014* when it replaced the now-defunct Google TV, and it is very fragmented, much like the mobile version of Android. Numerous Android TV box makers have tailored the operating system to suit individual requirements. Amazon's Fire TV OS is likewise a substantially modified version of Android TV OS, with numerous distinct releases in circulation due to the unpredictable update cycles, just like the smartphone version. Google distributes new versions regularly, but it might take a long time—in some cases, years—to reach all devices via over-the-air upgrades from a manufacturer. Android TV OS may also be found in smart televisions. Sharp, Sony, Philips, and Hisense have all employed Android TV OS at various periods to power their Televisions' smart features (Price & Dan, 2020).

Furthermore, essentially a mobile operating system, Android is quickly gaining market penetration with the introduction of smartphones and tablets—a modified version of the Linux kernel *2.6* powers this mobile operating system. The Open Handset Alliance, a group of firms in the hardware, software, and telecommunications industries committed to advancing open standards for mobile devices, was established the same year that Android was initially introduced. Android's user interface is primarily based on direct manipulation, moving objects on the screen with touch gestures that closely match real-world movements such as swipes, touches, and pinches, and using a virtual keyboard for text entry. Google introduced the user-interface-specific Android Wear for watches, Android TV for

televisions, Android Auto for vehicles, and Android Auto for motorcyclists (Vilma & Arora, 2017).

Functionality of Smart Television

Researchers can use the sophisticated information appliance to browse the internet, look at pictures, listen to music, and watch their preferred entertainment media via traditional broadcast or streaming over-the-top and on-demand video. There are several smart TV platforms to choose from, the best of which are Roku TV, Sony, Panasonic, Samsung, and LG. Shrewd TVs come outfitted with their working framework and a choice of implicit projects or applications frequently incorporating famous top picks like Netflix, Hulu, Spotify, YouTube, Amazon, and others. Using a built-in app store, like on a smartphone, the researchers can also add and remove apps from there (Fossenbell, 2020).

The researchers may also access their videos, music, and images using a Smart TV. A standard method is a cloud-based web platform like Windows Media Player or iTunes. Still, researchers can also connect directly to a computer or a removable storage device like a USB stick or hard drive. The researchers might even be notified when their preferred sports team or show airs. New Smart Televisions make purchasing apps, movies, games, and other content simple and accessing it using your smartphone, laptop, or tablet (Fossenbell, 2020).

Certain Smart TVs now have more navigation options, allowing for more natural engagement with information. They come with a companion device for the second screen that lets you use a touchscreen, motion-sensitive controls that let you use gestures like pointing at the screen, and voice instructions. The time-consuming text input that comes with using an on-screen keyboard and remote to submit search queries is avoided in these unique ways. You can use spoken commands like "Display local weather" or

"Mute TV volume" with some remotes, including built-in voice functionality (John, 2022).

One of the great features of Smart TVs is on-demand, where you can watch your favorite shows every day. Stream what you want instantly. Choose from a variety of specialty channels, including sports and movies. Services such as BT Sport, ITV Hub, and iPlayer are available. Users can also transfer programs from mobile phones, tablets, and laptops to their devices. There are various streaming sites, such as Netflix, Disney, Amazon Prime Video, and YouTube. Most smart TVs have these apps, but you can download additional apps in seconds. The smart TV's built-in web browser allows you to surf the web, view web pages, and watch videos. You now have access to millions of songs. Finally, you can scroll through social media (John, 2022).

Durability of Smart Television Compared to Digital Television

Smart televisions do not break any more easily than non-smart televisions, but any device will require proper care to last as long as possible. If the smart television is kept in a secure environment, is not overused, and is not compromised by hackers, it can last for more than eight years without needing to be replaced. At full power or on the highest settings, smart televisions should last nearly seven *(7)* years. Smart televisions are generally long-lasting, but their lifespan is determined by how they are used.

Operating Temperatures:

While smart TVs have air vents and heat sinks to control the temperature, in some cases, the heat causes the TV to break down faster. Keeping the smart TV in small, enclosed spaces contributes to the extra heat it may experience. Placing the smart TV near heat-emitting appliances harms the TV (Williams, 2022). The screen can often last much longer than *100,000*

hours. It has displays that have been on for over *15* years and have more than adequate brightness because the diode is only one component of the digital display's lifespan (Samsung for Business, 2022).

Weather, power, design, and content are all additional considerations. Heat is the most significant contributor to diode degradation. As the brightness of a diode increases, so does its heat output. The physical environment of the display also influences the temperature of the diodes, especially for outdoor displays. The quality of the power supply and how hard it drives the diodes can significantly impact the screen's lifespan. Other powered components, such as fans and electrical components, have their lifespans that are also influenced by the power supply. Consider the architecture and construction of the unit that houses the diodes on the screen. The circuit boards that power the display generate heat, which must be dissipated. Thermal stress will shorten the display's life if a strong design is not used. The display's content can also have an impact on its lifespan. Many variations in color and brightness will shorten the life of the diode. For example, black makes no use of any of the diodes (Samsung for Business, 2022).

Furthermore, if the content uses many grays, it has a much lower power output than white. Furthermore, this does not mean that rich, vibrant colors should be avoided; that is what Digital Television excels at. However, it affects the product's life expectancy (Samsung for Business, 2022).

Research Gap

Research data is valuable and utilized in all fields, including business, science, and education. Forbes magazine believes that companies that effectively utilize research data and comprehend its implications will have a competitive advantage in the market (Forbes, 2017). Research is integral to planning programs and projects in education, especially in policymaking

(Brommelstroet, 2019). Consequently, the lack of research data represents a gap detrimental to growth and development.

As presented in the following review of related literature and studies above, many research projects and studies focused on devices such as Chromecast, joystick, and even Android boxes as casting devices for digital television. However, there are new devices or computers that can be used as casting devices for digital television to function as Android television. In this study, the researchers focused on using single-board computers, specifically Orange Pi One Chip (OPOC) as a casting device and as an innovation. This OPOC is a useful device that can function as a casting device since it supports a wide range of operating systems. Along with this, there are studies proving heating issues when using single-board computers. To fill this gap, the researchers attached a CPU mini fan and used a heat sink to minimize the heating issues when using the Orange Pi One Chip.

Conceptual Framework of the Study

This study reused the Orange Pi One Chip (OPOC) from a broken Piso WIFI Net as a casting device for digital television to function as an Android or smart television.

Television is an unavoidable component of contemporary culture. It is an essential source of information and communication in everyone's life. The media has become an essential element of people’s lives in today's modern culture. Its responsibility is to inform, educate, and amuse. Television serves as a link between the governing entities and the general people.

Furthermore, with Android Television, the person, as an operator and customer, may be offered a clever, simple television experience with a

recognizable interface. The Android Television Operating System is a Google service that runs on top of a person's hardware, saving him the trouble of building his setup and providing access to Google's ecosystem. Hence, this study was realized to provide those households with internet connectivity and electricity; however, their television is still a digital television to function it like an Android or smart television by offering the researchers' study output- the reused Orange Pi One Chip as a casting device. In creating the said device, the recyclable materials found in a broken Piso WIFI Net, such as Orange Pi One Chip and other electronic materials still useful in reusing OPOC, were assembled to form a casting device.

Figure *2.9* on the next page shows the study's conceptual framework using the I-P-O model.

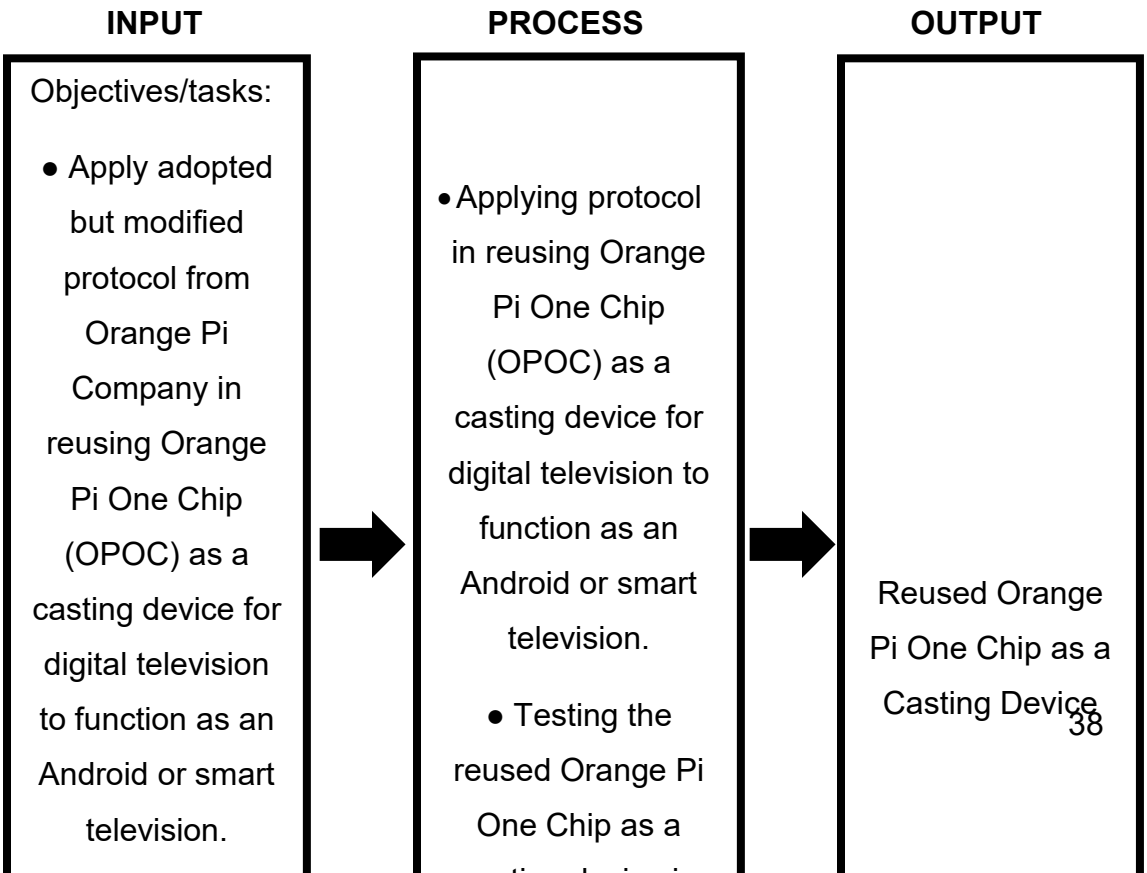


Figure 2.9 Conceptual Framework of the Study

Chapter 3
METHODOLOGY

This chapter describes the methodology that was used in this study. It discusses the research design, location, study duration, materials, tools, equipment, paraphernalia, procedures, variables, and statistical analysis.

Research Design

This study employed the adopted but modified protocol from Orange Pi Company in reusing the Orange Pi One Chip as a casting device that allows digital television to function as an Android or smart television. On the other hand, the quantitative method, mainly the descriptive design, was used

to help the researchers test the reused Orange Pi One Chip in terms of its effectiveness, durability, and functionality, as evaluated by the selected households and IT experts. According to McCombes (2019), the descriptive type of research is an appropriate choice when the research aims to identify characteristics, frequencies, trends, correlations, and categories. Further, she added that a descriptive research design could use various research methods to investigate one or more variables. Unlike in experimental research, the researcher does not control or manipulate any of the variables.

Location of the Study

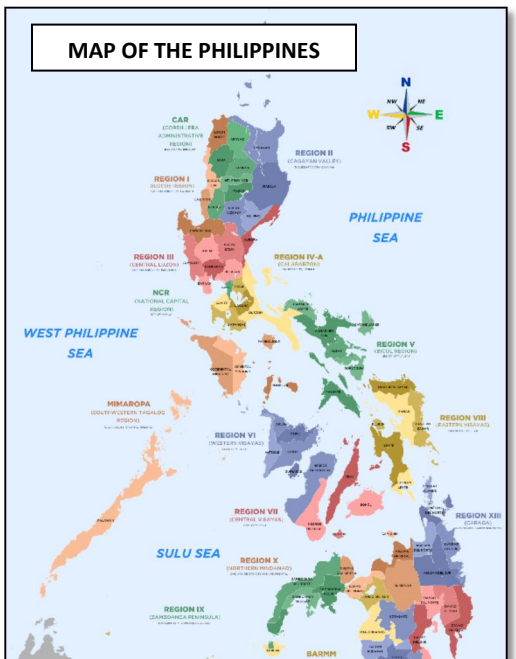
The researchers were currently enrolled as STEM students at Colon National High School. Since its humble foundation, this institution has consistently produced high-quality graduates by providing high-quality education. It has made significant academic strides, as seen by the numerous curricular and extracurricular competitions it has won and participated in. The school has opened its new Science, Technology, and Engineering Curriculum and the Special Program in the Art Curriculum. It has achieved level *3* in its School-Based Management System, Division Level.

These academic successes reflect the school's ongoing excellent practices. As shown by their triumphant participation in various academic activities, such as their capstone research stints winning second place in Division-wide Applied Research Competition, students can also flourish personally and academically.

Presently, the school has continued realizing its vision, mission, and goals for the betterment of all its clientele, the students. Specifically, in the STEM strand, students were given opportunities to be exposed to different research endeavors where they could thrive using their learned scientific skills. Since *2017*, the STEM strand has produced more than fourteen *(14)*

Capstone projects specially tailored to meet needs and address the problems in the locality.

In this batch, Callidus made history by completing Capstone projects in technology and robotics. The current researchers developed a Web-based system with the other group that also developed a casting device using Orange Pie One Chip (OPOC) that allows a digital television to function as smart television. A prototype fire-fighting robot named HEROBOT was also programmed to detect fire for immediate extinguishing. Indeed, these creative and scientific inventions and innovations made by STEM students proved that little things mean a lot to them.



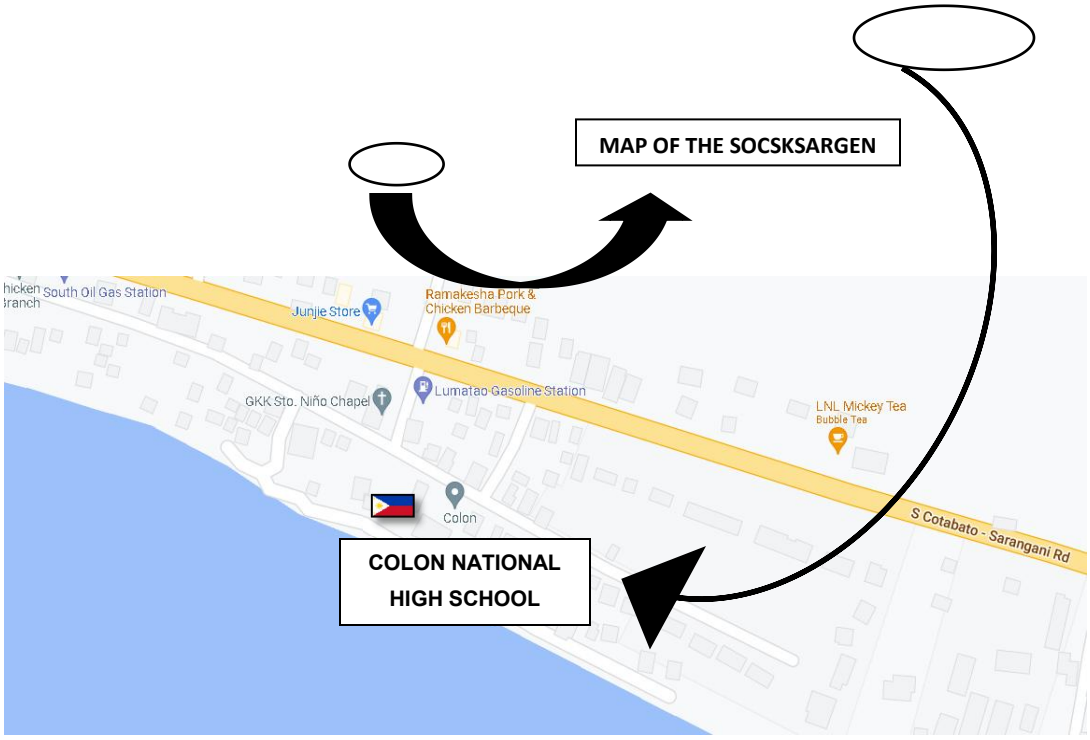


Figure 3.1 Map of the Locale

Duration of the Study

This study was completed in six *(6)* months. The tables below and on the next page show the specific time frame for each accomplished task.

Table 3.1 Duration: Timetable of the Study

DAY	INCLUSIVE DATE	TASK TO BE DONE	PLACE OF DOING THE TASK	REMARKS
1	October 07, 2022	Purchasing an Orange Pi One Chip and SD	Brgy. Poblacion Maasim,	Accomplished

		card for testing practice.	Sarangani Province	
2	October 08, 2022	First trial of programming and installing.	San Juan, Brgy. Kablacan, Maasim, Sarangani Province	Unaccomplished
3	October 09, 2022	Second trial of programming and installing.	San Juan, Brgy. Kablacan, Maasim, Sarangani Province	Unaccomplished
4	October 31, 2022	Ordering Orange Pi One Chip cases on *Shopee*.	Bo. Site, Brgy. Colon, Maasim, Sarangani Province	Accomplished
5	November 08, 2022	Assembling Orange Pi One Chip cases.	Colon National High School	Accomplished
6	November 23, 2022	Purchasing some of the materials online.	Bo. Site, Brgy. Colon, Maasim, Sarangani Province	Accomplished

Table 3.2 Duration: Continuation of the Timetable of the Study

DAY	INCLUSIVE DATE	TASK TO BE DONE	PLACE OF DOING THE TASK	REMARKS
7	December 03, 2022	Purchasing the rest of the materials.	General Santos City	Accomplished
8	December 09, 2022	Third Trial of Programming and installing.	San Juan, Brgy. Kablacan, Maasim, Sarangani Province	Accomplished
9	December 22,	Putting Heat Sink on	San Juan, Brgy. Kablacan, Maasim,	Accomplished

	2022	Orange Pi One Chip and testing its Durability.	Sarangani Province	
10	March 11-12, 2023	Testing the Functionality of the Reused Orange Pi One Chip	Around Brgy. Colon and Brgy. Poblacion, Maasim, Sarangani	Accomplished
11	March 23, 2023	Testing the Effectiveness of the Reused Orange Pi One Chip	Colon National High School	Accomplished
12	March 25, 2023	Testing the Durability of the Reused Orange Pi One Chip	Bo. Site, Brgy. Colon, Maasim, Sarangani Province	Accomplished

Materials, Tools, Equipment, and Paraphernalia

The researchers used the following materials, tools, equipment, and paraphernalia needed in the installation process.

Table 3.3 Materials Used

ORANGE PI ONE CHIP	MICRO SD CARD
 ORANGE PI ONCE CHIP CASE	 HEAT SINK
 CPU MINI FAN	 SCREW AND BOLTS

Orange Pi One Chip was the main material reused as a casting device that allows digital television to function as an Android or smart television. A *16*GB microSD card was also used in writing the image process. This is a smaller version of the Secure Digital (SD) card used in small portable electronic devices. The researchers inserted the microSD card into the SD card slot using an adapter.

Moreover, the Orange Pi One Chip case serves as the house of the Orange Pi One Chip. It protects the Orange Pi One Chip from damage, and the CPU mini fan was attached to this case. Also, the CPU mini fan was used to pull and blow hot air off the Orange Pi One Chip and help keep it cooler to last longer. It expels warm air from within and moves air across a heat sink to

cool the Orange Pi One Chip. The heat sink is an accessory that directs heat away from the Orange Pi One Chip. Screws and bolts help to attach the Orange Pi One Chip and the CPU mini fan to the case.

Table 3.4 Tools Used

 **MICRO SD CARD ADAPTER**	 **HDMI CABLE**
 **KEYBOARD**	 **MOUSE**

MicroSD card adapter houses the microSD card and allows researchers to insert it into SD card slots. The adapter works as a medium to transfer data between the microSD and the device with the SD card slot. The system H*3*Droid was downloaded from the researchers' laptops. To transfer the system, the researchers used a microSD card with the help of its adapter. The researchers used an HDMI cable, mouse, and keyboard to start the installation process.

Additionally, the HDMI cable connects the digital televisions to the Orange Pi One Chip. The keyboard was used to enter the needed numbers in the installation process. The mouse controls a cursor in a GUI or Graphical

User Interface on the installed Android television for pointing, moving, and selecting text, icons, files, and folders.

Table 3.5 Other Tools Used

 **WIFI ROUTER**	 **ETHERNET CABLE**
 **ORANGE PI ONE CHIP CABLE**	 **CHARGER ADAPTER**

The WIFI router was used for the internet connection to download applications and surf the internet. The Ethernet cable was connected to the Wi-Fi router or modem to the internet entry port. It provides an internet connection and connects devices to a local network. An Orange Pi One Chip cable is plugged into the Orange Pi One Chip to power. The adapter is connected to the Orange Pi One Chip cable for it to plug in on an outlet and to function.

Table 3.6 Continuation of Other Tools Used

	
USB *3.0* HUB	**SCREWDRIVER**

The USB *3.0* hub was inserted into the USB female port of the Orange Pi One Chip. It was an extension lead for USB devices. It was plugged into the computer, letting researchers connect more devices than their existing USB ports. The screwdriver was used to tighten and loosen the screws and bolts in Orange Pi One Chip.

Table 3.7 Equipment Used

	
LAPTOP	**DIGITAL TELEVISION**

The laptop was used to download the latest version of the H*3*ii SD card image and to format the unnecessary files on a *16*GB MicroSD Card. At the same time, the digital television was used in the installation process using Orange Pi One Chip.

Table 3.8 Paraphernalia Used

	
ANTI-RADIATION GLASSES	**ANTI-STATIC GLOVES**

Also, before the installation process started, the researchers followed the protocol of wearing protective gear. Anti-Radiation glasses were used to protect the researchers' eyes upon executing the installation process. Anti-Static gloves were used greatly for handling and assembling electronics, as static charges could damage sensitive parts in the OPOC.

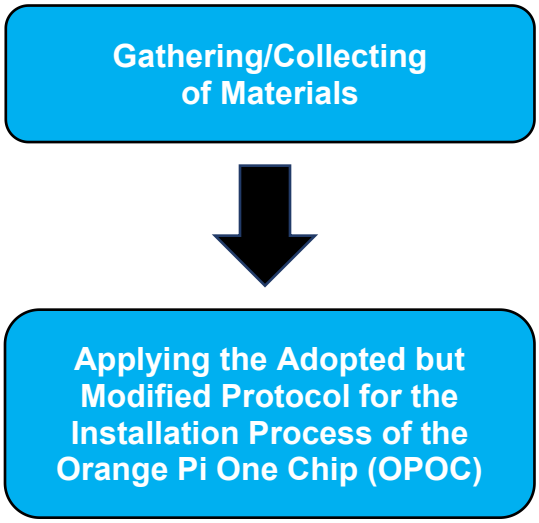
Procedures

A. Applying the Adopted but Modified Protocol for the Installation Process

First, the researchers downloaded the latest H*3*ii SD card image from *h3droid.com*. Second, they decompressed the downloaded image using a decompression tool named *WinRAR* which needed around *260* megabits free. Third, using the writing tool *Win32DiskImager*, the researchers wrote the image. Fourth, they booted the H*3* device after inserting the MicroSD

card, and it went through an automated installation process, where they expected to see a bunch of text on the screen; as it went through the installation process with a maximum of *5* minutes, and then, once the installation was completed, the laptop automatically restarted. Fourth, among the choices listed, they chose and typed *21* that indicated *switch uboot*. Fifth, after that, it displayed the different types of Orange Pi Chip, and specifically, they chose *14* (*uboots/u-boot-sunxi-with-spl.bin-orangepi_one*) and pressed enter. It immediately went back to the main menu where the installation process started, and they typed *22* (*switch fex*) and pressed enter. Sixth, they typed *10* (*H3/orangepione.bin*) and pressed enter. This led them to the main menu. Seventh, they typed *99* (*select OS and reboot*) and chose and typed *1* (*h3roid*). It rebooted for *10* seconds. And lastly, the cat icon appeared that lasted for about three minutes.

Figure *3.2* on the next page shows the procedure flow chart.



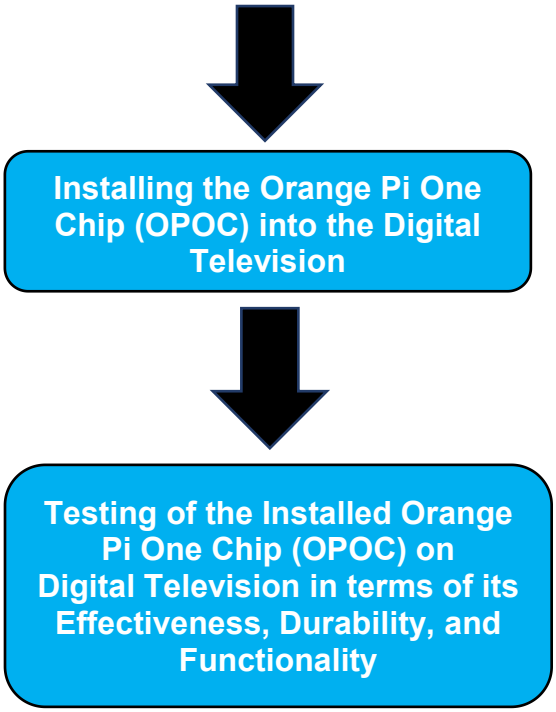


Figure 3.2 The Procedure Flow Chart

B. Installing the Orange Pi One Chip into the Digital Television

In installing the Orange Pi One Chip into the digital television, the researchers connected the Orange Pi One Chip to the digital television using an HDMI cable cord. Then, they attached the following to the Orange Pi One Chip: a microSD card where the downloaded image was stored, the Ethernet cable for internet connection, and the USB *3.0* hub for the other devices, just as the keyboard, mouse, and other devices.

C. Testing the Installed Orange Pi One Chip on A Digital Television

In testing the installed Orange Pi One Chip on digital television, the researchers executed a series of trials, observations, and evaluations to assess its effectiveness, durability, and functionality. The effectiveness of the OPOC was determined by performing three *(3)* trial-and-error schemes where indicators of whether the features of OPOC were effectively working. On the other hand, in testing its durability, the selected households and IT experts and researchers observed the temperature of the installed Orange Pi One Chip with and without the CPU mini fan and heat sink for comparative analysis. Lastly, the functionality of the OPOC was confirmed by the selected households and IT experts by answering the survey questionnaire that included indicators of whether the Android television, with the help of installed OPOC, demonstrated similar functions to a smart television, like connecting to the internet to download applications, access any social media platforms, listen to music, and watch shows.

The researchers made the survey questionnaire which the experts validated. A questionnaire often solicits respondents' opinions about a particular topic or issue (Ben-Shlomo, Brookes, & Hickman, 2019). This study's close-ended questions included all possible answers or prewritten response categories. Respondents were asked to choose their answers among the options. This type of question was used to generate statistics in quantitative research. Also, because these followed a set format, most responses could be entered easily into a computer for easy analysis (Dawson, 2016).

This study's English survey questionnaire used dichotomous variables/choices (YES or NO). In interpreting the responses, Ebel's Criteria were utilized, as shown in Table *3.9-3.10* below:

Table 3.9 Interpretation of the Effectiveness of the OPOC

PERCENTAGE	INTERPRETATION OF THE FUNCTIONALITY OF OPOC
86-100	Very Highly Effective *(All the indicators are evident.)*
71-85	Highly Effective *(There were 1-2 indicators that were not evident.)*
40-70	Moderately Effective *(Three of the indicators were not evident.)*
15-39	Less Effective *(Four indicators were not evident.)*
0-14	Least Effective *(All five indicators were not evident.)*

Table 3.10 Interpretation of the Functionality of the OPOC

PERCENTAGE	INTERPRETATION OF THE FUNCTIONALITY OF OPOC
86-100	Very Highly Functional *(All the indicators are evident.)*
71-85	Highly Functional *(There were 1-4 indicators that were not evident.)*
40-70	Moderately Functional *(Five to eight indicators were not evident.)*
15-39	Less Functional *(Nine to twelve indicators were not evident.)*
0-14	Least Functional *(More than twelve indicators were not evident.)*

Variables of the Study

The study's independent variable is the installed Orange Pi One Chip (OPOC) as a casting device that allows digital television to function as an Android or smart television. In contrast, the study's dependent variables are the effectiveness, durability, and functionality of the installed Orange Pi One Chip (OPOC).

Statistical Analysis

Average and Percentage Mean were used to determine the effectiveness, durability, and functionality of the Orange Pi One Chip as a casting device.

Chapter 4
RESULTS AND DISCUSSIONS

This chapter discusses how data are presented, analyzed, and interpreted. The findings are shown in the following tables, organized following the goals and sub-problems in Chapter *1*.

Installing Orange Pi One Chip as a Casting Device

First, the researchers downloaded the latest H*3*ii SD card image from *h3droid.com*. Second, they decompressed the downloaded image using a decompression tool named *WinRAR* which needed around *260* megabits free. Third, using the writing tool *Win32DiskImager*, the researchers wrote the image. Fourth, they booted the H*3* device after inserting the MicroSD card, and it went through an automated installation process, where they expected to see a bunch of text on the screen; as it went through the installation process with a maximum of *5* minutes, and then, once the installation was completed, the laptop automatically restarted.

Fourth, among the choices listed, they chose and typed *21* that indicated *switch uboot*. Fifth, after that, it displayed the different types of Orange Pi Chip, and specifically, they chose *14* (*uboots/u-boot-sunxi-with-spl.bin-orangepi_one*) and pressed enter. It immediately went back to the main menu where the installation process started, and they typed *22* (*switch fex*) and pressed enter. Sixth, they typed *10* (*H3/orangepione.bin*) and pressed enter. This led them to the main menu. Seventh, they typed *99* (*select OS and reboot*) and chose and typed *1* (*h3droid*). It rebooted for *10* seconds. And lastly, the cat icon appeared that lasted for about three minutes.

Effectiveness of the Orange Pi One Chip (OPOC)
As a Casting Device

This study had undergone the effectiveness testing of the insta Orange Pi One Chip as a casting device. This testing was done in three trial-and-error schemes and evaluated by the selected households in Maasim and

the selected IT experts. The results of the effectiveness testing are shown in Table *4.1* below.

Table 4.1 Effectiveness of Orange Pi One Chip as A Casting Device

INDICATORS	% OF YES	DESCRIPTION & INTERPRETATION
The Orange Pi One Chip (OPOC) shows a red or yellow light, indicating it works.	100	Very Highly Effective
A bunch of texts appeared that were needed in the installation process.	100	Very Highly Effective
WLAN cable and Wi-Fi router are working when connected to the Orange Pi One Chip (OPOC).	100	Very Highly Effective
The SD card with the downloaded image in the installed Orange Pi One Chip (OPOC) works.	100	Very Highly Effective
HDMI, mouse, keyboard, USB Hub, and SD Card plugged into the Orange Pi One Chip (OPOC) work.	100	Very Highly Effective
Mean	**100**	**Very Highly Effective** ***(All the indicators are evident.)***

Ebel's Criteria: (86-100) Very Highly Effective (71-85) Highly Effective (40-70) Moderately Effective (15-39) Less Effective (0-14) Least Effective

Table *4.1* shows that the installed Orange Pi One Chip (OPOC) casting device that allows a digital television to function as an Android or smart television is **very highly effective,** as evidenced by the mean of *100* (x=*100*). Meaning that all the indicators, i.e., The Orange Pi One Chip (OPOC) shows a red or yellow light, indicating it works; a bunch of texts appeared that were needed in the installation process; the WLAN cable and Wi-Fi router are working when connected to the Orange Pi One Chip (OPOC);

the SD card with the downloaded image in the installed Orange Pi One Chip (OPOC) works, and the HDMI, mouse, keyboard, USB Hub, and SD Card plugged into the Orange Pi One Chip (OPOC) work, are evident as tested and evaluated by the selected households and IT experts.

Indeed, the installed Orange Pi One Chip (OPOC) is very highly effective as tested and evaluated by the selected households and IT experts.

Implications

The results suggest that the researchers successfully reused and installed the Orange Pi One Chip (OPOC) as a casting device that allows a digital television to function as an Android or smart television since it demonstrated all the required indicators that signify successful and complete installation. These results are supported by List (2022), who averred that the Orange Pi One Chip emits a red or yellow light. The red light means the Orange Pi One Chip is still processing, and the yellow light means the process is done. The SD Card with the downloaded image in the Orange Pi One Chip, needed for the installation process, is working effectively. The Orange Pi One Chip displays some text without errors during installation. Moreover, when plugged into the Orange Pi One Chip, the WLAN cable and Wi-Fi router, the HDMI, mouse, keyboard, USB hub, and SD Card are successfully working. Indeed, the Orange Pi One Chipboard has all the typical TV inputs, Ethernet, and a few extra USB ports tucked away in the Wi-Fi interface.

Durability of the Orange Pi One Chip (OPOC)

As a Casting Device

This study had also undergone the durability testing of the installed Orange Pi One Chip as a casting device. Two setups were used for

comparison, i.e., OPOC without CPU Mini Fan and Heat Sink and OPOC with CPU Mini Fan and Heat Sink at a room temperature of *36.20*°C as the basis. The researchers, the selected households in Maasim, and IT experts observed and recorded the temperature results of four trials conducted using the Infrared Thermal Gun Scanner. The results of the durability testing are shown in Table *4.2* below.

Table 4.2 Durability of the Orange Pi One Chip as A Casting Device

VARIABLES COMPARED	TRIALS				AVERAGE
	1st Hour	2nd Hour	3rd Hour	4th Hour	
OPOC without CPU Mini Fan and Heat Sink	50.90°C	52.70°C	56.00°C	59.70°C	**54.83°C**
OPOC with CPU Mini Fan and Heat Sink	36.60°C	36.70°C	36.80°C	36.90°C	**36.75°C**

It could be gleaned from the table above the durability test results done with the two variables or setups being compared, i.e., OPOC without CPU mini fan and heat sink and OPOC with CPU mini fan and heat sink. It is noticeable that the former produced an average heat temperature of *36.75*°C - quite above the room temperature of *36.20*°C set as the basis, compared to the latter, which generated an average temperature of *54.83*°C, signifying a higher temperature than the room temperature.

Specifically, the Orange Pi One Chip that is not yet installed in digital television, without the CPU mini fan and heat sink, has a room temperature of *36.20*°C. In the first hour, while testing Orange Pi One Chip's temperature, it increased to *50.90*°C. Indicating a *14.70*°C was added only by using the installed Orange Pi One Chip in digital television for the first hour. In the second hour, the temperature reached *52.70*°C. Followed by the third hour,

the temperature reached *56.00*°C. And finally, in the fourth hour of testing, the Orange Pi One Chip's temperature increased to *59.70*°C.

On the other hand, the Orange Pi One Chip that is not yet installed in digital television, with the CPU mini fan and a heat sink, also has a room temperature of *36.20*°C. The temperature of the Orange Pi One Chip attached to the CPU mini fan and heat sink had increased to *36.60*°C. Adding only *0.40*°C in the first hour. In the second hour, the temperature reached *36.70*°C. Along with the third and fourth hour, it reached *36.80*°C and *36.90*°C, respectively. Thus, adding only *0.10*°C every hour.

Indeed, the OPOC with CPU Mini Fan and Heat Sink created by the researchers is durable, compared to an OPOC without CPU Mini Fan and Heat Sink, for it could last four hours without heating issues.

Furthermore, during the testing, the researchers, the households, and IT experts observed that if the Android television (Cast by OPOC) is used continuously, for instance, watching videos on YouTube, the temperature will go up high. Whereas, if the Android television is used for scrolling on any social media, the temperature increases by a minimal gain.

Implications

The results mean that the researchers successfully created a durable OPOC with a CPU Mini Fan and Heat Sink since it could last four hours. Having a durable casting device like the reused OPOC made by researchers solves the heating issues regarding Orange Pi One Chip (OPOC) and the system that can be shut down if all the cores are used or when the system is used to its maximum capacity. Cores may become locked if the system is not shut down when the heating occurs (Pedamkar, 2022).

Further, Orange Pi One Chip is powered by an *Allwinner* H*3* quad-core CPU. At the same time, utilizing this board without a CPU heat sink will result in overheating and may cause the board to fail. Use a *15*x*15*mm heat

sink made of aluminum or copper. Another issue is that the CPU frequency and voltage settings in most operating systems available for the Orange Pi One Chip are set to the highest feasible values, which can be deemed overclocked (orangepione, 2016).

Functionality of the Orange Pi One Chip (OPOC)

As a Casting Device

The Orange Pi Once Chip as a casting device was also subjected to its functionality. By distributing a survey questionnaire to the selected households in Maasim, and IT experts, their evaluation results were gathered and presented in Table *4.3* on the next page.

Table 4.3 Functionality of Orange Pi One Chip as A Casting Device

INDICATORS	% OF YES	DESCRIPTION & INTERPRETATION
Does the OPOC, as a casting	100	Very Highly Functional

device, function when HDMI Cable is connected to the television?		
Does the OPOC, as a casting device, use an all-in-one remote?	0	Least Functional
Does the OPOC, as a casting device, have a virtual cursor?	100	Very Highly Functional
Can the OPOC, as a casting device, connect directly to the Wi-Fi network or via an Ethernet cable?	100	Very Highly Functional
Can the OPOC, as a casting device, access Google Play Store?	100	Very Highly Functional
Can the OPOC, as a casting device, browse the Internet Web?	100	Very Highly Functional
Can you watch videos on YouTube using OPOC as a casting device?	100	Very Highly Functional
Can you access Netflix using OPOC as a casting device?	0	Least Functional
Can you play music through Spotify or any music player using OPOC as a casting device?	100	Very Highly Functional
Can you access any social media platforms (Facebook, Twitter, TikTok, etc.) using OPOC as a casting device?	100	Very Highly Functional
Can you play online and offline games using OPOC as a casting device?	100	Very Highly Functional
Can you synchronize OPOC as a casting device with other devices?	0	Least Functional
Can you use voice control using OPOC as a casting device?	0	Least Functional
Can you create photo slideshows using OPOC as a casting device?	100	Very Highly Functional
Can you connect OPOC, as a casting device, to Bluetooth?	0	Least Functional
Mean	**66.67**	**Moderately Functional** ***(Five to eight indicators were not evident.)***

Ebel's Criteria: (86-100) Very Highly Functional (71-85) Highly Functional (40-70) Moderately Functional (15-39) Less Functional (0-14) Least Functional

It could be construed from the given results in Table *4.3* that the respondents evaluated the functionality of the Orange Pi One Chip (OPOC) to be **moderately functional**, as demonstrated by the mean of *66.67*

(x=*66.67*), which can be interpreted as five to eight indicators were not evident during the testing of the OPOC as a casting device that allows digital television to function as an Android or smart television. Significantly, it is remarkable that indicators such as its functionality to use an all-in-one remote for OPOC as a casting device, to access Netflix using OPOC, to synchronize OPOC with other devices, to use voice control using OPOC, and to connect OPOC to Bluetooth were not evident as proven by the mean of *0.00* (x=*0.00*) across these five indicators, interpreted as least functional.

On the contrary, Orange Pi One Chip (OPOC) as a casting device is very highly functional when HDMI Cable is connected to the television, when it has a virtual cursor, when it connects directly to the Wi-Fi network or via an Ethernet cable, when it accesses Google Play Store, when it browses the Internet Web, when the user can watch videos on YouTube , when the user can play music through Spotify or any music player, when the user can access any social media platforms (Facebook, Twitter, TikTok, etc.), when the user can play online and offline games, and when the user create photo slideshows as evidenced by the mean of *100* (x=*100.00*) in all ten indicators.

In sum, the respondents evaluated the Orange Pi One Chip (OPOC) as a casting device to be moderately functional.

Implications

As a casting device, it implies that the Orange Pi One Chip (OPOC) performs most functions that an Android or smart television can perform. Although there are a few features that the OPOC could not achieve, these are its limitations and need further investigations and mechanisms to address these gaps. Indeed, Single Board Computer (SBC) such as Orange Pi One Chip is built on a single circuit board. Ideal for applications like gaming, media streaming, and even light-duty web browsing and email. Moreover,

Single Board Computers have expansion slots allowing additional I/O or storage devices (KI, 2023).

Chapter 5
SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter deals with a summary of findings, conclusions, and recommendations.

Summary of Findings

The digital television successfully performed like an Android or smart television by installing an Orange Pi One Chip (OPOC) as a casting device. It was successfully done using Version *4.4* of the Android operating system, which can be downloaded from the H*3*Droid website. Also, an adopted but modified protocol from Chambers (2022) was utilized in installing Orange Pi One Chip (OPOC). Further, the Orange Pi One Chip (OPOC) has an SD Card containing the downloaded version. The HDMI, Ethernet cable, USB hub, mouse, and keyboard attached to it encompassed the installation requirements and process, allowing the digital television to function as an Android or smart television.

To ensure the effectiveness, durability, and functionality of the OPOC, various testing was conducted and observed by the researchers, selected households in Maasim, Sarangani Province, and IT experts who shared their evaluation of the testing made. With respect to its effectiveness, OPOC **is very highly effective**, as evidenced by the mean of *100* (x=*100*), which means that all the indicators observed for the effective installation of OPOC were evident.

Moreover, concerning its durability, it could be understood that OPOC with CPU mini fan and heat sink produced an average heat temperature of *36.75*^{o}C - quite above the room temperature of *36.20*^{o}C set as the basis, compared to the OPOC without the mini fan and heat sink, which generated an average temperature of *51*^{o}C, signifying a higher temperature than the room temperature. Indeed, the **OPOC with CPU Mini Fan and Heat Sink** created by the researchers is **durable**, compared to an OPOC without CPU Mini Fan and Heat Sink, for it could last four hours without heating issues.

Finally, when it comes to its functionality, OPOC as a casting device, is **moderately functional**, as demonstrated by the mean of *66.67* (x=*66.67*), which can be interpreted as five to eight indicators were not evident during the testing of the OPOC as a casting device such as its functionality to use an all-in-one remote for OPOC as a casting device, to access Netflix using OPOC, to synchronize OPOC with other devices, to use voice control using OPOC, and to connect OPOC to Bluetooth were not evident as proven by the mean of *0.00* (x=*0.00*) across these five indicators, interpreted as **least functional**.

Nevertheless, Orange Pi One Chip (OPOC) as a casting device is **very highly functional** when HDMI Cable is connected to the television, when it has a virtual cursor, when it connects directly to the Wi-Fi network or via an Ethernet cable, when it accesses Google Play Store, when it browses the Internet Web, when the user can watch videos on YouTube , when the user can play music through Spotify or any music player, when the user can access any social media platforms (Facebook, Twitter, TikTok, etc.), when the user can play online and offline games, and when the user create photo slideshows as evidenced by the mean of *100* (x=*100.00*) in all ten indicators.

Conclusions

Based on the study's findings, it is concluded that OPOC as a casting device could be successfully installed in digital television to function like an Android or smart television using the adopted but modified protocol from Orange Pi Company. Also, considering the testing undergone by the OPOC as a casting device, the selected respondents and the researchers evaluated it to be very highly effective since all the required indicators for the successful installation of OPOC in digital television were evident. With respect to durability, the OPOC with mini fan and heat sink is durable since it could last four hours without any heating issues, compared to OPOC without the mini

fan and heat sink, which generated a higher average temperature than the room temperature set as the basis. Lastly, regarding its functionality, five indicators were not evident during the testing, which signifies the limitations or gaps of the OPOC as a casting device; hence, the OPOC is only moderately functional. However, concerning the other ten indicators or functions, OPOC demonstrated a very highly functional characteristic.

Recommendations

With the findings and the conclusions, the researchers recommend the following:

1. Future researchers may use a Single Board Computer (SBC) that is capable of connecting to Wi-Fi without using an Ethernet cable, operating using an all-in-one remote, connecting to Bluetooth, using voice controls, and synchronizing other devices;
2. Future researchers may also use other Single Board Computer (SBC) that can install more than *4.4* versions of Android so that additional features and functions can be performed by OPOC as a casting device.
3. Future researchers may provide other suitable and appropriate indicators to measure the effectiveness and functionality of the OPOC.
4. Other ways of testing the durability of the OPOC may be employed to investigate further the strength of OPOC when and while in use. Also, the results of other durability tests may be subject to comparative analysis.