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FACULTY OF ENGINEERING

FINAL REPORT

EPE3016 CAPSTONE PROJECT

EC02 – Near-field Communication (NFC) Home Automation System

TRIMESTER 2 SESSION 2019/2020

Title: Learning Origami for Kids using Near Field Communication Technologies

Group No. : 10

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Declaration of originality:

I declare that all sentences, results and data mentioned in this report are from my own work. All work derived from other authors have been listed in the references. I understand that failure to do this is considered plagiarism and will be penalized.

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ABSTRACT

Colrigami NFC is a project developed to teach children and hobbyist in learning origami with the aid of NFC technology. Origami is a Japanese paper folding art that helps in improving eye-coordination, motor skills and mental concentration of the person who practiced it. However, origami is becoming less popular due to advancement in technology. Nowadays, youngsters are more into digital gaming than involving in something crafty for entertaining themselves. In this project, we develop the solution for preserving the culture of origami and aid learning origami to be more fun and interactive especially in classroom or at home by using current technology. We implemented smartphone, Raspberry Pi, Bluetooth Low Energy (BLE) and Near Field Communication (NFC) technology to develop our prototype of Colrigami NFC.

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List of Abbreviations

3D	Three Dimensional
ALO	Augmented Learning Object
AoA	Activity on Arrow
AoN	Activity on Node
BLE	Bluetooth Low Energy
CAD	Computer-Aided Design
CAMJAL	Context-Aware Mobile Japanese Learning System
CLS	Contextual Learning Activity
CSUL	Computer Supported Ubiquitous Learning
IEEE	The Institute of Electrical and Electronics Engineers
LMS	Learning Management System
LRN	Learn, Research, Network
MMU	Multimedia University
MoLS	Mobiquitous Learning System
NAEYC	The National Association for the Education of Young Children
NFC	Near Field Communication
P2P	Peer to Peer
RFID	Radio Frequency Identification
TV	Television
UI	User Interface

Chapter 1: Introduction

1.1 Introduction

Origami is the Japanese art of paper folding. It literally translates as “ori” (folding) and “gami” (paper). In Japan, children learn origami at their mothers' knees. In the West, children are learning it at school. Research has shown that paper-folding, particularly in the elementary school years, is a unique and valuable addition to the curriculum. Origami is not only fun, but it is also a helpful mechanism for developing vital skills. It is one of the methods of hands-on learning that can be practice for kids in the kindergarten or elementary school. Nowadays, new generations are being raised with technology, and they understand how to interact with it very early in life. Near Field Communication (NFC) is a wireless technology based on RFID that allows storing data to and reading data from small electronics components named NFC tags. NFC allows expanding user interfaces to the environment and permits building bridges between the physical and digital worlds. With NFC technology, we can embed digital content in the environment using NFC tags and easily access them with an NFC enabled smartphones. An NFC smartphone can use the content read from an NFC tag and facilitates embedding applications’ user interfaces in the space around the users. Thus, we make use the advantage of Origami and build interactive application using NFC technology to make educational process more productive for kids.

1.2 Problem statement

Nowadays, kids have limited time for play or doing hands-on activities in classroom. Decades of research show that hands-on learning at preschool is preferred. As misguided politicians, bureaucrats, school administrators, parents, and the public, though, push for more formal academics at earlier ages, it's gotten devalued and minimized. Those knowledgeable about early childhood education understand how valuable it is, but many with decision-making power do not. That is why it is important that the elderly educate themselves on the matter and become advocates for hands-on learning at preschool and, in the process, become champions of young children. Other than that, we also can observe that technology is replacing play at home and at school.

The advancement of technology has contributed on kids having trouble making friends and unable to practice social skills at the fullest. In a study titled “Comparing the Kindergarten Curriculum Framework of the Philippines and Malaysia [1],” one of the key problems with preschools in Malaysia is the teachers have limited training in making lessons more interesting and fun. It is true that in the majority of preschools, teachers only prioritize finishing activity books and worksheets. A once developmentally appropriate hands-on curriculum got overtaken by teacher-led lessons, paper-pencil tasks, and long periods of sitting still and listening. When these escalated activities increase, developmentally appropriate practices decrease. There is simply less time for hands-on learning, unstructured play, socialization, and creative pursuits. The preschool classroom shifts from a child-centered environment to an adult-centered one.

1.3 Motivation and objectives

Academic studies have proven the “right” use of play or hands-on activities multiplies the ability of young children to excel in higher education and social life, not least because they develop the right side of their brains first. Play-based learning raises children’s language skills through conversation and curiosity, supports “pre-literacy” and “pre-numeracy” that rapidly improve their reading, counting and writing abilities. Then, it develops the social and emotional skills imperative to building and maintaining healthy relationships as adults, and turns them into creative problem-solvers. Thus, parents and teachers must realize that when structured around clear objectives, hands-on activities are far more beneficial to the mental and emotional development of young children than memorization or mindlessly filling worksheets. The National Association for the Education of Young Children (NAEYC) [2] - the world's largest organization of early childhood professionals—says a quality early childhood education is one in which “Children are given opportunities to learn and develop through exploration and play...materials and equipment spark children's interest and encourage them to experiment and learn.”

This has allowed us to create a friendly and easy solution for kids, “COLRIGAMI NFC” to learn origami through smartphone or tablet. With the NFC technologies that played a role in the daily life, we also decided to implement it which may able to assist teacher in teaching the origami at kindergarten. One of the objectives of this project is we know that origami is good for kids as it develops eye hand coordination, sequencing skills, spatial skills, memory, and also attention skills. Origami allow kids to develop fine motor skills and mental concentration. All of this combined stimulates the brain – especially when both hands are being used at the same time. COLRIGAMI NFC promotes user friendly, mobiquitous and stationary learning system, that can be implemented in class, to ease the process of teaching and learning.

1.4 Scope of the project

To encourage interactive hands-on activities in children, and bridge the gap between a student and teacher despite the usage of mobile application and devices.

1.5 Overview of report

The overview of this report consists of 6 chapters. The first chapter will include the introduction of our project, the problem statement, motivation and objectives and scope of the project. In the second chapter, we will review of the existing implementation techniques and their advantages or disadvantages. Next, the third chapter will discuss about the details of the design such as the design consideration, design configuration and analysis. Then, the fourth chapter is the presentation of data and discussion and also the analysis on the impact of the project. The fifth chapter will discuss on the project management such as project planning, budget planning and cost analysis. Finally, the sixth chapter is the summary of the work done and also the recommendation for future improvement.

Chapter 2: Review of Literature

2.1 Review of existing implementation techniques

We need to identify 3 literature reviews in this chapter where we will further explain and identify the benefits that occur in the related works as well as the drawbacks. These are required so that our proposed system can address their limitations.

2.1.1 The Implementation of a Context-Aware Mobile Japanese Conversation Learning System Based on NFC-enabled Smartphones

(Chun-Chia Wang, Department of Information Management, Taipei Chengshih University of Science and Technology, 2014)

This paper focused on learning conversation in Japanese as an application domain of Computer Supported Ubiquitous Learning (CSUL), because Japanese conversation is strongly influenced by situations for native speakers of Japanese, e.g. the formality of conversation scenes. The proposed system was called Context-Aware Mobile Japanese conversation Learning system (CAMJAL) [3] to tackle the issues of right time and right place learning in a ubiquitous computing environment. Learners of this system are students of one University in Taiwan, who want to learn Japanese Language. They used NFC-enabled smartphones, and CAMJAL provides the learners the appropriate conversation in the context. The contributions of this study are to describe the applications of NFC-enabled smartphones in the field of Japanese conversation, develop and implement the CAMJAL environment, and consider the initial experimentation of the CAMJAL system as a future work.

Figure 1 - System Architecture of the Context-aware Mobile Learning

A preliminary experiment yielded promising results regarding the acceptance of this novel interaction technology and the usability of the system prototype. Learners could interact with them by touching attached NFC-tags with their mobile devices to download learning materials that teachers assigned in advance. In addition, the interaction between the dynamic NFC-enabled smartphones, the learning materials could be delivered between peers with the P2P functionality. Such a CAMJAL system could also play an interesting role for collaborative learning between multiple learners.

2.1.2 Near Field Communication Mobiquitous Learning System (NFC MoLS)

(Soon Nyean Cheong, Ian Chai, Faculty of Engineering, Multimedia University, Cyberjaya, 2013)

A novel design and development of a Near Field Communication mobiquitous Learning System (NFC MoLS) with the use of photo interface and NFC-enabled smartphone is presented in this paper [4]. The aim of the proposed system is to bridge the gap of cyber-physical spaces by enabling students to learn without imposing undue technological effort and inconvenience, through user-friendly and intuitive touch-driven interaction.

A prototype of the NFC MoLS application was developed using the Android SDK and tested on a Sony Experia NFC-enabled smartphone for students to learn the C programming language on either the smartphone or TV. Intuitively, a student knows that he or she can watch the selected screencast video on the actual TV in the physical world by using the touch-to-connect mechanism. This is achieved by sending the control signals from the smartphone to the media server through WiFi LAN.

NFC mobiquitous learning applications is a great way for children to explore and learn while creating links between the physical and digital world. For instance, Riekki et al. (2013) proposed an English learning application that supports children in learning to recognize words by touching objects using an NFC-enabled smartphone [5]. NFC mobiquitous learning applications also provide a fun and enjoyable learning atmosphere that could elevate a digital learning lifestyle beyond conventional mobile learning [6].

2.1.3 Pervasive Learning Activities for the LMS .LRN through Android Mobile Devices with NFC Support

(Gustavo Ramírez-González, Catalina Córdoba-Paladinez, Omar Sotelo-Torres and Camilo Palacios, Departamento de Ingeniería Telemática, Universidad del Cauca, Colombia, 2012)

This research tells about how the “NFC Contextual Learning” App helps in improving education in school. The app was developed with integration between .LRN platform and Android mobile devices with NFC support to interact with real world objects. The proposal provides an interaction model based on Augmented Learning Object (ALO), Learning Space, Contextual Learning Activity (CLA) and Interaction Scenarios. [4]

A research of this application was done at University of Cauca – Colombia. The teacher was assigned a task to preconfigure the NFC tag that will associates multimedia resources to it. The tag was then placed on an object and around the defined learning space. The student used their NFC enabled smartphone to interact and discover about the objects. The application provide server-side support for the management of augmented learning objects and contextual learning activities on the platform .LRN. They can also see the movement of the students in form of logs. A survey shows that student found the application intuitive and they would like the application to be implemented in their course [7].

As observed in the development of experiences in real learning environments, both students and teachers, are attracted by the mobility and ubiquity enabled devices used. A factor that can directly influence in a student's motivation to carry out learning activities in LMS systems.

2.2 Summary on their advantages/disadvantages

Existing implementation techniques	Year	Advantages	Disadvantages
Context-Aware Mobile Japanese conversation Learning system (CAMJAL)	2014	To download the learning material, the learner just need to touch an NFC tag on the wall with an NFC-enabled smartphone. Thus, making the learning experience more efficient.	CAMJAL can be only practice alone and peer to peer. It does not aimed to be practice in a group of more than two people.
Near Field Communication Mobiquitous Learning System (NFC MoLS)	2013	To bridge the gap of cyber-physical spaces by enabling students to learn without imposing undue technological effort and inconvenience, through user-friendly and intuitive touch-driven interaction.	The wireless computer network used is Wi-Fi LAN. The connection may be disrupted due to unstable connection and hardware breakdown.
Pervasive Learning Activities for the LMS .LRN through Android Mobile Devices with NFC Support	2012	Allow user to interact with real world objects in physical space using NFC enabled smartphone.	Interacting with ALO is only by using NFC enabled smartphone and is limited to a defined space.

Table 1 - Summary of advantages or disadvantages of existing implementation techniques

Chapter 3: Details of the Design

This chapter will describe about our proposed system which includes the design consideration involved, the system architecture, software design and prototype design.

3.1 Design consideration

We aim to make learning origami more fun and interactive for children and hobbyist alike. Before we begin designing our system, there are several design considerations that we need to consider. First, our system must be affordable and cost effective, so teacher or parent does not have to face financial burden to allow their student or children to learn origami. Next, our system should be mobile which can be carried around anywhere and can be learned or taught at any time. Furthermore, our system should be as easy as plug and play so user can start learning or teaching origami immediately without having to go through tutorials to use our system. Lastly, our product must ensure compliance to child safety standard set by the authority to ensure our product is safe for children to use.

3.2 Design configuration and analysis

3.2.1 System Architecture

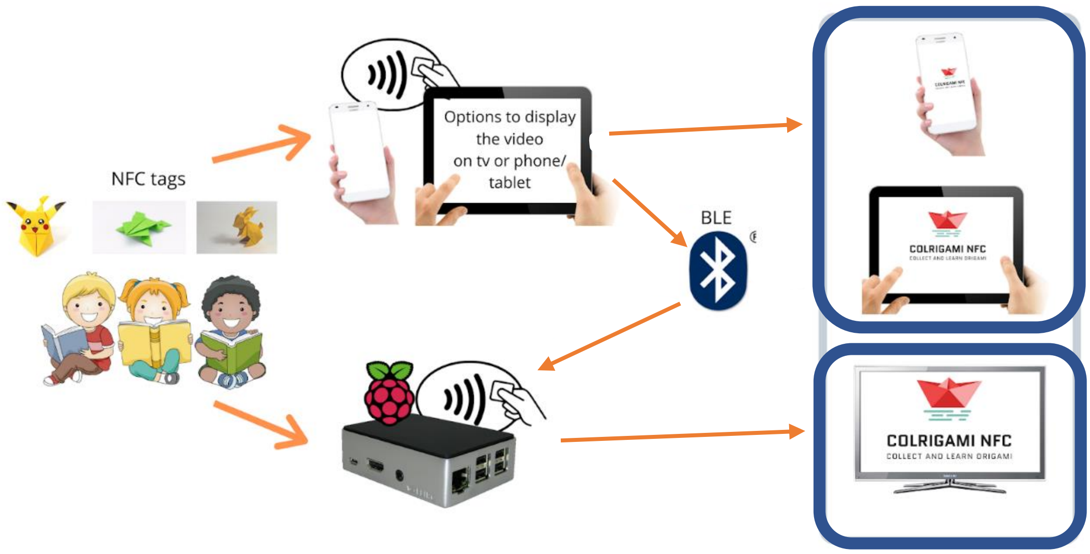


Figure 2 - System Architecture of Colrigami NFC

Colrigami NFC is a project to help teaching and learning origami easier. NFC video control cards and NFC origamis will be provided to teachers and learners to interact with the device. The children can learn origami by using an NFC enabled mobile device and view the origami video steps on their phone or tablet.

Raspberry Pi is designed to be used in class where teacher can place the Raspberry Pi on their desk connected to a display. Video playback control NFC card is given so teacher can control the speed, pause or stop the video. If origami is being taught in a big classroom, the teacher can use our Raspberry Pi device to display the video on the big screen so all student can learn origami together. With the help of mobile application, Teacher can use the mobile device as a remote control which is connected via BLE with the Raspberry Pi. Thus, will allow teacher to be able to move around the class and control the video on the Raspberry Pi remotely while monitoring the students' progress. The Colrigami NFC mobile application is designed for both learners and teachers to learn or teach on the go.

3.2.2 Software System Design

In this project, my role is to develop an Android Application for the Colrigami NFC system.

3.2.2.1 Raspberry Pi

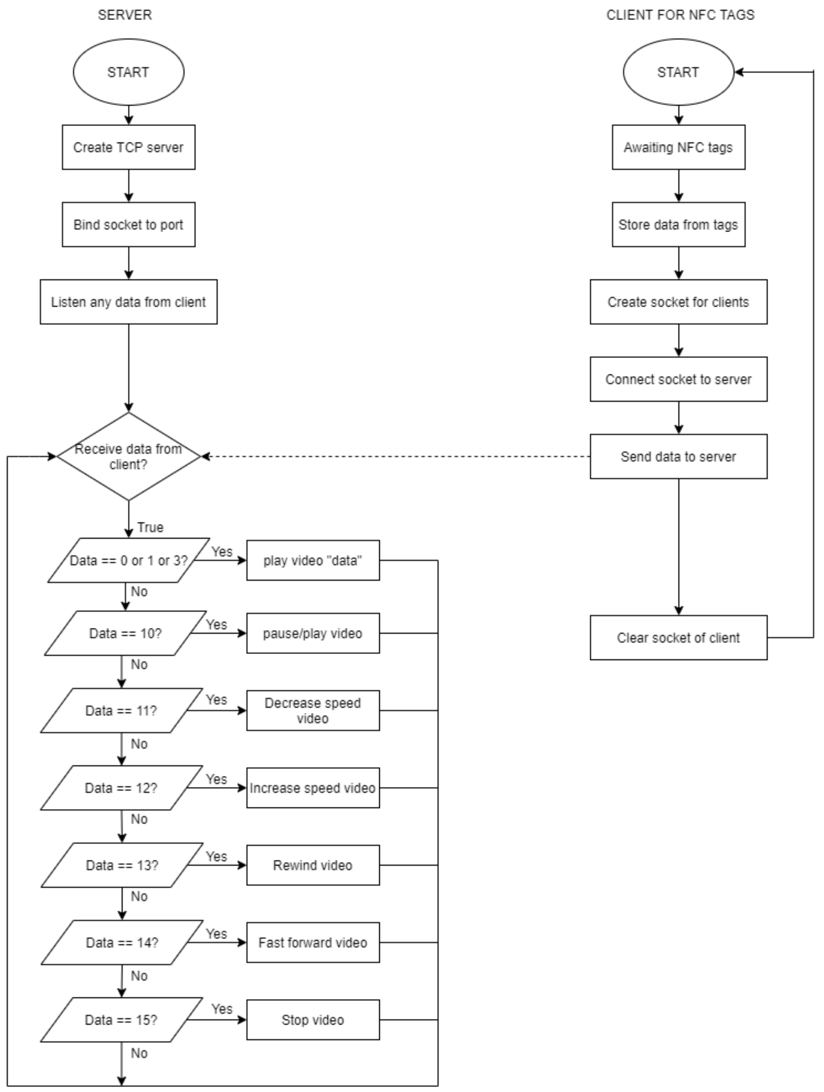


Figure 3 – Colrigami NFC Raspberry Pi Server and NFC Client Flowchart

3.2.2.1 Bluetooth Low Energy (BLE)

These days, almost all devices are going for wireless connection. One of the players in the field of radio modules is Bluetooth Low Energy (BLE), or also called as Bluetooth Smart. BLE is a wireless personal area network technology intended to provide reduced power consumption and cost while maintaining similar communication range as Classic Bluetooth. It uses 2.4 GHz radio frequencies, the same as Classic Bluetooth, and also allows dual mode devices to share a single radio antenna. BLE is a good choice of wireless standard, as the number of product designs that implement BLE has increased rapidly, thanks to the early and active adoption of BLE by mobile industry big leaguers such as Apple and Samsung which breakthrough wider adoption of BLE in mobile devices.

In Colrigami NFC, we used BLE to connect Raspberry Pi and the mobile devices. We use Generic Attribute Profile (GATT), a general specification for sending and receiving short pieces of data known as attributes over a BLE link. In order to construct a GATT service, a GATT characteristic is used, whereas a basic data element is sent. In this project, every NFC tag is specified with a number which acts as the data element. Then, a GATT service is performed using the collected GATT characteristics which operate to play and control the tutorial videos. Raspberry Pi plays the peripheral role which broadcasts BLE advertisement so that a connection can be made. This is done by using Bleno. Ble.js module is used to implement BLE into Raspberry Pi and the programming language used is JavaScript. Next, a mobile device which plays the central role then scans for these advertisements and connect.

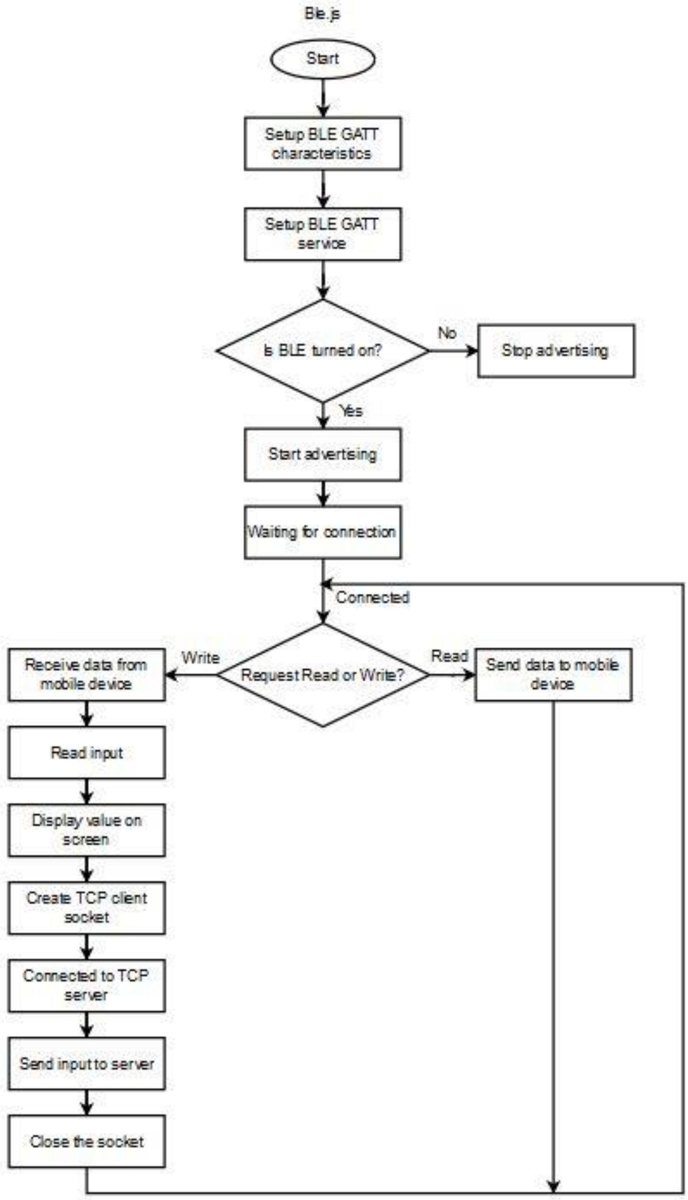


Figure 4 – Colrigami NFC Raspberry Pi BLE Client Flowchart

Above figure describes the flowchart of a Raspberry Pi BLE. As shown above, using Bleno, first we setup BLE GATT characteristics, which can handle Read or Write request. And then, we setup GATT service, which then checks if BLE is on or off. If BLE is on, the Raspberry Pi starts advertising, but if the BLE is off, it stops advertising. As soon as it starts advertising, it waits for a connection and when it is connected, ble,js checks whether the GATT characteristic is a read or write request. If the request is 'write', the Raspberry Pi receives data from the mobile device, reads the input and then displays the value on screen or terminal. A Transmission Control Protocol (TCP) client socket is created to allow the two devices to communicate, and connected to

TCP server. The input is sent to the server, and the socket is closed to save memory. However, if the request is ‘read’, data is sent to the mobile device.

3.2.2.1 Android Application

Most modern smartphone nowadays are equipped with NFC capability and BLE connectivity. But, this technology are rarely used and making them obsolete. Hence, in this project, we make full use of NFC and BLE feature in a smartphone to interact with origami. We choose Android operating system to develop our app because it is widely used smartphone OS with around 85% market share. Furthermore, most Android smartphone are equipped with NFC and BLE feature and due to the nature of open source OS, Android app developer can utilize this feature for their app.

We use Android Studio provided by Google and Android open-source community to develop Colrigami NFC app. Android Studio is the best IDE for Android mobile app development as it is the most table which provide the best in class features and fast way to publish an app. The main programming language used to develop the functions of our app is Java because it is one of the most supported language in Android app development and many of learning resource for developing Android app with Java can be found online. As for the UI, we use XML which is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable.

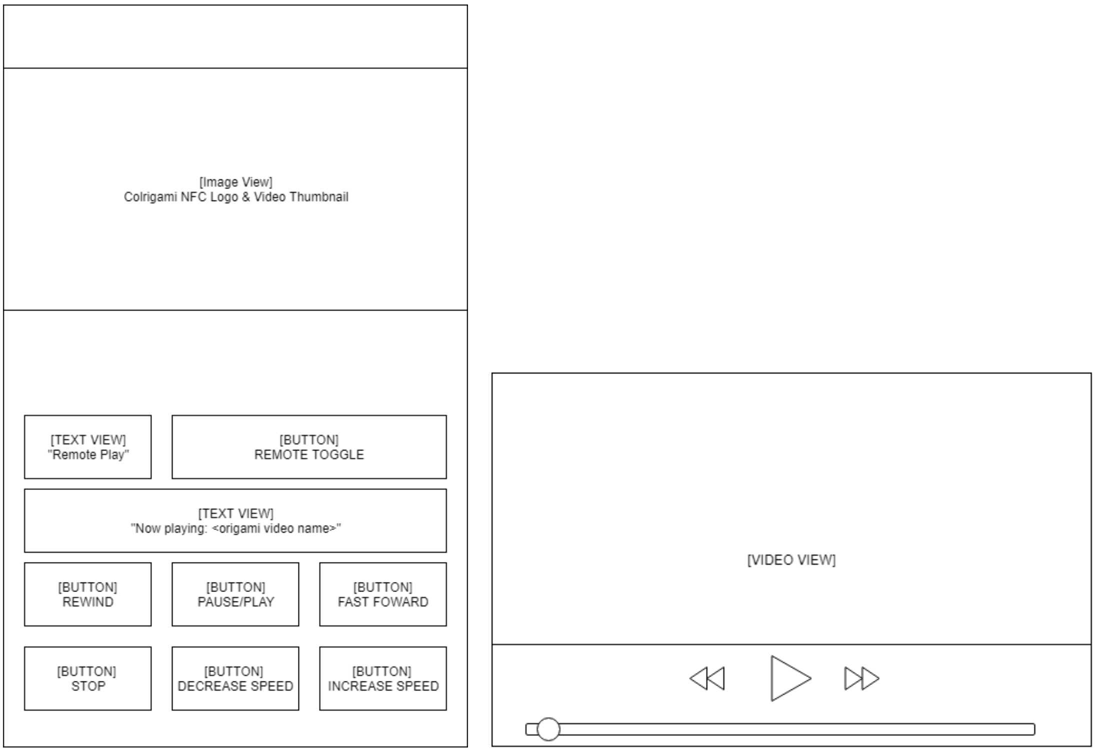


Figure 5 - The proposed user interface of the Android Application

Figure above shows the proposed UI design of the app. We design our Android application as simple as possible with only one-page view where details of the origami video and remote control is packed in one page. This design is proposed to be user friendly as new user does not have to waste time going through tutorial about learning how to use the app.

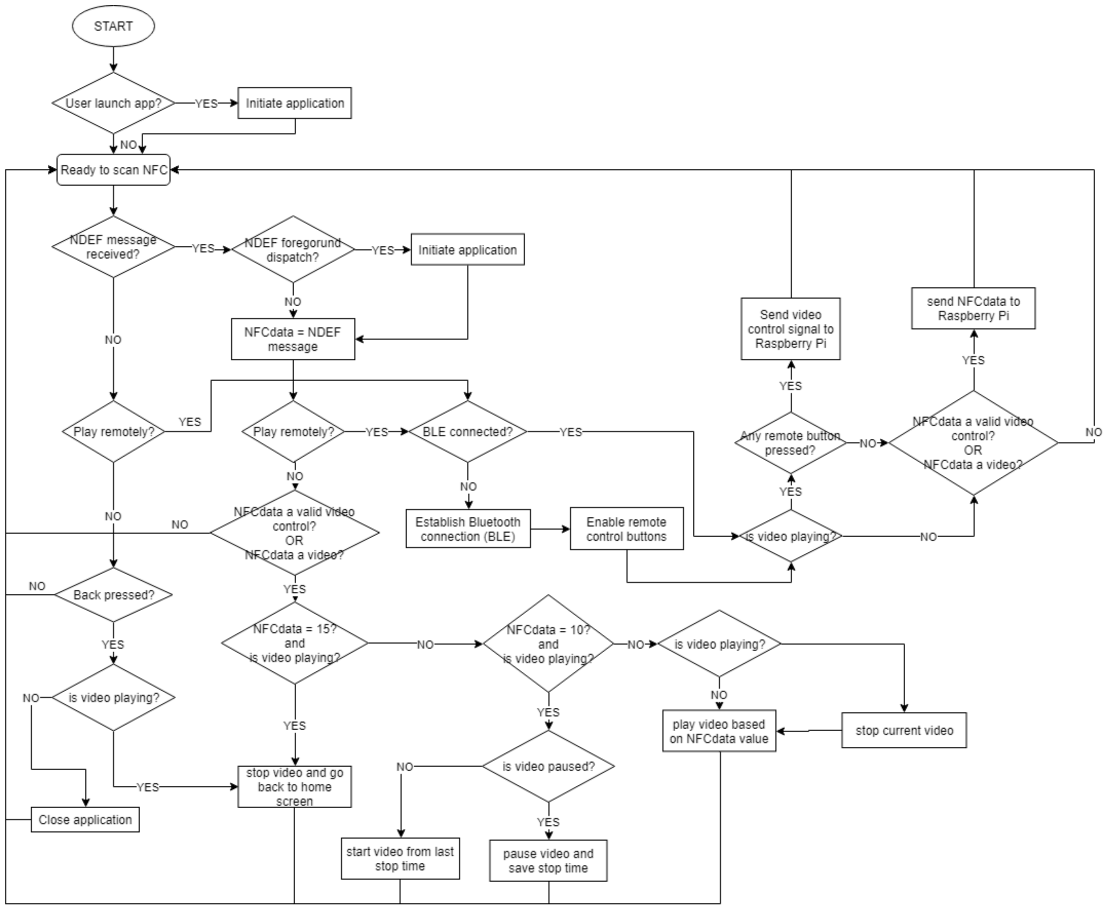


Figure 6 – Colrigami NFC Android Application Flow Chart

From the flowchart above, we can see that the application can be opened by tapping the app icon shown on the smartphone screen or by tapping the NFC tag on the smartphone NFC reader. With the Intent feature provided for developer in Android OS, we hard code our program which make our app as default launcher every time NFC tag is detected while the app is not yet launched. If user scan an NFC tag while the app is in the background or not yet launched, the system will read the NDEF tag and commence foreground dispatch to launch and initiate the Colrigami NFC app and process the NDEF data. If the user already launched the application, they could tap an NFC card and the app will process the NDEF data via background dispatch. While processing the NDEF data, the program will check whether the data contained is a video or a video control. If it is a video, it will immediately play the video. If not, the app simply will not do anything and wait for another NFC tag to be read. When the video is playing, the application will react on the video whether to pause, play or stop depending on the NDEF value stored on the NFC tag when it is tapped. User could also control the origami video using the on screen buttons and slider. To stop the video, they can simply press the back button. If the user is currently on the app homescreen, another back press will exit the application.

There is a toggle for user to remotely play and control the origami video on Raspberry Pi. When the toggle is set for the first time, the application will start the Bluetooth service and establish the BLE connection to the predefined address Raspberry Pi. Once connected, the app will allow user to interact with the Raspberry Pi remotely by tapping the NFC cards on their phone or tapping the remote buttons on their screens. If the user tap an NFC tag on their phone, the phone will immediately send the NDEF data to the Raspberry Pi via BLE and the Raspberry Pi will process the NDEF value for what it should do next. If the user tap an NFC origami video card, the NDEF value will be sent to the Raspberry Pi, and the video will immediately played on the Raspberry Pi display. The user can control the video playback either by using the NFC cards or by tapping the remote buttons on their phone.

3.2.3 Prototype Design

We designed the enclosure for Raspberry Pi and its NFC reader using a beginner friendly CAD software called Autodesk TinkerCAD. We make sure that our design to be minimal and modular so it is easy to be kept and easy to be carried around. There is also a card slot compartment placing the video control NFC cards. We designed the NFC reader to be able to swivel back and forth to allow more user-friendly way to tap the NFC cards or placing NFC origami on the reader.

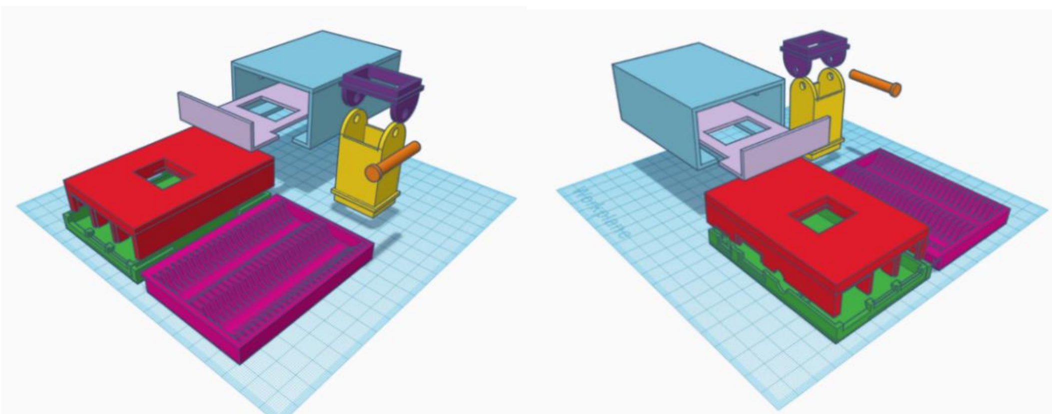


Figure 7 - 3D Design of prototype

The design is then 3D printed using the available 3D printer in MMU. The 3D printing filament chosen was TPU material which is cost-effective, non-toxic and safe for many application. We used Ender-3 Pro 3D printer to print our design. By using Cura Ultimaker software for slicing our 3D design prototype, the estimated time taken to print was about 16 hours and 50 minutes which uses about 116g or 38m of 1.75mm wide TPU filament.

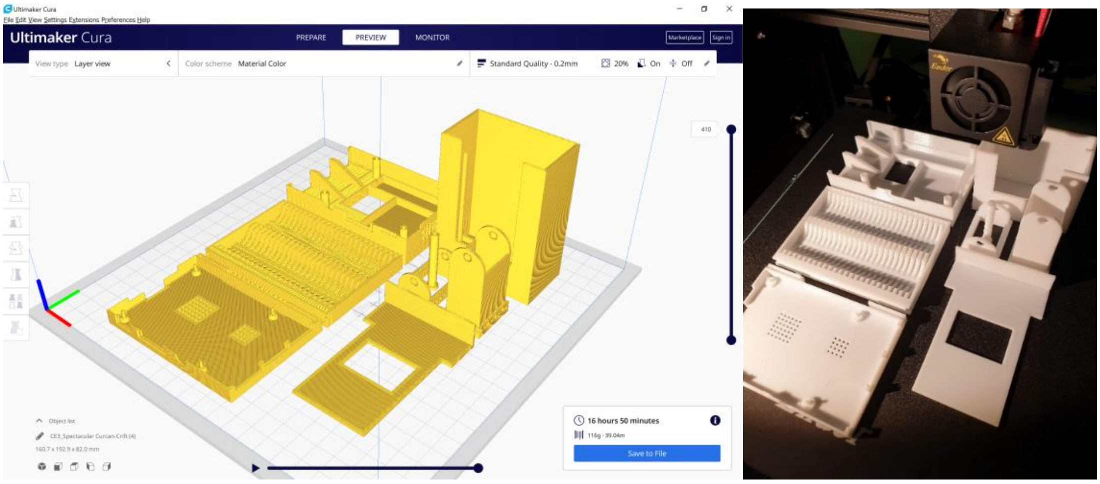


Figure 8 - 3D Printing configuration and printing process

Chapter 4: Presentation of Data and Discussion

This chapter describes the outcome of our developed system and how our system will impact to users.

4.1 Results and Discussion of Implementation

4.1.1 Prototype design

Figure 9 - Finished prototype

Figure above shows the completed prototype. Our prototype consists of cute and attractive storage for the Raspberry Pi, NFC cards and NFC origami. This design will surely attract the young kids to learn origami. It would be very beneficial for teacher to carry it around.

We planted NFC tag at the base of the attractive ready-made origami so kids can choose which origami they want to make at should expect the exact shape of the ready-made origami they have picked. This allow the children to easily analyze what they should expect when they want to build the same origami because they have hands-on of the ready-made origami. We design the video playback control NFC cards with symbols and description of what the card will do. This will allow the kids or computer illiterate user to know what each symbol mean.

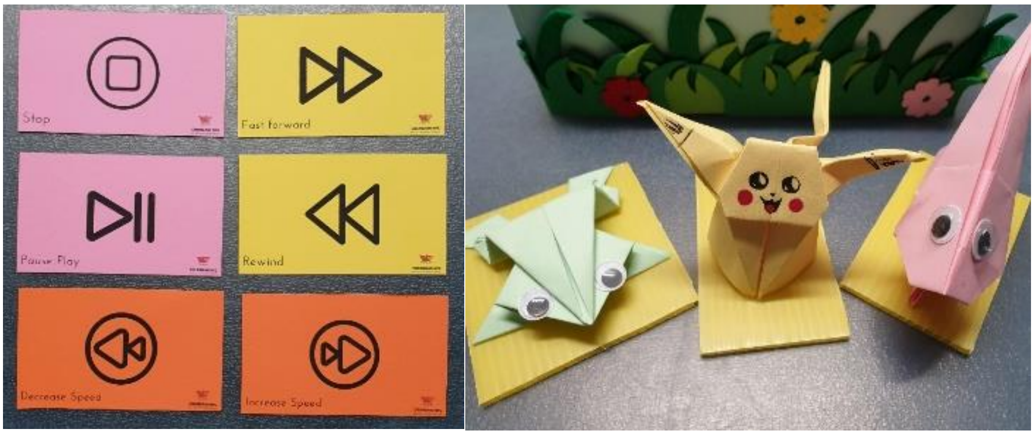


Figure 10 - NFC Cards and NFC Origamis

Furthermore, the 3D printer design of slotted compartment is useful for storing the video playback control NFC cards. It is detachable so it can be placed at different places. The 3D printed compartment for Raspberry Pi and NFC Reader is uniquely design which allow the reader to swivel. This will allow user easily reach the NFC reader for scanning thus reduce the risk of muscle strain if the device is not easy to reach.

4.1.2 Raspberry Pi

4.1.2 Bluetooth Low Energy (BLE) - able to use mobile app and their functions, able to play using app at the monitor and control using Raspberry Pi and NFC tag, one way only

Adopted BLE system has enabled users to interact between Raspberry Pi and mobile devices. In other words, data can be transmitted from mobile device to Raspberry Pi with the integration of BLE. Furthermore, in Colrigami NFC, BLE integration is very important in enabling the usage of remote feature, where tutorial video can be played onto Raspberry Pi display; which should be bigger than a device display and the device will act as a remote instead.

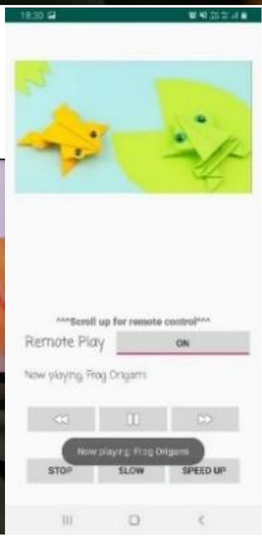
When NFC tags is tapped onto mobile device, a mobile application will pop up and the user can choose to either play the tutorial video on the device itself or to screen it onto the monitor where the Raspberry Pi is connected to. Shall screening onto the monitor is preferred, user just have to turn on the remote feature toggle from the application. The video will be played on the Raspberry Pi display which can be a TV or a screen for the whole class to watch and learn to fold their origamis. This remote feature is useful for teachers as they can control the screen tutorial video on the monitor, either through their phone or tablet while being able to move around and supervise students' work. Whenever a student requests the video to be slowed, paused or rewind, in case the video is too fast for them to catch up, the teachers can just control the video from the application itself by clicking the button functions built in the application or by tapping NFC video function tags onto the mobile device. This way, the mobile device acts as a 'remote control' for the teachers. Except that it is more manageable due to the simple and hassle-free mobile application interface. Easy access to function buttons helps students to be able to learn better on doing hands-on activities, should the video be too fast or slow, or calls for a rewind, the teacher can just simply control the video for them. Therefore, the students, especially children, can learn based on their own speed and capability. Without BLE integration, such remote control is not possible to be executed.

This feature not only ease the teachers in teaching the students and keeping the class under control, but also bridges the gap of between students and teachers in class as students are still required to interact with their teacher in order to get their origamis folded correctly. This shows that the it is possible to bridge the gap between students and teachers in a classroom while still implementing technology.


Pause
00:00:26


Playspeed: 0.250


Play
00:00:26


18:30
^^^Scroll up for remote control^^^
Remote Play
ON
Now playing: Frog Origami
Now playing: Frog Origami
STOP
SLOW
SPEED UP

4.1.2 Android Application

We design our android application as user-friendly as possible, so user does not have to go through steep learning curve to use the app. Every time the user launches our app, they will be greeted with the home screen as shown in the figure on the right. As we can see, the app is a simple one paged view with complete feature of our system. Simple design helps computer illiterate user or kids who are new to smart devices to learn origami at ease.

Figure 11 - Colrigami NFC Android App Home screen

To start learning origami, user need watch an origami tutorial video of their choice by scanning the NFC video tag which is attached at the base of readymade origami. Either the app has already been launched or the app is running in the background or the app is not yet running, by default, the video will be played in the application when the video NFC tag is tapped on the Android device NFC reader.

The figure on the below shows the video view after NFC video tag is scanned. Playback control such as pause, play, fast forward, rewind and slider are available on the screen. Alternatively, user can tap NFC video control card to control the video playback. These video playback functions are crucial to allow learner to learn origami at their own pace and at any time they want. This is because the instruction of the video might be to fast for the learner to follow. So learner has the ability to rewind the video if they miss out any important folding part to make their origami beautiful.

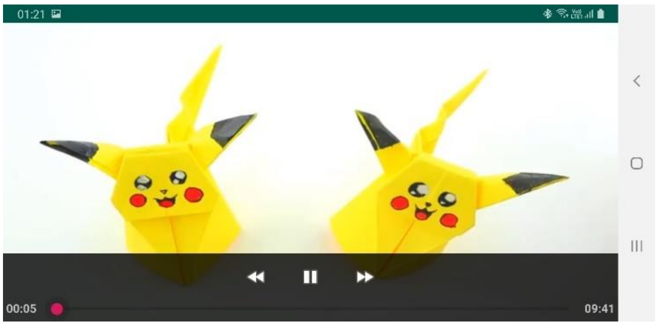


Figure 12 - Colrigami NFC Android App Video View

Remote feature was implemented in the Colrigami NFC application. This feature work by communicating with Raspberry Pi through BLE. The remote feature of this application can be enabled by toggling on the remote play button on located on the home screen of the app. After the remote play function is enabled, user can tap NFC video tag on the phone to play the video remotely on the Raspberry Pi display. This feature is beneficial for classroom use where teacher can hook up the Raspberry Pi to a larger screen such as a projector or a TV for the students to watch.

Figure 13 - Colrigami NFC Android App with Remote Play Enabled

Figure on the left shows the app screen after a video NFC tag is scanned. The Colrigami NFC logo will changed to the origami tutorial video thumbnail and the detail of the video is shown. This is to ensure the right origami tutorial video is played on the Raspberry Pi display.

The remote video playback control buttons can be used to interact with currently playing video on the Raspberry Pi screen. Alternatively, user can use the NFC video control card to do the same. This feature is also beneficial for teacher to move around the class, monitoring their student progress. If the student request the video to be rewind a bit or the teacher want to change to another video, teacher can do it right on his or her android device without having to go to his or her desk where the Raspberry Pi is attached. This allow teacher to be mobile around the class to guide student learning origami. Figure on the left shows remote video playback control buttons in action.

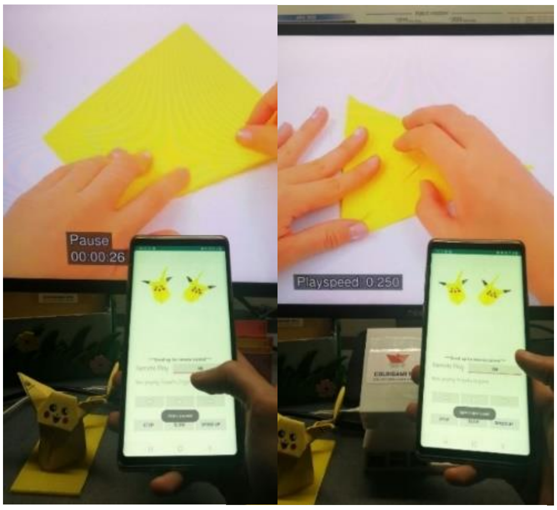


Figure 14 - Colrigami NFC App Remote Play Control button in action

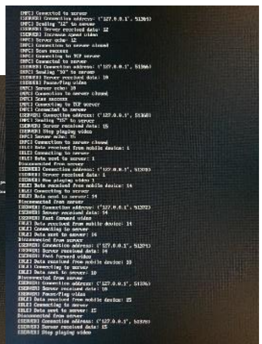
Gallery (Not part of report)

General



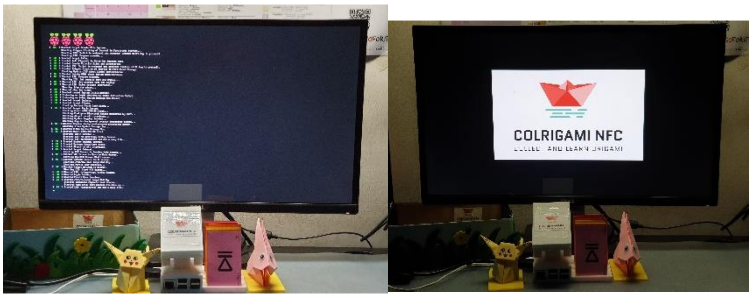
Raspberry Pi & BLE

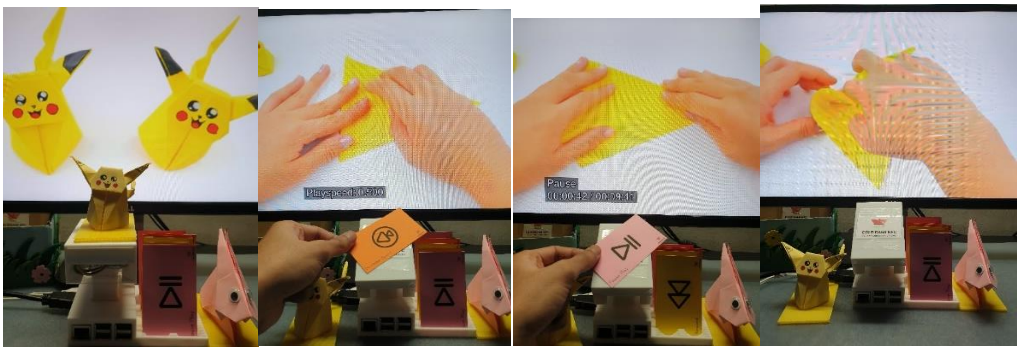
- Terminal

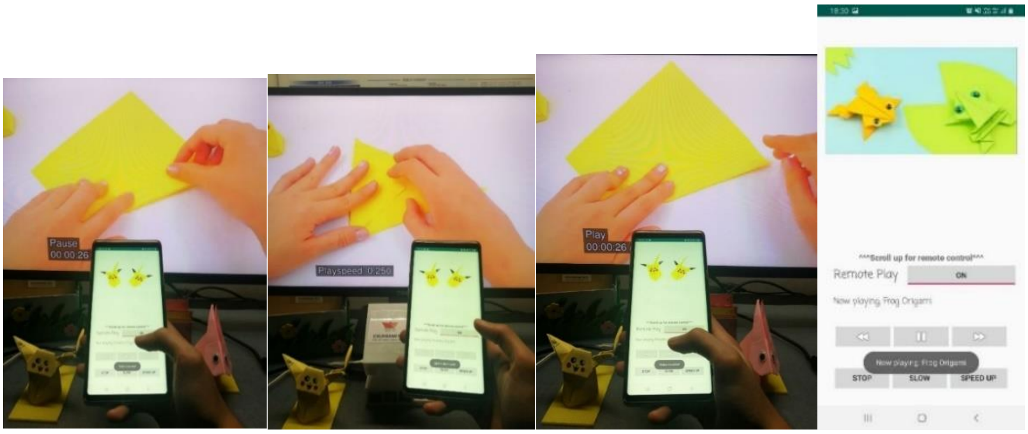
Raspberry Pi

- Raspberry Pi boot up & auto start





Android & BLE



4.2 Analysis on the impact of the project

Our developed prototype is simple and user-friendly to kids and teachers since the application in Raspberry Pi is straight forward and understandable. This is because a system with less complexity gives kids to further use our system. This will encourage kids to do hands-on activity and learn to make origami with Colrigami NFC. Next, students in kindergarten or elementary school can make the origami at their availability of free time with the help of teachers. This will ensure the kids to spend their free time wisely. Other than that, our developed prototype consists of embedded Raspberry Pi that allows the kids to watch the tutorial video via bigger screen. Thus, it will strengthen the bonding and the cooperation between the classmates as they can discuss and help each other to make the origami together. Moreover, Colrigami NFC is cost effective and can be affordable to teachers or parents to buy for the preschoolers. With cheap in price, it will reduce the burden for teachers to find the effective and reasonable price of hands-on activities that they can implement to their student in class.

Chapter 5: Project Management

5.1 Project planning

This project is done in a group of 3 members and each member is assigned with a role to make our project a success. There were 3 roles in this project namely Raspberry Pi developer, BLE developer and Android developer. My role in this project is Android developer which is to develop an Android application for our Colrigami NFC system. The total time taken to complete this project is 99 days.

5.1.1 Time Estimate

Phase	Activity	Description	Immediate Predecessor	Optimistic	Most Likely	Pessimistic	Duration (Days)
Proposal and preparation	A	Formation of team	-	1	1	2	1
	B	Briefing and guidance by the lecturer	A	7	10	14	11
Planning, requirement and design	C	Project idea generation and literature review	B	5	7	10	7
	D	Budget and resource planning	B	3	5	7	5
	E	Planning and design of prototype	C,D	5	7	7	7
Milestone 1 Development	F	Development of script for Raspberry Pi NFC and BLE	E	15	20	25	20
	G	Development of TCP server for BLE and NFC client	E	14	16	20	14
	H	Testing, bug fix and evaluation	F,G	5	7	10	7
	I	**Milestone 1 Presentation**	H	1	1	1	1
Milestone 2 Development	J	Development of Android Application	I	20	25	30	22
	K	Raspberry Pi code and scripts refinement	I	12	14	17	14
	L	Integration of Android app with Raspberry Pi with BLE	J,K	4	5	7	5
	M	Overall testing, bug fixing, refinement and evaluation	L	7	10	14	10
	N	Prototype building	J,K,L	3	4	5	4
	O	**Milestone 2 Presentation**	M, N	1	1	1	1
Documentation	P	Report and documentation	O	5	7	10	7

Table 2 - Time Estimate

5.1.2 Activity on Node

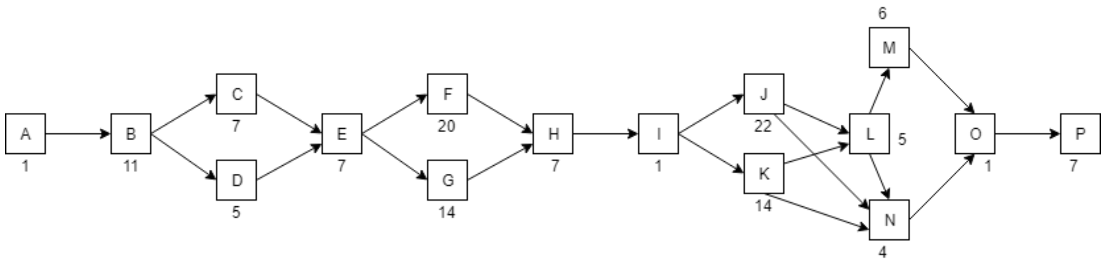


Figure 15 - Project Activity on Node (AoN)

5.1.3 Activity on Arrow

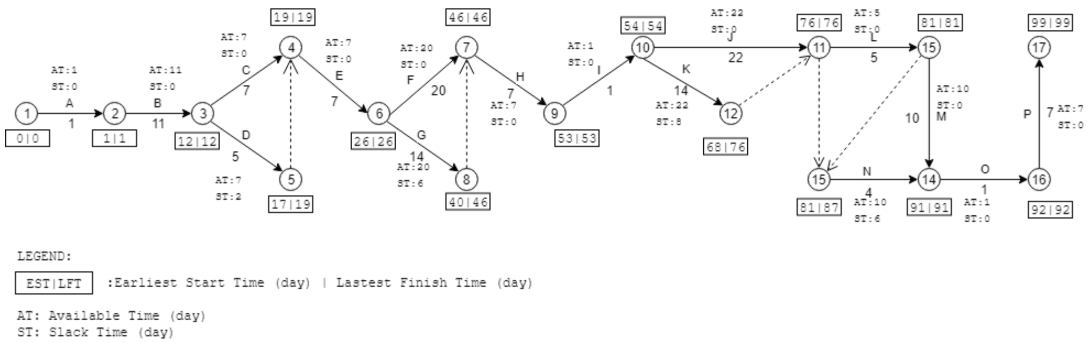


Figure 16 - Project Activity on Arrow (AoA)

5.1.4 Gantt Chart

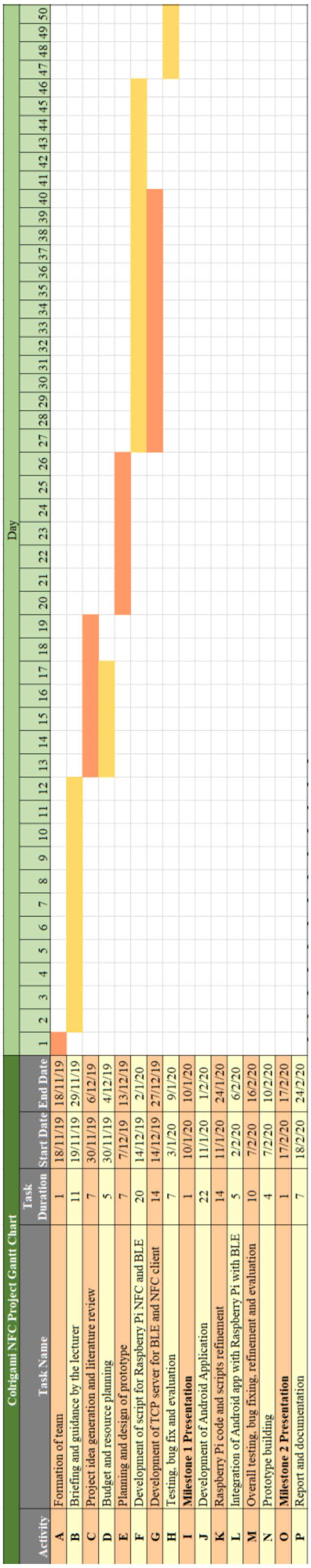


Figure 17 - Project Gantt Chart (Part A)

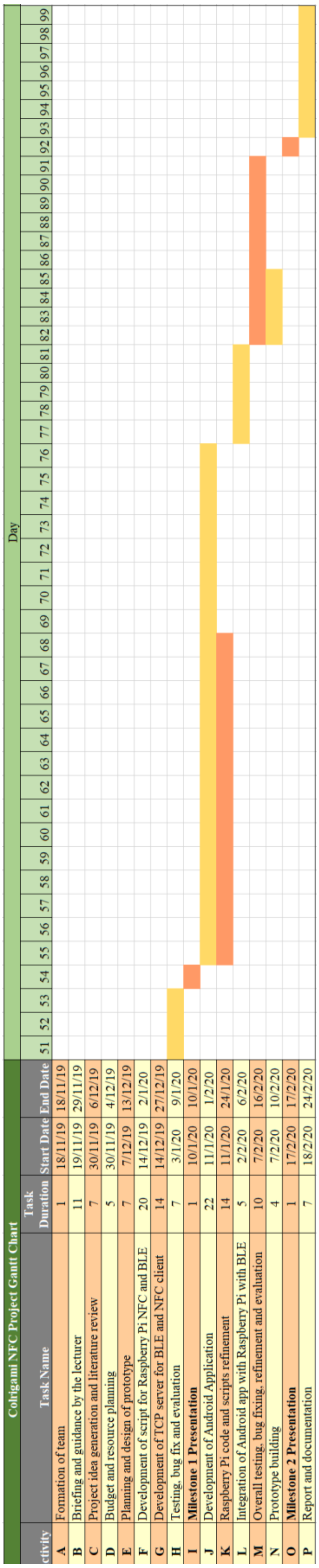


Figure 18 - Project Gantt Chart (Part B)

5.2 Budget planning and cost analysis

5.2.1 Project cost baseline

Colrigami NFC Project Cost Baseline				
Item	**Unit**	**Price per unit**	**Total**	**% of total**
Hardware				
Raspberry Pi 3 Model B	1	165.00	165.00	53.63%
NXP NFC	1	120.84	120.84	39.28%
Jumper wire	6	0.13	0.78	0.25%
Material				
3D printing TPU filament	50 metres	0.05	7.50	2.44%
Coloured paper	6	0.20	1.20	0.39%
Card board	1	1.00	1.00	0.33%
Corrugated plastic board	1	4.00	4.00	1.30%
NFC tag sticker	9	0.48	4.32	1.40%
Decorations	1	3.00	3.00	0.98%
		Total	RM 307.64	100%

Table 3 - Project Cost Baseline

The table above shows the total cost of individual material and hardware required to build this project. Fortunately, the Faculty of Engineering provide all the hardware needed for us to build the prototype of this project. Hence, the actual cost spent to build this project prototype is as shown in the table below.

Colrigami NFC Project Cost Baseline (Actual)				
Item	**Unit**	**Price per unit**	**Total**	**% of total**
Material				
3D printing TPU filament	50 metres	0.05	7.50	35.68%
Coloured paper	6	0.20	1.20	5.71%
Card board	1	1.00	1.00	4.76%
Corrugated plastic board	1	4.00	4.00	19.03%
NFC tag sticker	9	0.48	4.32	20.55%
Decorations	1	3.00	3.00	14.27%
		Total	RM 21.02	100%

Table 4 - Project Cost Baseline (Actual Spending)

Chapter 6: Conclusions and Recommendations

6.1 Summary on the work done

In this era of technology, it is undeniable that the usage of technology has increased the gap between teachers and students during a classroom session and also tarnished hands-on learning in children. This paper contributes to (1) encouraging interactive hands-on activities in children through origami, and (2) bridging the gap between a student and teacher despite the usage of mobile application and devices. We have chosen Japanese art of paper folding; Origami as the medium of hands-on learning in classroom or at home. We implemented smartphone, Raspberry Pi, Bluetooth Low Energy (BLE) and Near Field Communication (NFC) technology to develop Colrigami NFC. Literature reviews are done whereas shortcomings and solutions were identified and analysed, to help us solve our problem. In order to bridge the gap between teachers and students, we designed the best teaching and learning experiences for them, by implementing video functions on Raspberry Pi using NFC tags so that the teacher can control at the monitor. The prototype of Colrigami NFC was designed in such a way that is portable, interesting, fun and hassle-free. The mobile application eases teachers to control the flow of the class and children are able to use NFC tags directly onto mobile devices. To demonstrate the practicality of Colrigami NFC, testing and development of hardware and software components have been successfully done. This project is a good application that contributes to the conceptualisation and development of mobiquitous learning experience for academicians and developers to look up to, in order to enhance the learning experience especially in children.

6.2 Recommendation for future improvement

Further improvements can be done on this project. One of the improvements that can be implemented is adding the ability to change tutorial videos directly when a different video tag is tapped onto Raspberry Pi and mobile device, without having to tap the Stop card first. This would really ease both teachers and learners to switch tutorial videos at an instant. Another enhancement that can be done on Colrigami NFC is the volume function on the videos. And last but not least, children would be able to follow the tutorials better, if the videos come with clear subtitles.

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[1] S. N. Shamsudin, "Comparing the kindergarten curriculum framework of the Philippines and Malaysia," *International Journal of Early Childhood Education Care,* pp. 27-40, 2017.

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[3] C. W. Chun and R. W. Ching, "The Implementation of a Context-Aware Mobile Japanese Conversation Learning System Based on NFC-enabled Smartphones," in *2014 IIAI 3rd International Conference on Advanced Applied Informatics,* Kitakyushu, 2014.

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Appendices

Raspberry Pi Program Scripts

server.py

```
#!/usr/bin/env python

import socket
import sys
import subprocess

TCP_IP = '127.0.0.1'
TCP_PORT = 5010
BUFFER_SIZE = 20  # Normally 1024, but we want fast response

s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.bind((TCP_IP, TCP_PORT))
s.listen(1)

#Global Variable
data = ""
videoSW = 0

#Main
while True:
    conn, addr = s.accept()
    print '[SERVER] Connection address:', addr
    while True:
        data = conn.recv(BUFFER_SIZE)
        if not data: break
        print "[SERVER] Server received data:", data
        conn.send(data)  # echo
        if (videoSW == 0 and int(data) >=0 and int(data) <=2):
            print "[SERVER] Now playing video " +data
            vidpath = "/home/pi/Downloads/"+str(data)+".mp4"
            process = subprocess.Popen(['omxplayer', '-
b', vidpath], stdin=subprocess.PIPE, stdout=subprocess.PIPE, stderr=subprocess.PIPE
, close_fds=True)
            videoSW = 1
        elif (data == "10" and videoSW == 1):
            print "[SERVER] Pause/Play video"
            process.stdin.write('p')
        elif (data == "11" and videoSW == 1):
            print "[SERVER] Decrease speed video"
            process.stdin.write('1')
        elif (data == "12" and videoSW == 1):
            print "[SERVER] Increase speed video"
            process.stdin.write('>')
        elif (data == "13" and videoSW == 1):
            print "[SERVER] Rewind video"
            process.stdin.write('\033[D')
        elif (data == "14" and videoSW == 1):
            print "[SERVER] Fast forward video"
            process.stdin.write('\033[C')
        elif (data == "15" and videoSW == 1):
            print "[SERVER] Stop playing video"
            process.stdin.write('q')
            videoSW = 0
        else:
            print "[SERVER] Sorry, invalid input"
conn.close()
```

client.py

```python
import pexpect
import socket
import time

TCP_IP = '127.0.0.1'
TCP_PORT = 5010
BUFFER_SIZE = 1024

p = pexpect.spawn('/home/pi/linux_libnfc-nci/nfcDemoApp poll', timeout=None)

for line in p:
    if "Text :" in line:
        print "[NFC] Scan success"
        print "[NFC] Connecting to TCP server"
        s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
        s.connect((TCP_IP, TCP_PORT))
        print "[NFC] Connected to server"
        NfcContent = line.strip()
        NfcContent = NfcContent.replace('Text :','')
        NfcContent = NfcContent.replace('   ','')
        NfcContent = NfcContent.replace(' ','')
        NfcContent = NfcContent.replace('"','')
        print "[NFC] Sending \"" + NfcContent + "\" to server"
        s.send(NfcContent)
        serverData = s.recv(BUFFER_SIZE)
        print "[NFC] Server echo:", serverData
        s.close()
        print "[NFC] Connection to server closed"
p.close()
```

ble.js

```javascript
// requires bleno module
var bleno = require('bleno');
const Net = require('net');

const port = 5010;
const host = '127.0.0.1';

// the value that can be read and written from Android
var value = 1;

// setup BLE GATT characteristics with descriptors
var CapstoneCharacteristic = bleno.Characteristic;

var capstoneCharacteristic = new CapstoneCharacteristic({
    uuid: '13333333333333333333333333330001',
    properties: ['read', 'write'],
    descriptors: [
            new bleno.Descriptor({
                uuid: '2901',
                value: 'Capstone demo string.'
            })
    ],
   onReadRequest: function(offset, callback) {
        if (offset) {
                callback(this.RESULT_ATTR_NOT_LONG, null);
        } else {
                var data = new Buffer(1);
                data.writeUInt8(value, 0);
            console.log('[BLE] Data sent to mobile device: ' + value);
```

```
                callback(this.RESULT_SUCCESS, data);
        }
    },
    onWriteRequest: function(data, offset, withoutResponse, callback) {
        if (offset) {
                callback(this.RESULT_ATTR_NOT_LONG);
        } else if (data.length !== 1) {
                callback(this.RESULT_INVALID_ATTRIBUTE_LENGTH);
        } else {
                value = data.readUInt8(0);
            console.log('[BLE] Data received from mobile device: ' + value);
            const client = new Net.Socket();
            console.log('[BLE] Connecting to server');
            client.connect({port: port, host: host});
            client.write(String(value));
            console.log('[BLE] Data sent to server: ' + value);
            client.end();
            console.log('Disconnected from server');
            callback(this.RESULT_SUCCESS);
            delete client;
        }
    }
});

// setup BLE GATT services
var CapstoneService = bleno.PrimaryService;

var capstoneService = new CapstoneService({
        uuid: '13333333333333333333333333333337',
        characteristics: [
            capstoneCharacteristic
        ]
});

// start BLE advertising if USB BLE is on
bleno.on('stateChange', function(state) {
  if (state === 'poweredOn') {
    bleno.startAdvertising('Capstone G10 Colrigami', ['13333333333333333333333333333337'], function(err) {
      if (err) {
        console.log(err);
      }
    });
  }
  else {
    bleno.stopAdvertising();
  }
});

// start BLE Gatt services
bleno.on('advertisingStart', function(err) {
  if (!err) {
    console.log('Advertising...');
    bleno.setServices([
      capstoneService
    ]);
  }
});
```