Greeny: NAO As Assistive Teaching Tool For Recycling in Early Childhood Education

by

Emmanuel Fallancy
16496

Dissertation submitted in partial fulfillment of
the requirements for the
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CERTIFICATION OF APPROVAL

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Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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EMMANUEL FALLANCY

ABSTRACT

Greeny is proposed as an assistive teaching tool for early childhood education to improve on the learning experience of the students, as well as facilitating the teaching and learning process for young children (from the age of 3 to 5 years old, or pre-school students) on the importance of saving the Mother Nature through recycling items. The undertaking of this approach is motivated by the interest of improving the teaching and learning experience in early childhood education, as well as improving the awareness of recycling and sustaining the environment. The approach will utilize the commercially available robot, which is NAO. Greeny will demonstrate to the young children on sorting recycle items into the right container and explaining the significance of recycling. Surveys are conducted as preliminary investigation to assess the recycling awareness in the public. An interactive module for the Greeny is to be developed and implemented to assist the teacher in teaching and learning process. Iterative development model is being used as the methodology for development. At the end of the development, testing will be done onto the prototype before being implemented for the teaching and learning. After completion of prototype testing, testing on young children will be done by evaluating the success and failure of sorting the recycle items into the right bin to assess on the grasp of understanding on the input gain from the teaching and learning with intervention of robot as assistive teaching tool.

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CHAPTER 1

INTRODUCTION

1.1 Background Of Study

The rapid increase of the population and urbanisation in Malaysia had contributed towards the influence onto the municipal solid waste (MSW) generation with an increase of more than 8 million tonnes from 5.6 million tonnes in 1997 to 2010 and this will be expected to rise up to more than 9 million tonnes by 2020 (Noor et. al., 2013). Moreover, with the current estimation of over 30 million people in population by Ministry of Statistics Malaysia (2014), the management of solid waste will continue to be one of the major challenges in urban areas, particularly in developing areas of the country. The common approach in managing MSW is landfilling. On average, 50% of the local authority's budget is spend on MSW with more than 50% of it is spent on collecting the waste (Ramayah, Lee & Lim, 2013). However, with the increase in MSW, landfilling will eventually be scarce and significantly incur a great cost on managing the waste.

In relation to managing MSW, recycling program had widely been initiated since 1993 and considerably and important strategy to overcome problem of overloaded landfills (Mahmud & Osman, 2010). Two of the program is the 3R (Reduce, Reuse and Recycle) Recycling program and No Plastic Bag Day on every Saturday. Apparently, the recycling awareness in Malaysia is still low compared to Singapore with 40 percent of recycling rate while Malaysia is expected to project at 22 percent by 2020 (Ramayah, Lee & Lim, 2013). Despite the effort made on recycling by the Ministry and the participation of the organization, as well as the community, the effectiveness of the programme might not be impactful. The availability of the recycle disposal bin might not be enough in creating awareness as the first-class mindset and civic culture is mostly not present, as well as the recycling habit among Malaysians are still not largely practice (Bernama, 2015). Lacking of public awareness could cause an indirect severe harm to the environment and the society in the long run.

Despite the situation experience currently, an educational approach could be one of the approaches on gaining attention on significance of recycling. The incorporation of Environmental Education (EE) in educational system in Malaysia was introduced through the infusion and integration approach, namely in relevant subjects, such as English Language, Malay Language, Geography and Science (Mahmud & Osman, 2010). Relatively, the subjects stated are of the primary school and secondary school subjects. With EE being one of the important roles in promoting recycling awareness among Malaysians, it should be inculcated since childhood (Mahmud & Osman, 2010). The awareness of recycling should be nurture in the community, especially young children as they are the future leader and stewards of the earth (Zahari, 2012). This can be initiated by implementing it in early childhood, by using a humanoid robot as assistive teaching tool for the teachers in the classroom, which will also contribute in improving the learning experience of the young children.

1.2 Problem Statement

Recycling basically deals with the process of changing waste materials into new products and could relate to the practice of sorting waste disposal into designated disposal bin. Relatively, it is a practice done to conserve the environment by applying the principle of reduce, reuse and recycle. One of the initiatives to promote recycling is by incorporating it into the educational system. However, there are few problems that regards onto this issue.

i. Less focus of environmental education in early childhood education

Environmental education is mostly being introduced and made as part of the educational syllabus in some subjects in the school, particularly subjects that are being found in the primary and secondary school through infusion and integration approach, such as English language, Malay language, Geography and Science (Mahmud & Osman, 2010). Apart from that, the exposure and participation of students to be involved in the recycling competition is mostly done at the primary school and secondary school level, but not in early childhood school.

ii. Children have a short span of attention of learning.

Children are known to have a short span of attention on learning. Particularly, the average time spent to focus on certain subject is about 15 minutes for preschoolers (Children's Hospital of Richmond, 2015). However, the attention span may lead to more than 15 minutes according to the interest of the children onto the subject matter. Furthermore, children are more likely to engage with more interactive approach or paying more attention towards things that fascinates them, such as robots. As to our knowledge, there have not been any concrete indications that preschooler or children having a specific amount of time on the attention towards learning. Relatively, it may have contributed by many factors that would somehow increase or decrease the interest of the children to focus their attention onto something that fascinates them.

1.3 Scope of Study

The scope of the study is divided into 3 categories as follows:

i. Early Childhood Children

For this scope, the pre-school children are being selected as the target group for the approach. They are between the ages of 3 to 5 years old.

ii. Type of robots used

Robot being used in this context is as an assistive teaching tool or teaching aid for teaching and learning process for the teachers to use it.

iii. Teaching and learning method about recycling

The module used will be based according to the target group of the audience, which in this case, are the pre-school children between the ages of 3 to 5 years old.

1.4 Objectives

There are several objectives identified and as follow:

i. To investigate the current teaching and learning approach for young children about recycling.

ii. To conduct comparative study on existing robotic approach used in education that highlights the recycling practice.

iii. To develop the program for NAO robot to perform Human-Robot Interaction (HRI) function to teach young children about recycle.

iv. To validate the effectiveness of the proposed robotic method in enhancing the understanding of young children on recycling practice.

CHAPTER 2

LITERATURE REVIEW

2.1 Recycle

Recycle is the term used to describe on converting waste into a reusable materials. As of recycling, it is the process of changing waste materials or products that had already being used previously into reusable or new products. Recycling is also considered to be a practice of reusing used items which otherwise is as discarded waste. Recycling can be in variations, such as upcycling, whereby it is a process of recycling waste materials, often into product of higher quality or something useful. Other than that, another variation is the downcycling, which also known as the process of recycling waste materials into product of lower quality with reduced functionality than the original product. However, there is also another process known as precycling, which is the practice of avoiding items from being taken into home that eventually generate waste with the aim of reducing consumer waste. In particular, precycling involves decision-making (Halifax, 2014).

In the year of 2013, waste managed was accounted at 46.3kg per population (Ministry of Statistis Malaysia, 2014). According to the Ministry of Statistics Malaysia (2014), a total of RM 2321.4 million being spent on the environmental protection itself in the year of 2012 and 61.3% of the total expenditure was accounted for the operating expenditure itself. Particularly, the government spent a lot on conserving the environment in the country and undoubtedly, the majority of the expenses are portion towards the operating cost. Relatively, the expenses record in the year of 2012 has significantly shown the governmental effort is sustaining the environment and clearly indicated on the governmental emphasis pertaining the importance of recycling, as well as managing the municipal solid waste. However, the recycling rate in Malaysia is relatively low that currently rates at 10.5% in the year of 2015 as mentioned by Datuk Ab Rahim Md Noor, chief executive officer of

Solid Waste Corporation (Zamani, 2015). On the other hand, most developing countries, such as Singapore, having a high recycling rate of 40% compared to Malaysia, which targeted on getting 22% by 2020 (Ramayah, Lee & Lim, 2012).

Practically, the recycling practices are driven by the recycling program effort and exposure of the recycling awareness. Recycling program effort such as 3R (Reduce, Reuse and Recycle) is widely campaign throughout Malaysia. Moreover, the program also incorporates on the effort by the government to increase the recycling awareness and practice recycling. In addition, most big supermarket and grocery stores in Malaysia has taken the initiative to cultivate on not using plastic bag on every Saturday. Other than that, recycling practices in Malaysia are commonly done by sorting waste materials accordingly to its designated bin which being labeled based on the type of material. Nonetheless, Boldero describe recycling as a behavior that requires considerable effort in individual part especially household waste, which must be sorted, prepared and stored (as cited in Ramayah, Lee & Lim, 2012). Studies shown by Latif, Omar Bidin and Awang (2012) stated that consumers who have better environmental values or more pro-environment would have greater changes to participate on recycling. Recycling should not be limited to the use of color bins for various materials, and recycling must be made a part of Malaysian lives when buying, using or even throwing out rubbish (Ramayah & Rahbar, 2013). Therefore, recycling behavior plays a significant role and influence on recycling awareness, which also relates onto recycling practices.

Recycling is typically being linked as the practices of preventing waste of potential useful materials. According to Ramayah and Rahbar (2013), recycling promotes on the environmental advantages, the convenience on the reused of materials and the health improvement to the community. Recycling is known to benefit on saving energy. For example, in normal paper processing, it requires on chopping down the trees to produce a pulp. Continuing from the pulp process, the pulp will then need to undergo bleaching process before proceeding into becoming paper. In contrary, recycling could reduce the paper processing by accumulating the used paper and produce it into a pulp, without having to chop down the trees. After the pulping process is done, it will then proceed into the next process, which is bleaching it, followed by producing it into paper. The outcome of the recycling of paper would reduce the impact of global warming, due to the reducing in the activities of chopping down the trees. Relatively, conserving the trees would help to improve the air quality of the surrounding area, as such, more photosynthesis process takes place and more oxygen can be produced. Thus, it contributes to the reduction of greenhouse gases.

Energy saving through recycled products goes a long way in helping the global climate change especially by reducing the emission of greenhouse gases when the energy used is minimized during manufacturing. Environmentally, recycling helps in reducing the amount of waste being disposed into the landfills and incinerators. Most waste management method is done either through landfills or incinerators. However, Lee and Paik stated that with attitude for waste management the strongest factor related to waste management behavior, to enhance sustainable pro-environmental attitudes, there is a need for educational programmes and continuous policies (as cited in Ramayah & Rahbar, 2013). Thus, the cost of managing waste could significantly be reduced.

2.2 Teaching The People to Recycle

Environmental education is typically viewed as one of the ways to encourage recycling awareness. In Malaysia, environmental education was introduced through the infusion and integration approach in education system, which can be seen in relevant subjects like English Language, Malay Language, Geography and Science (Mahmud & Osman, 2010). Within this prospect, the objective of it is to promote the sense of awareness in delivering the information regarding recycling and importance of it (Lounsbury, 2001).

Along the educational line, teachers had been extensively being brief on the importance of the exposure on recycling to the students. Teachers have thought to play an important role in shaping the achievement of implementing environmental education among young age group (Said et al., 2003). Teachers learned on to attract the interest of the students by making the learning even more interesting. One of the initiatives done by the teachers is introducing the recycling program in school to promote on the exposure of recycling and significance of environment sustainability, such as Recycling Month. In addition, teachers and students get to participate in the program. One of the activities done from it is the introducing of recycling bin across the school, as well as involved in the recycling competition.

Relatively, most schools in Malaysia had introduced the recycling program and made visible on the existence of recycling club in the school as part of extra-curricular activities. Besides that, the program being introduced in the recycling club is not subject to the discussion of the importance of recycling but also the involvement of practicing a proper way to manage waste materials, such as segregating the waste materials accordingly into a proper wastage place. Melaka International School had made an initiative on teaching the students to recycle wastes, which being made as part of their curricular structure by exposing their students to develop learning on healthy lifestyle.

Apart from that, schools in other country, such as in United Kingdom, had made the learning even more interesting and interactive by introducing a number of fun activities, such as engaging the participants into a role play that allows them to express their opinions and encouraging debate about recycling. Other than that, children are being involved into educational game such as word search puzzles for the objective of allowing the children to explore different terms that relates to recycling (Recycling Guide, 2015).

Nevertheless, the current teaching methods introduced in the school in Malaysia about recycling is through the exposure on the ways to recycle waste materials accordingly in a proper waste disposal management, such as segregating recycle waste like papers, into proper wastage container. Additionally, the teachers will explain on the importance of recycling and the impact of recycling, by presenting some facts based on current statistics. Generally, the environmental education mostly being conducted as part of extra-curricular activities instead of having it as core curricular activities (Said, Yahaya, & Ahmadun, 2007).

However, most recycling teaching and effort are focused on primary school level and above. There are less implementation being made onto the early childhood education and incorporation of environmental education into early childhood is less seen. Moreover, there had been no studies regarding recycling in early childhood education in Malaysia as to the acknowledgement of this research.

2.3 Early Childhood Education

Early childhood education is imperative towards maintaining a continuous learning experience. It is an integral part of the learning process as they mature. The common approaches being practice in education for early childhood teaching are Montessori, Reggio Emilio and High/Scope. Each represents its own environmental setting whereby Montessori is more home-like environment, Reggio Emilio is similar to Montessori except with the extended use of "third teacher" and High/Scope environment is material-rich learning environment.

Nonetheless, common approaches have been shifted towards the integration of teaching and learning through play approach, and project-based approach of which are being incorporated into the teaching and learning process in early childhood education. Both approaches are known for the effort of capturing the attention of young children. According to Children's Hospital of Richmond (2015), young children are known for short span of attention in distracting environment and a child may attend for 15 minutes or more with attractive themes to an activity.

Besides that, early childhood education assists in terms of building a strong foundation for lifelong learning and pIays a significant role in a child's development. Ensuring all children starts at an equal footing can also mitigate social inequalities. Thus, it is important to promote sustained public funding to support the growth and quality of early childhood programmes.

According to Mathers et al. (2014), from the moment they are born, babies seek proximity to familiar people and have a strong drive to form to close, emotionally satisfying and engaging relationships. They also offer emotional nurturing, providing the feelings of safety, comfort and care which are so important for young children's developing sense of themselves within the world. Young children's bodies are the centre of their experience. From the very beginning they explore the world through all their senses, such as through touch, sight, sound, taste, smell and movement.

Equally important are opportunities for movement and physical development. Sensory and physical exploration of their environment helps young children to develop perceptual and spatial awareness, and to become oriented in space. According to Timmons et al. (2012), movement is also essential for health and for the improvement of motor skills (as cited in Mathers et al., 2014).

The early years of a child's life present a unique opportunity to foster healthy development, and research has underscored the importance of the first five years of life – both positive and negative experiences – in shaping children's cognitive, behavioral, social, and emotional development. This brief outlines the risks faced by young children with social, emotional, and behavioral problems, as well as barriers to eligibility, access to services, and service utilization. Therefore, National Association for the Education of Young Children (2013), concludes that recommending policy improvements such as assistive teaching aid is needed by young children.

Besides that, the teaching of recycling into early childhood education can foster the children's interest towards the nature. Activities that expose the children towards environmental program is able to foster the development of positive feelings and attitudes towards the nature, as well as providing the opportunities for them to explore the elements of the environment (Boyle, 2006). It will help the children to have a broader understanding on how the people and nature interelated.

2.4 Robotic Approach in Early Education

Educational robots are widely being used as part of the early education. Educational robots may have the contents and capacities that advance socio-passionate collaborations among youngsters and robots (Yang, 2012). According to Yang (2012), robots are likely to be more applicable when being used in the classroom and near to children. For example, the use of iRobiQ in language domain for teaching in kindergarten shows a positive outcome as it improves linguistic abilities in the aspect of story making, story understanding and word recognition for the young children. The degrees of the children's adaptive and active behavior improved at the same time.

Apart from that, the uses of robotics are known to possess a constructionist approach. Abiding to the four basic tenets of constructionism in early childhood education, which are learning by designing, use of concrete object to build and explore the world, identification of powerful ideas and importance of self-reflection as part of learning process, constructionist approach is able to stimulate the children into exploring and learning new concepts and ways of thinking (Bers, Ponte, Juelich, Viera, & Schenker, 2002). For example, the involvement of students in the classroom with robotic projects, such as using LEGO Mindstorm robotic sets are able to stimulate their creativity due to their engagement in exploring and learning new concepts and ways of thinking.

Besides that, the introduction of Science, Technology, Engineering and Mathematics (STEM) educational learning into the early childhood education had promote on the use of robotics as part of the learning process. It provides the open-ended environment to the teacher in developing constructive curriculum that integrates technology among different content areas (Bers and Portsmore, 2005).

2.5 Existing Robotic Educational Aids Related To Recycling

Some of the existing robots being used as educational aids for recycling is Curby the Recycling Robot. Curby features in a recycling container look alike and fully animated movement with the ability to sing, talk, listens, move and play prerecorded cassettes which being controlled using remote control (Robotronics, 2010). Besides that, information delivered through Curby is promoting on the 3R, which is reduce, reuse and recycle while pricing at the cost of $9,995. Apparently, Curby is not being able to be programmed according to desired condition.

FIGURE 2.1. Curby The Recycling Robot

Other than that, Rapping 'Recycler' Robot has the features of singing and rapping to the audiences while delivering informative message within the song. Generally, this robot has the ability to interact with the people on teaching them to reduce, reuse and recycle, as well as explaining the lifecycle of resources on everyday objects (Wastewatch, 2015). Additionally, this robot uses the approach of using songs, drama and games as teaching materials. However, this robot is the proprietary of Wastewatch and being used as part of their program.

FIGURE 2.2. Rapping 'Recycler' Robot

2.6 Comparative Study

TABLE 2.1. Comparative Study Table

Existing Recycling Robot	Cost	Features	Autonomous	Educational Used	Object Recognition	Programmable	Human-Robot Interaction
Curby Robot	$9995	- Able to dance - Able to sing - Can be control by using remote control - Mobility - Able to listen	No	Yes	Not able to recognize object	No	- Yes
Rapping 'Recycler' Robot	*No information regarding about the price	- Able to sing - Deliver informative facts - Mobility	No	Yes	Not able to recognize object	No	- Yes
Greeny (NAO Robot)	$7990 (Offered by RobotsLab)	- Able to dance - Able to sing - Able to recognize human face and movement - Mobility - Autonomous - Able to interact with audience	Yes	Yes	Able to recognized object	Yes	- Yes

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will further discuss and explain on the methodologies being used throughout the project. This chapter will be divided into 2 parts. The first part is the research methodology, which highlighted an overall approach of the methodologies and the second part is the development methodology that details on the methodology used to develop the module of the robotic approach.

3.2 Research Methodology

The methodology used for the research throughout the project compromises of six phases or areas that goes chronologically or similarly to the waterfall model. The first phase in the research methodology is identifying the problem faced or found that motivates on the undertaking of the research project or related to it, as well as the objectives of the project. The second phase is preparing literature review that addresses on related research of the project and conducting surveys for the project. The third phase will be the prototype development of the project, which is also known as the development phase. Fourth phase is the testing phase of the project. Fifth phase would be the result and discussion about the project, after the testing is done. Lastly would be the conclusion and recommendation or future works of the project. The details of each of the phases in the methodology will further be explained and the research methodology is illustrated on Figure 3.1.

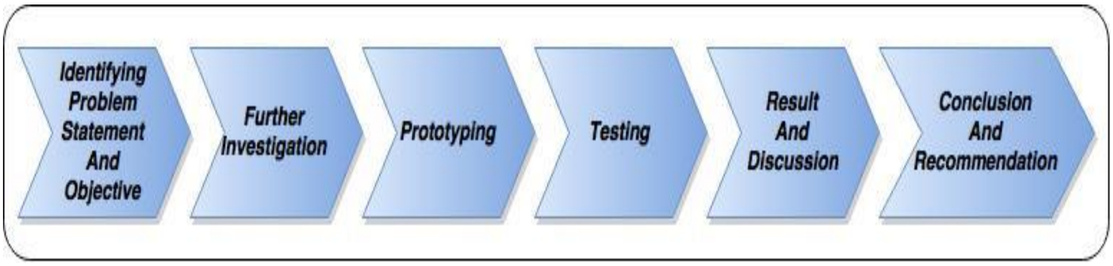

FIGURE 3.1. Research Methodology Diagram

3.2.1 Identifying Problem Statement and Objective

The first phase of the research methodology or the project is identifying the problem regarding the project that focuses on the recycling matter and environmental education in the educational system. Practically, this phase formulates on the problem statement of the project and the objectives. However, a brief study on the area of research should be conducted before formulating the problem statement and objectives of the project. Therefore, the background of study is done as a pre-requisite of the formulation of the problem statement and objectives. This phase entails on defining the scope of the project.

3.2.2 Further Investigation

The second phase of the project, which is the preparation of literature review, regards on further research and finding on the area or field of the research on the project. It is as a mean of conducting further investigation on related studies in similar area of the research project. Besides that, the studies done in this phase consist of a comparative study of existing method or approach on proposed assistive teaching tool approach. Apart from that, surveys are done as preliminary study within this phase to identify the level of awareness on recycling and gather relevant information regarding recycling matters whereby a random questionnaire is given to random respondent. Nonetheless, the outcome of the surveys is kept confidential and the respondents remain anonymous. The analysis result of the surveys will be discussed on results and discussions phase, which is the fifth phase of the research project. The questionnaire can be found on the appendix section of this dissertation.

3.2.3 Prototyping

Prototyping, which is also known as the development phase, focuses on the development of the teaching module of the robotic approach as assistive teaching tool. Prototyping phase methodology or known as development methodology will be presented in the development methodology section and details of prototyping phases will further be elaborated. The methodology is illustrated in Figure 3.2. The prototyping is done extensively on NAO robot whereby a program that package as a module for assistive teaching tool will be developed and implemented in the NAO robot. Completion of the prototyping phase will then proceed to testing phase for examination of the prototype.

3.2.4 Testing

Testing phase is being conduct to assess the effectiveness of the proposed assistive teaching tool approach, which is the prototype. Relatively, this phase is to validate and verify the effectiveness of the module. Apart from that, usability testing is done to gather feedback or information for future works and enhancement on the module and the approach itself.

3.2.5 Results and Discussions

The outcome of the testing and surveys or the results of the finding will be further analyze in results and discussions phase. Discussions will be done based on the findings of the analysis on the details of the outcome from the surveys, as well as the testing.

3.2.6 Conclusion and Recommendation

This phase will conclude on the research project from the overall findings of the project. Other than that, this will also include on future works that could further be explored within this project, as well as recommendation for the project.

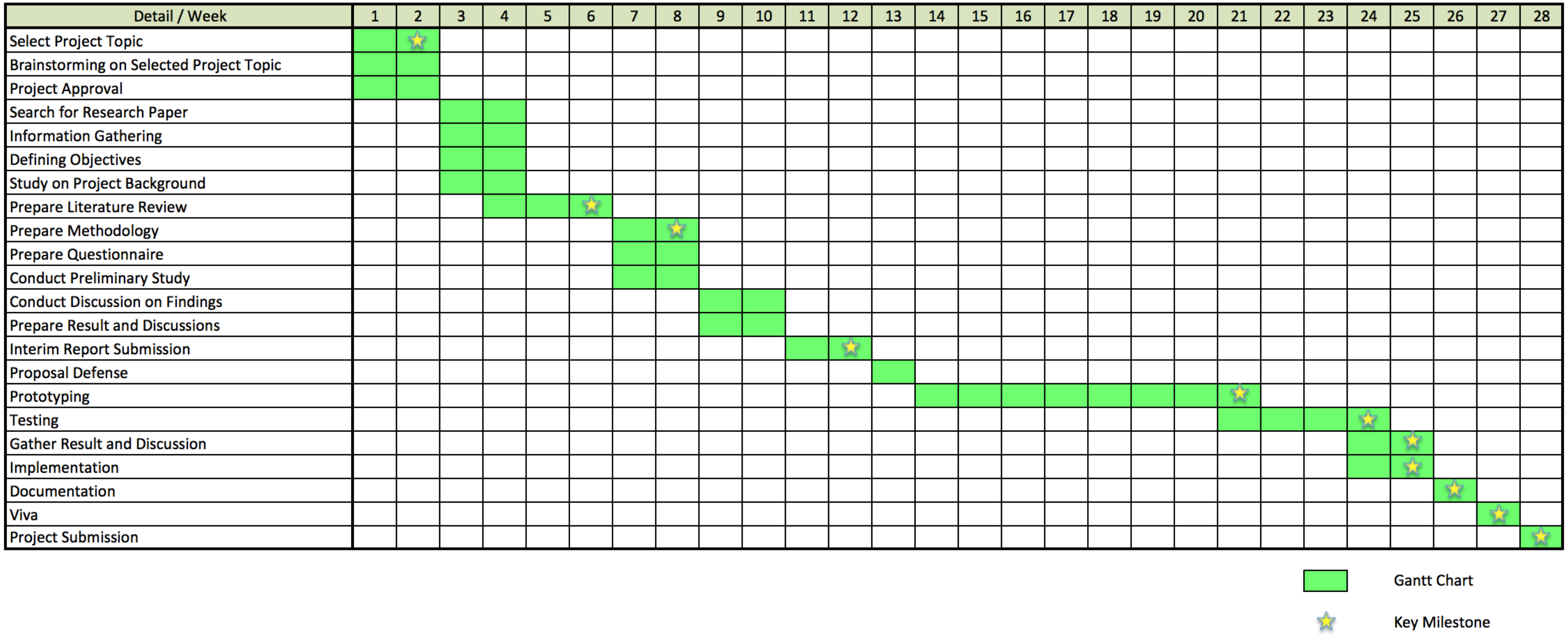

FIGURE 3.2. Gantt chart Timeline

3.3 Development Methodology

This section will elaborate on the third phase of the research methodology, which is the prototyping phase. Moreover, the development methodology will further explain in detail on the methodology being used for the development of the prototype. Prototype, as of this research, simply refers to the program to be developed for the research project.

The development methodology being used for prototyping is iterative development methodology. This methodology consists of six phases or stages of development. The methodology is illustrated in Figure 3.2 below and the development detail of each stage is explained in sections below.

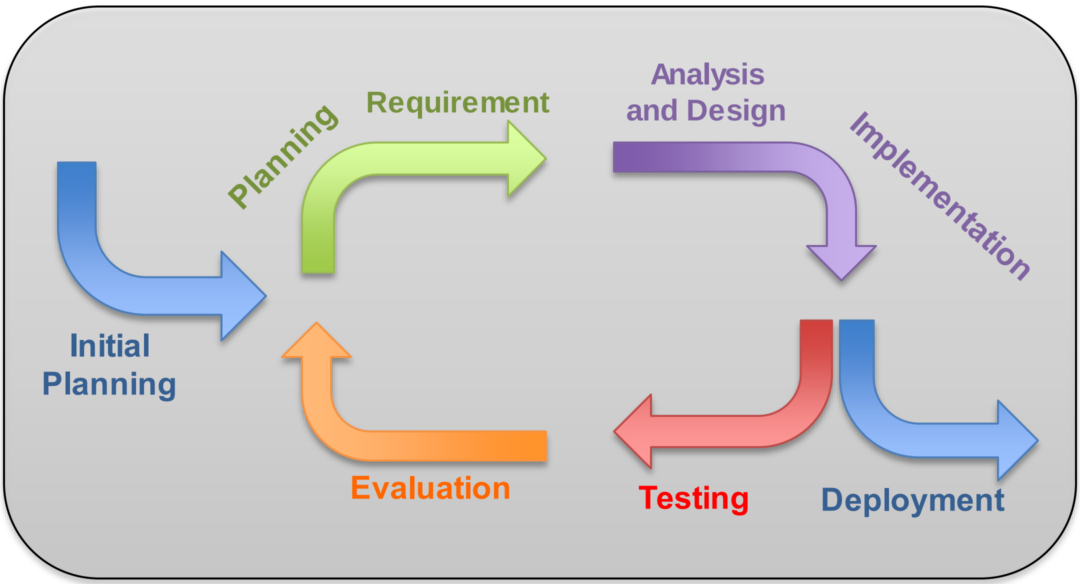

FIGURE 3.3. Development Methodology Diagram

3.3.1 Initial Planning

The initial planning compromises on the preparation and gathering of the information before proceeding onto the actual development phase itself. Apart from that, this also include on the initial draft on what needed to be done for the prototyping upon moving to planning phase.

3.3.2 Planning and Requirements

In planning phase, details of what needed to be done are finalized which includes on tools needed for the development and the requirements of the prototyping. The requirements serve as the guideline for the development of the prototype in order to ensure the development is done accordingly.

3.3.3 Analysis and Design, and Implementation

Analysis and design is done according to the requirement criteria that needed to be achieved. Once the design is finalized, proceeding onto the next phase will only then be done, which is implementation phase. Implementation phase is the preparation phase before proceeding to testing phase or deployment. Apparently, the deployment will only proceed if it passes all the requirements of the development, which is after evaluation and review of the prototype.

3.3.4 Testing

Testing phase is carried out to examine the prototype after designing and implementing it.

3.3.5 Evaluation

Evaluation phase is the analysis phase of the outcome from the result of the testing. The end result from the analysis of testing will be compared as reviewing purpose whether it meets the requirements of the project. However, if it does not fulfill the requirement of the development, the analysis and design phase will be undergone for another cycle, continuing to implementation and proceeding to testing and evaluation, until it fulfills all the requirements.

3.3.6 Deployment

Deployment phase will serve as a basis of preparation before proceeding on testing it on the real environment, which is testing on the outcome in the research or project perspective.

The underlying reason for choosing this method for development is in lieu of its iterative or incremental nature of developing the program. Moreover, this methodology fits the criteria for incremental development approach of the program, as it needs to adapt to continuous review on the development of the program. Program in methodology context refers to the module, which is also the software that drives the action of the robot to perform the Human-Robot Interaction (HRI) for the proposed approach.

3.4 Tools

NAO robot, which is a humanoid robot, is being used as an assistive tool for this research project. NAO robot has been commercialized and being used vastly for educational purposes, researches, as well as a companion. The NAO robot offers programmable features onto the robot itself, apart from the sensors, motors, infrared and WiFi connectivity. The NAO robot is program under its own proprietary programming language platform, which is Choregraphe. The anatomy of the NAO robot hardware is presented on Figure 3.5.

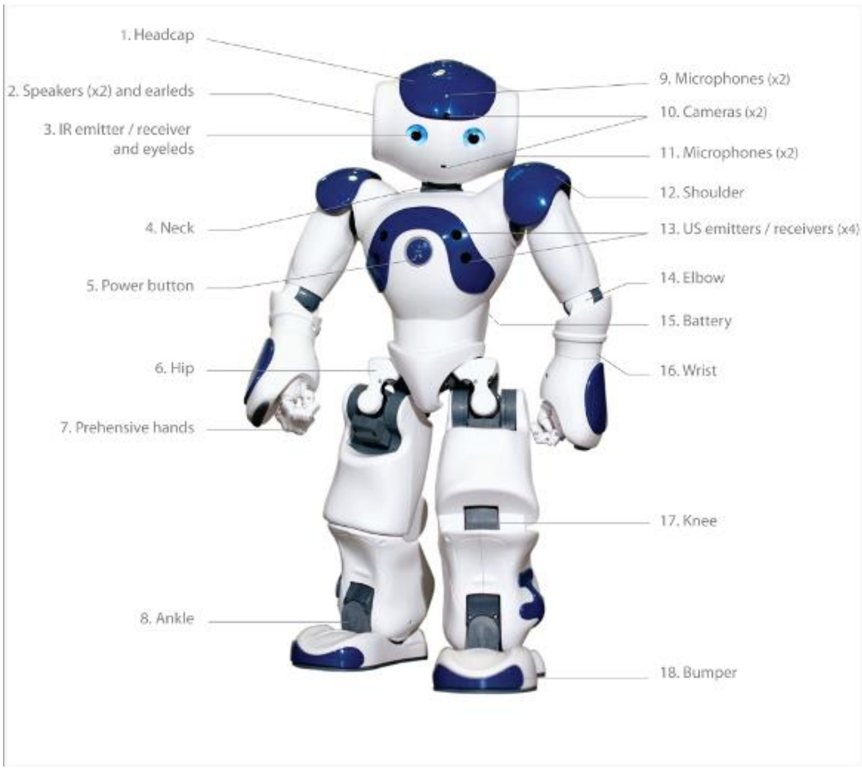

FIGURE 3.4. The anatomy of NAO robot.

The use of humanoid robot is able to teach and even read to children. According to Montalbano (2012), robot is able to do the same thing repeatedly and would not get tired (as cited by C, n.d.). Besides that, humanoid robot is known for being able to attract children's interest.

3.5 Evaluations and Testing Method

3.5.1 Prototype Testing

The prototype will be put into testing and evaluation before deploying it into the real environment for use. The evaluation will consist of three parts, which are the speech recognition, sorting action and speech mechanism. The setting of the prototype for testing, evaluation and real environment are illustrated in Figure 3.3 and Figure 3.4 below. The test cases for prototype evaluation are presented in Test Cases section of Methodology chapter on this dissertation.

FIGURE 3.5. Receiving item to be sorted into the bin.

FIGURE 3.6. Sorting the item into the designated bin.

3.5.1.1 Speech Mechanism

The speech mechanism compromises of three highlighted areas whereby the first part of it is the introduction speech of the robot and the second part is speech related to the sorting mechanism, as well as speech recognition, while the third part is the acknowledging of complete initialization of the program in the robot before it can be used.

The setting for the testing is divided into two parts, whereby the first part of the testing that relates to the acknowledgement of complete initialization is done after a complete boot of the robot. The test case for the first part is presented in test case ID of TC01. The second part of the speech testing will be done after the booting of the robot.

The second part of the speech testing will consist of three part of testing. Details of the testing are as below:

a. Introduction of the robot

   The test case of this part can be referred in test case ID: TC02

b. Prompting item to recycle

   The test case of this part can be referred in test case ID: TC03, TC04, TC05, TC06, TC07

c. Post-sorting speech

   The test case of this part can be referred in test case ID: TC08

Each part of the speech testing after booting will involve some animated movement that runs concurrently with the speech action of the robot. The evaluation for speech mechanism focuses in the ability of the robot to perform the speech mechanism.

3.5.1.2 Speech Recognition

The evaluation criteria for the prototype is focusing on the recognized word that are programmed and listed in the list of recognize words in the program of the robot. In order to evaluate the speech recognition, it is assume that there are no external factors that influence the process of evaluating the speech recognition functionality. As such, the evaluation process will be done under the environment with minimal distraction of noise in the surrounding.

The testing will be conducted for 2 iterations, whereby the test case consists of 10 runs. This is being done to ensure the usability of the functionality is able to operate with minimal or zero error in recognizing the words. Besides that, it is also to ensure the stability of the functionality being used under repetitive condition. Nonetheless, the outcome of the run should be able to achieve the expected result of 10 successful runs on all iterations. The test case of speech recognition usability is presented in test case ID of TC09.

3.5.1.3 Sorting Mechanism

The sorting mechanism involves in the mechanical movement of sorting the items to be recycle into the right bin. The current settings will involved the robot itself (referring to NAO robot) and three bins that resemble the recycling bin in a smaller scale which being labeled accordingly to the actual recycling bin.

The testing will depend on the speech recognition in order to perform the testing of the sorting mechanism. Apparently, the test will only be valid after performing the speech recognition testing. The evaluation focuses on the successful sorting of the item being recycled into the right bin. The test case of sorting mechanism is presented in test case ID of TC07.

3.5.1.4 Test Plan Execution

Since the speech mechanism, speech recognition and sorting mechanism are interdependent with one and another, some part of the testing will be covered by some test cases. However, speech mechanism could be separated into few parts, as some of the testing parts are not dependent on speech recognition and sorting mechanism. The testing will be divided into three parts. Details are as below, along with the test case ID that will be executed for testing.

a) Booting of Program

Testing will compromise of Test Case on Program Boot Acknowledgement that relates to speech mechanism (TC01).

b) Introduction (After Booting Acknowledgement)

Testing will compromise of Test Case on Introduction Speech that relates to speech mechanism (TC02).

c) Sorting (After Booting Acknowledgement)

Testing will compromise of Test Case on Speech Recognition Usability that covers Speech Recognition and Sorting Action, which are speech recognition, speech mechanism and sorting mechanism related (TC09).

3.5.2 Teaching and Learning Evaluation

The teaching and learning evaluation would involve in the real environment setting with the involvement of the teacher and the students. The audience will involve a teacher and ten students. The setting of the testing environment will be divided into two groups. Initially for both groups, the teacher will teach and brief on the students about the subject matter of the teaching and what needs to be done, which is also known as introduction of the learning. After the introduction by the teacher, the next agenda will proceed on the action of the students to sort the items. The details of each group are as follow:

a. First Group

The first group will consist of one teacher with 5 students and the absence of a robot as an assistive teaching tool for teacher, along with ten items that needs to be sorted by the students.

b. Second Group

The second group will consist of one teacher with 5 students and the presence of the robot as an assistive teaching tool for the teacher, along with ten items that needs to be sorted by the students.

In both groups, each student is required to select two items to be sorted into the bin from the ten items provided to them. The teacher will then observe and record the outcome of the student's action on sorting the items into the bin. Any successful and unsuccessful sorting will be tabulated in a table form result. The state transition of the teaching module is presented in Figure 3.6.

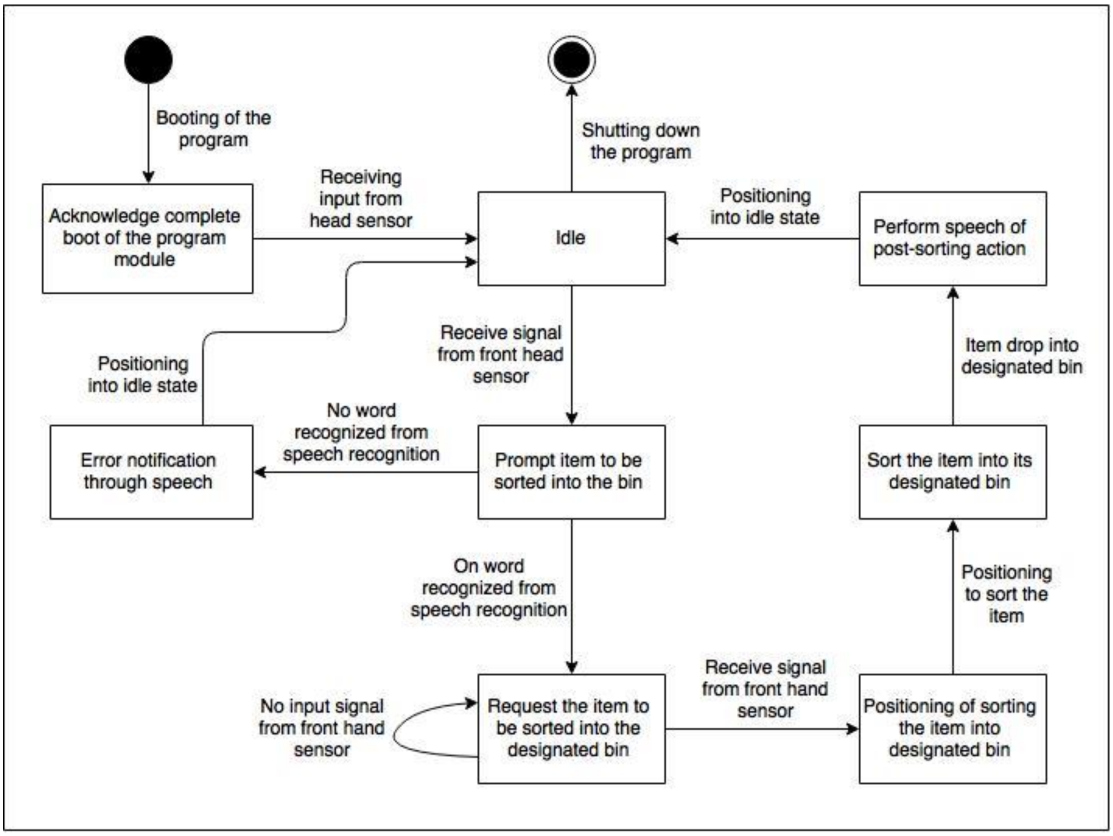

FIGURE 3.7. Teaching Module State Transition Diagram

3.6 Test Cases

The test cases presented in this section refer to the prototype evaluation as being stated in previous section of the methodology (referring to Prototype Evaluation part in Testing and Evaluation Method section). The environment for the testing will consist of an acceptable indoor free space with three labeled bins that resembles and represent actual bin for simulation. The prototype testing shall be conducted on actual robot with the following specification:

TABLE 3.1. Robot Specifications

Hardware Name	NAO
Manufacturer	Aldebaran Robotics
Version	5

The details of the test cases are presented in this preceding section.

TABLE 3.2. Program Boot Acknowledgement Test Case

Test Title	Program Boot Acknowledgement		
Test Case ID	TC01		
Test Summary	Speech to notify a complete boot of the program before being used.		
Pre-Condition	None		
Post-Condition	Robot move into idle state.		
#	**Test Step**	**Expected Result**	**Intercase Dependency**
1	Start the robot.	Robot is booting up.	None
2	The program is fully boot after a while.	A speech message is heard from the robot.	

TABLE 3.3. Introduction Speech Test Case

Test Title	Introduction Speech		
Test Case ID	TC02		
Test Summary	Speech for introduction of the robot.		
Pre-Condition	Requires a fully loaded program [TC01]		
Post-Condition	Robot move into idle state.		
#	**Test Step**	**Expected Result**	**Intercase Dependency**
1	Tap the front head sensor	1. Flash indication on front head sensor is seen.	None
		2. The robot perform introduction speech.	

Table 3.4. Speech Recognition with Input (Paper) Test Case

<table>
<tr><td>Test Title</td><td colspan="3">Speech Recognition - Input As Paper</td></tr>
<tr><td>Test Case ID</td><td colspan="3">TC03</td></tr>
<tr><td>Test Summary</td><td colspan="3">Sorting action of the robot - "paper" as speech input</td></tr>
<tr><td>Pre-Condition</td><td colspan="3">Requires a fully loaded program [TC01]</td></tr>
<tr><td>Post-Condition</td><td colspan="3">Proceed to next test case in Test ID: TC08</td></tr>
<tr><td>#</td><td>Test Step</td><td>Expected Result</td><td>Intercase Dependency</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Tap the middle head sensor.</td><td>1. Flash indication on middle head sensor is seen.</td><td rowspan="3">None</td></tr>
<tr><td>2. Robot prompt items to be recycle and waiting for speech input from user.</td></tr>
<tr><td>2</td><td>Reply "paper"</td><td>Robot recognized the speech input and raise its right hand for positioning on receiving the item.</td></tr>
</table>

TABLE 3.5. Speech Recognition with Input (Glass) Test Case

Test Title	Speech Recognition - Input As Glass		
Test Case ID	TC04		
Test Summary	Sorting action of the robot - "glass" as speech input		
Pre-Condition	Requires a fully loaded program [TC01]		
Post-Condition	Proceed to next test case in Test ID: TC08		
#	**Test Step**	**Expected Result**	**Intercase Dependency**
1	Tap the middle head sensor.	1. Flash indication on middle head sensor is seen.	None
		2. Robot prompt items to be recycle and waiting for speech input from user.	
2	Reply "glass"	Robot recognized the speech input and raise its right hand for positioning on receiving the item.	

TABLE 3.6. Speech Recognition with Input (Plastic) Test Case

Test Title	Speech Recognition - Input As Plastic		
Test Case ID	TC05		
Test Summary	Sorting action of the robot - "plastic" as speech input		
Pre-Condition	Requires a fully loaded program [TC01]		
Post-Condition	Proceed to next test case in Test ID: TC08		
#	**Test Step**	**Expected Result**	**Intercase Dependency**
1	Tap the middle head sensor.	1. Flash indication on middle head sensor is seen.	None
		2. Robot prompt items to be recycle and waiting for speech input from user.	
2	Reply "plastic"	Robot recognized the speech input and raise its left hand for positioning on receiving the item.	

TABLE 3.7. Speech Recognition with Input (Metal) Test Case

Test Title	Speech Recognition - Input As Metal		
Test Case ID	TC06		
Test Summary	Sorting action of the robot - "metal" as speech input		
Pre-Condition	Requires a fully loaded program [TC01]		
Post-Condition	Proceed to next test case in Test ID: TC08		
#	**Test Step**	**Expected Result**	**Intercase Dependency**
1	Tap the middle head sensor.	1. Flash indication on middle head sensor is seen.	None
		2. Robot prompt items to be recycle and waiting for speech input from user.	
2	Reply "metal"	Robot recognized the speech input and raise its left hand for positioning on receiving the item.	

TABLE 3.8. Invalid Input Speech Recognition Test Case

Test Title	Speech Recognition - Invalid Input		
Test Case ID	TC07		
Test Summary	Sorting action of the robot - invalid input		
Pre-Condition	Requires a fully loaded program [TC01]		
Post-Condition	Robot move into idle state.		
#	**Test Step**	**Expected Result**	**Intercase Dependency**
1	Tap the middle head sensor.	1. Flash indication on middle head sensor is seen.	None
		2. Robot prompt items to be recycle and waiting for speech input from user.	
2	Reply with word apart from "plastic", "glass", "metal", "paper".	Robot shall not recognized the speech input and notify by replying error speech message.	

TABLE 3.9. Sort Item Into Designated Bin Test Case

<table>
<tr><td>Test Title</td><td colspan="3">Sort Item Into Designated Bin</td></tr>
<tr><td>Test Case ID</td><td colspan="3">TC08</td></tr>
<tr><td>Test Summary</td><td colspan="3">Sorting action of the robot. This test case will only be executed which continued from previously executed test case. Dependencies of the test cases are shown in Intercase Dependency column.</td></tr>
<tr><td>Pre-Condition</td><td colspan="3">Requires a fully loaded program [TC01] and previously executed test case.</td></tr>
<tr><td>Post-Condition</td><td colspan="3">Robot move into idle state</td></tr>
<tr><td>#</td><td>Test Step</td><td>Expected Result</td><td>Intercase Dependency</td></tr>
<tr><td>1</td><td>Continue from previously executed test case.</td><td>Proceed to next test step.</td><td rowspan="3">TC03, TC04, TC05, TC06</td></tr>
<tr><td>2</td><td>Place the item on the robot hand and touch the hand sensor.</td><td>Robot grab the item and position itself to the designated bin and drop the item into the bin.</td></tr>
<tr><td>3</td><td>Robot perform post-sorting action.</td><td>Robot perform speech action and animated movement concurrently.</td></tr>
</table>

TABLE 3.10. Speech Recognition Usability Test Case

Test Title	Speech Recognition Usability		
Test Case ID	TC09		
Test Summary	Usability test to be executed for 10 runs. To ensure the stability of speech recognition when undergone a repetitive action.		
Pre-Condition	Requires a fully loaded program [TC01] and 3 speech recognition test cases (TC03, TC04, TC05, TC06, TC07)		
Post-Condition	Robot move into idle state		
#	**Test Step**	**Expected Result**	**Intercase Dependency**
1	Execute any three test cases of speech recognition from TC03, TC04, TC05, TC06, TC07.	Expected result is similar to the test case expected result.	TC03, TC04, TC05, TC06, TC07
2	Repeat test step 1 for 9 times.	Expected result is similar to the test case expected result.	

CHAPTER 4

RESULT AND DISCUSSION

4.1 Surveys

4.1.1 Surveys on Recycling Awareness

A survey is conducted by distributing questionnaires online and offline, which targeted to the public, mainly in Malaysia. The objective of this survey is to investigate on the depth of the understanding on the discussion towards the level of recycling awareness. There are 39 respondents with the majority of 27 female respondents, then followed by a total of 12 male respondents. Overall, the findings from the result obtained from the responses made by anonymous respondents had shown prominent awareness on recycling. However, majority of the respondents stated that recycling is not widely being practice. Nonetheless, majority of the respondents believed that the nurturing of recycling practice and exposure at young age would significantly given a positive impact in improving the recycling awareness and implant the interest to better grasp the importance of recycling. Moreover, most respondents agree that the exposure of recycling awareness through early childhood education would promptly reflect a positive outcome from it and they believe on using NAO robot as assistive teaching tool in teaching and learning about recycling would attract the interest of young children to know more about recycling.

4.1.2 Questionnaires

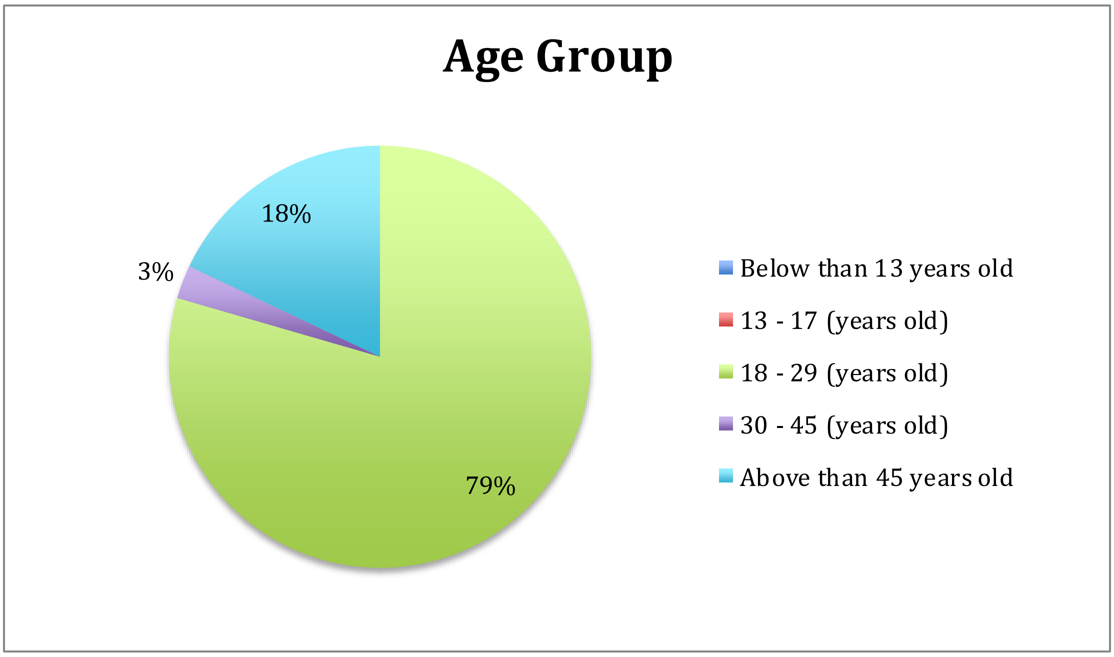

FIGURE 4.1. Age Group Distribution of Respondent.

Based on the results obtained from the questionnaires in Figure 4.1 above, 79% of the respondent is from the age group of 18 to 29 years old, with a total of 31 respondents while 18% of the respondents are of the age group above 45 years old with a total of 7 respondents. However, 3% of the respondents, which is equivalent to one respondent, belong to the group of 30 to 45 years old.

Significantly, the respondent for the age group of 18 to 29 years old compromises of students in higher institution, with majority of them are from Universiti Teknologi PETRONAS. Other than that, respondents for the age group above than 45 years old are mostly having careers in the industry.

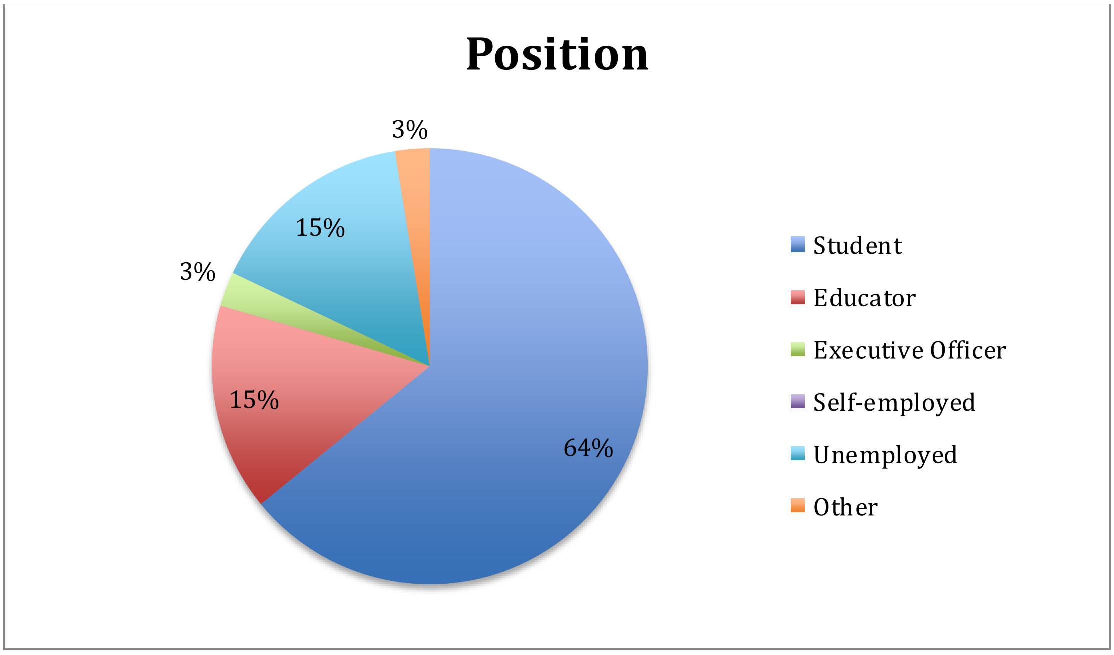

FIGURE 4.2. Respondents' Career Position.

From the outcome of the questionnaires shown in Figure 4.2, it has shown that 64% of the respondents of the questionnaires are student, with a total of 25 respondents, followed by 15% respondents who are unemployed and another 15% respondents that represent educator, while the remaining respondents which both of 3% are an executive officer position and other position which states as non-executive position.

4.1.3 Recycling

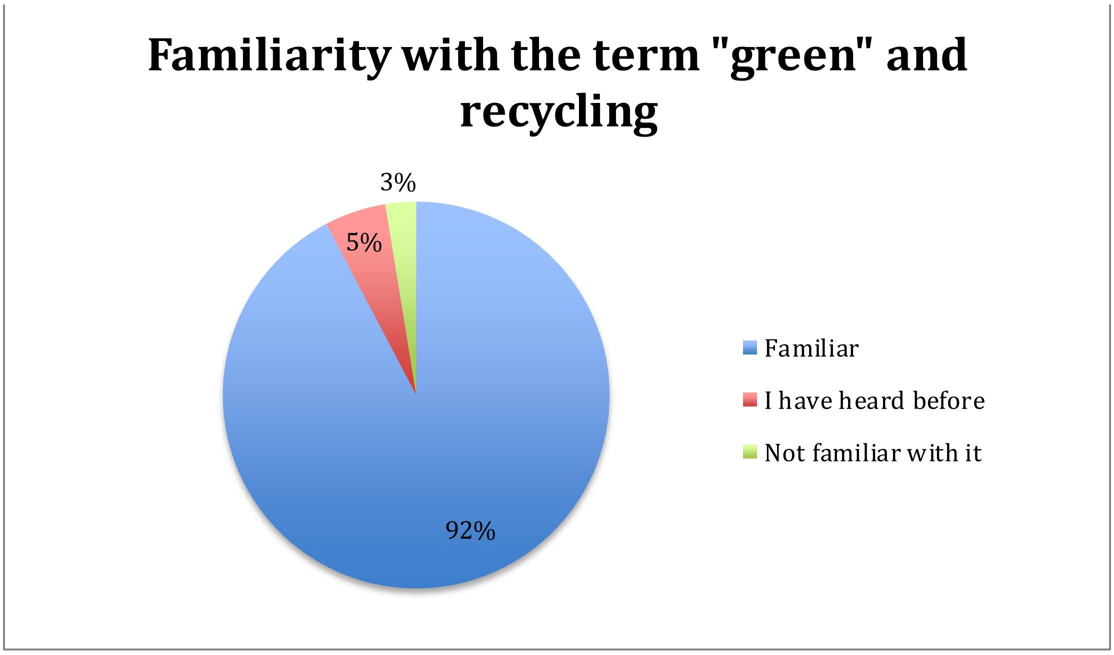

FIGURE 4.3. Familiarity of respondent on the term “green” and recycling.

Based according to the results obtained from the questionnaires in Figure 4.3, 92% of the respondents had demonstrated on their familiarity with the term of ‘green’ and recycling. However, 3% of the respondents had stated on not familiar with recycling and the term of ‘green’. Reason being is due to lack of exposure with the term used for ‘green’ but however, the respondent is familiar with recycling. Moreover, only 5% of the respondents have come across to the term ‘green’ though they are more familiar with recycling.

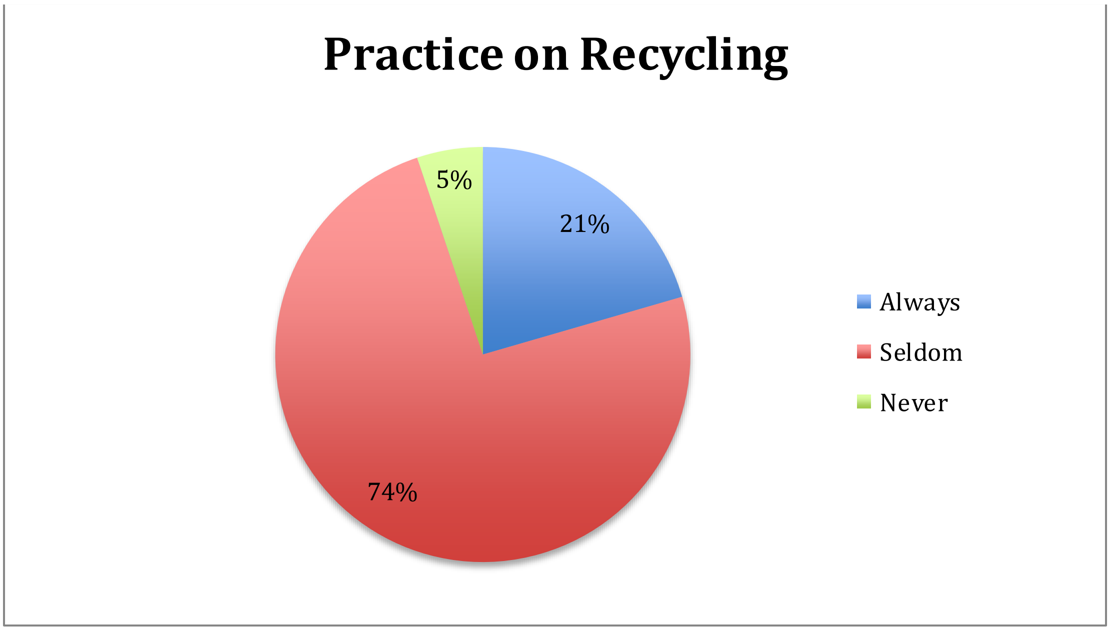

FIGURE 4.4. Practicing of Recycling Done by Respondent

In the questionnaire, a question that regards on the practice of recycling is projected to the respondent. From the results obtained that is shown in Figure 4.4, 21% of the respondents practice recycling which commonly associating towards practicing on sorting recycle items into recycle bin. Besides that, 74% of the respondents occasionally do recycling while 5% of the respondents had never recycle.

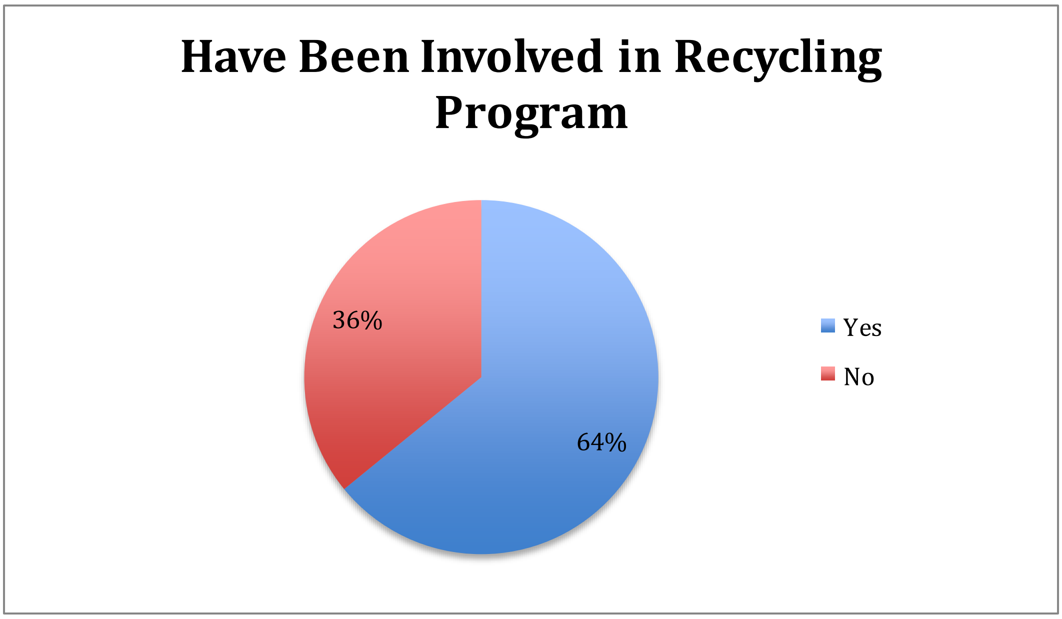

FIGURE 4.5. Involvement of respondent in Recycling Program

A question regarding the involvement in recycling program is being stated in the questionnaire, with the objective to investigate on the participation of the respondents on recycling program made available to them. Based on the results obtained and being shown in Figure 4.5, 64% of the respondents have ever been involved in recycling program while the other 36% of the respondents have never been involved in any recycling program, which could be the reason of low interest on participating with any recycling program.

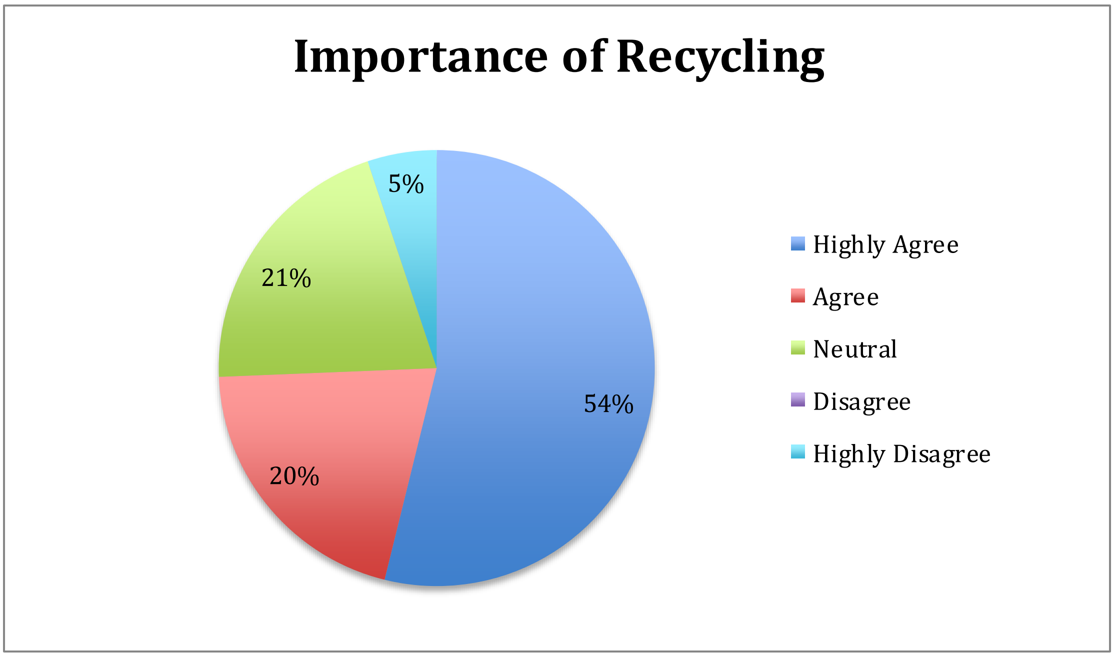

FIGURE 4.6. The Importance of Recycling based on responses by respondents.

Besides that, a question regarding the discussion on the importance of recycling with people is mentioned in the questionnaire and the result is shown in Figure 4.6. It has shown that 54% of the respondents highly agree on the importance of recycling and always discuss about the importance of recycling among their family, friends and even, strangers. The other 20% respondents agree on the importance of recycling and had always been discussing about it with family, friends and even, strangers while 21% of the respondents have neutral thoughts about it. Apparently, 5% of the respondents do not think that recycling is important and indicated that they do not agree on discussing about the importance of recycling.

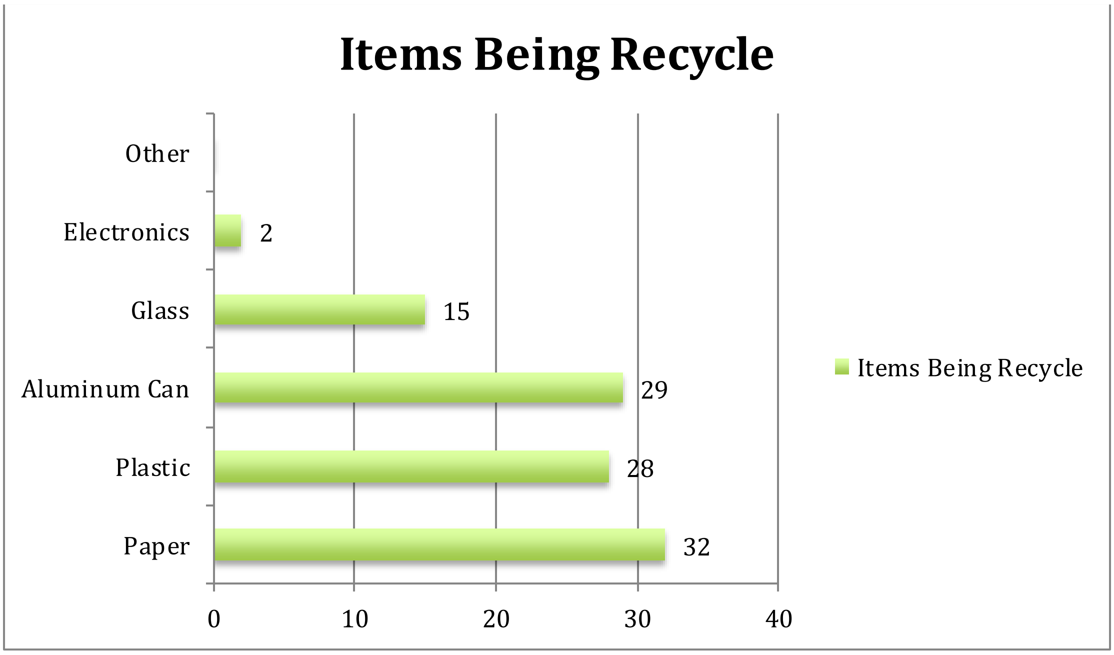

FIGURE 4.7. Items being recycled by respondents

Based on the results obtained from the questionnaire on Figure 4.7, paper ranks as the most items or materials being recycle often, with 32 respondents that stated on recycling papers. The second most items being recycled by the respondents is aluminum can, with a total of 29 respondents recycle aluminum cans. The third most recycled item is plastic, with a total of 28 respondents that recycle plastic items or materials. Besides that, a total of 15 respondents recycle glass items or materials while two respondents do recycle electronic items.

Paper being ranked, as the highest amount for being recycle is due to the use of paper in daily routine such as printing, writing on papers and other paper related works. Besides that, aluminum can is considerably being mostly be consumed by people due to the usage of aluminum can as storing water. Apart from that, plastic is considerably being less recycle compared to the other two highest ranked recycle materials in the questionnaire is due to the less use of plastic bag which being mostly substitute with paper bag. Moreover, the use of plastic is less. In contrary, glasses and electronics are less being recycled. Generally, for electronics, the most recycled materials would be mobile phone, remote control or old television.

4.1.4 Recycling Rates

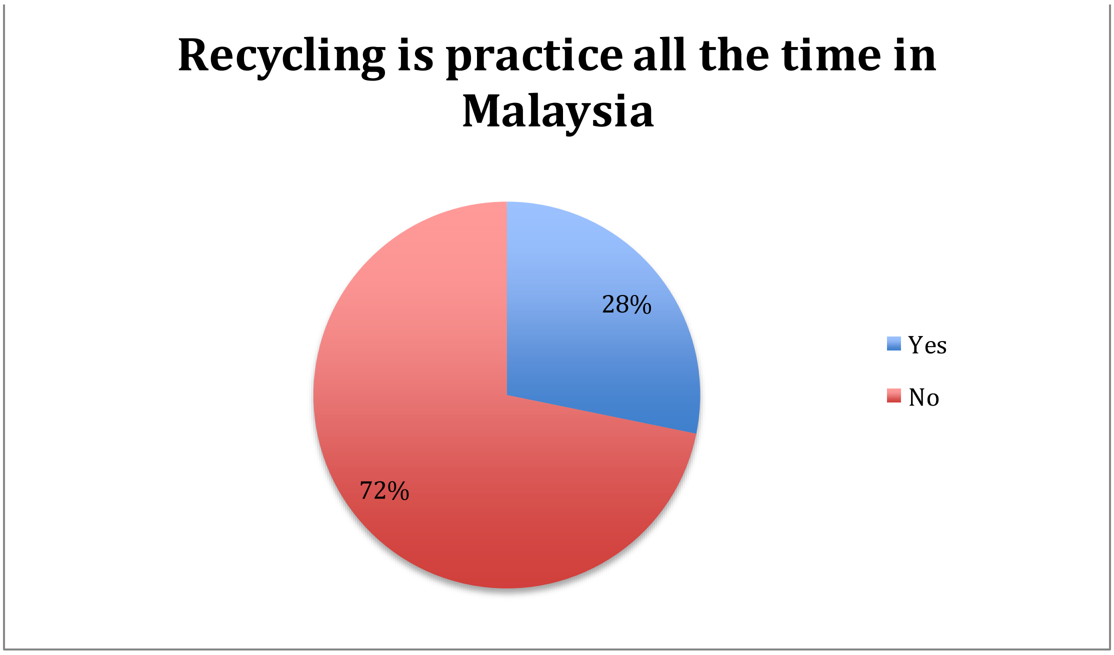

FIGURE 4.8. The Recycling Practice in Malaysia based on respondents' responses.

Based on the results obtained from the survey in the questionnaire that is shown in Figure 4.8, it has indicated that in Malaysia, recycling is not being practice all the time according to the answer made by 72% of the respondents from the questionnaire. Apparently, 28% of the respondents had different thoughts and think otherwise. Opinions made by the respondents are possibly being based from their observation or otherwise, as to what they experienced in their surrounding.

4.1.5 Exposure of Recycling at Early Childhood

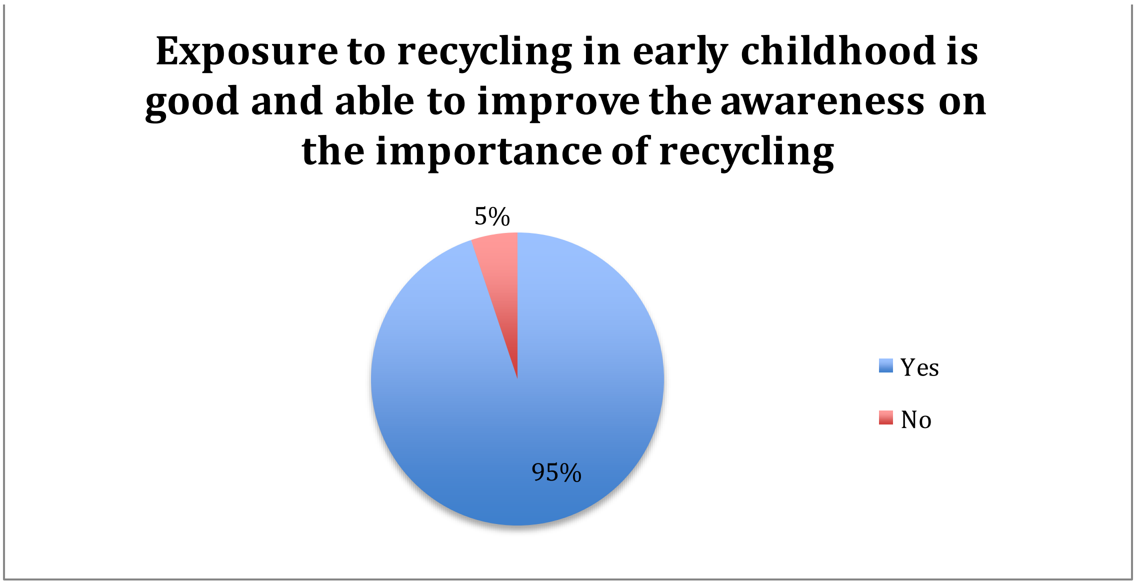

FIGURE 4.9. Results on the thoughts of exposure to recycling in early childhood and the impact towards the awareness on the importance of recycling.

From the results obtained in the questionnaire as shown in Figure 4.9, 95% of the respondents agree that the exposure of recycling in early childhood would be good and be able to improve the awareness on the importance of recycling. However, 5% of the respondents do not agree that the exposure would be able to improve on the awareness of the importance on recycling, which probably lead to the believe of young children might not be able to understand what is recycling and not the right age timeline for the introduction of recycling.

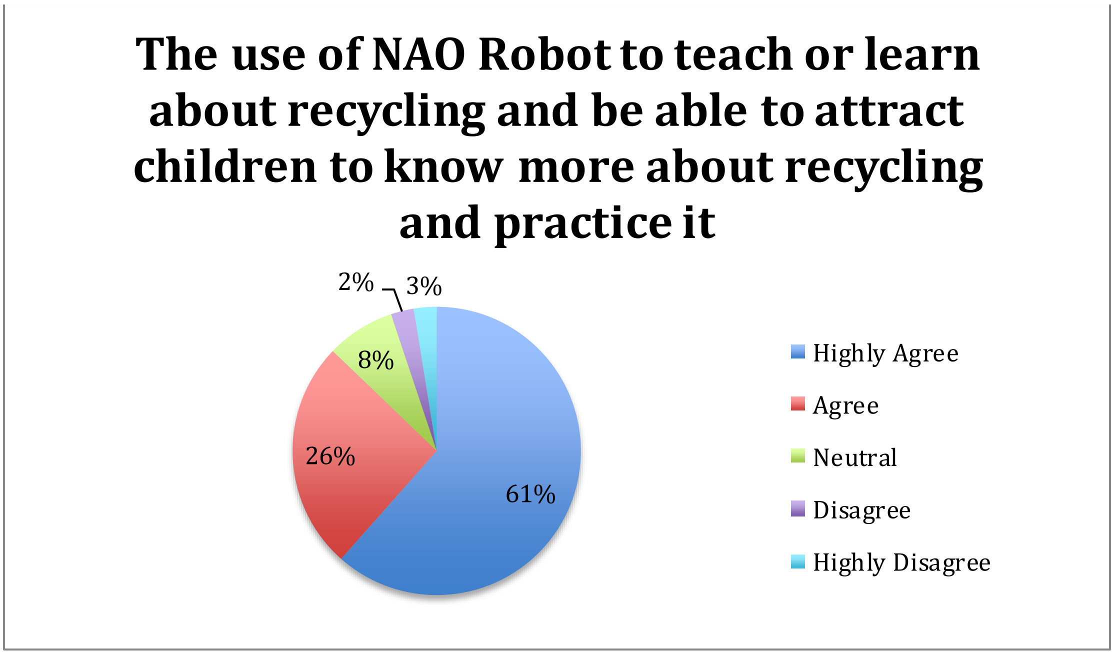

FIGURE 4.10. Responses on the use of NAO Robot as teaching aid and to sustain the interest of children on recycling.

Based on the result shown in Figure 4.10, 61% of the respondents highly agree on the use of NAO Robot as assistive teaching tool to teach or learn about recycling and be able to attract the children to know more about recycling, as well as nurturing the habit on the practice of recycling, followed by 26% of the respondents that agree on it while 8% of the respondents are having a neutral thoughts of using NAO Robot as assistive teaching tool for teaching or learning about recycling. However, 3% of the respondents that disagree, as well as 2% of the respondent highly disagree on the thoughts of using NAO Robot as assistive teaching tool to teach and learn more about recycling, as well as being able to attract children and nurturing the habit of practicing recycling. The potential reason of the disagreement could probably be the thoughts that the use of NAO Robot would replace the role as a teacher.

4.2 Prototype Testing

Prototype testing, as being stated in previous sub-chapter of Methodology, that is Teaching and Evaluation Method, is a testing carried out to assess the result of the prototype development. In reference to the test plan execution, the testing is to be conducted in three parts, which are booting of program, introduction and sorting.

4.2.1 Booting of Program

The purpose of this test is to acknowledge a complete boot of the module or the program to be used. The test case being executed is Program Boot Acknowledgement (TC01). The test is executed once and the test summary is presented in table below.

TABLE 4.1. Booting of Program Test Result

Test Case Executed	TC01			
Test Case Remark	None			
#	**Test Step**	**Actual Result**	**Status**	**Remark**
1	1	As expected with expected result in test case	Pass	None
2	2	As expected with expected result in test case	Pass	None
Test Case Status	Pass			

The test result shows a positive outcome and able to notify or acknowledge a complete boot of the module or the program.

4.2.2 Introduction (After Booting of Acknowledgement)

The purpose of this test is to ensure the robot will perform the speech for its introduction with animated movement at the same time. The test case being executed is Introduction Speech (TC02). The test is executed once and the test summary is presented in table below.

TABLE 4.2. Introduction Speech Test Result

Test Case Executed	TC02			
Test Case Remark	None			
#	**Test Step**	**Actual Result**	**Status**	**Remark**
1	1	As expected with expected result in test case	Pass	None
Test Case Status	Pass			

The outcome of the result shows a positive outcome and the robot is able to perform an introduction speech with the pre-requisite of a complete boot up of the module.

4.2.3 Sorting (After Booting of Acknowledgement)

The purpose of this test is to ensure the robot being able to perform the speech mechanism, speech recognition and sorting mechanism. Besides that, this test is also to verify its usability to be used repetitively. The test involves interrelated test cases that compromises of a valid input test cases and invalid input test cases. The test case to be executed is Speech Recognition Usability (TC09). The test is executed twice and the test summary is presented in two tables on both iterations.

First Iteration

TABLE 4.3. First Iteration Sorting Test Result

Test Case Executed	TC09			
Test Case Remark	First Iteration			
#	**Test Step**	**Actual Result**	**Status**	**Remark**
1	1	As expected with expected result in test case	Pass	First run - Glass as input
2	1	As expected with expected result in test case	Pass	Second run - Metal as input
3	1	As expected with expected result in test case	Pass	Third run - Paper as input
4	1	As expected with expected result in test case	Pass	Fourth run - Invalid input
5	1	As expected with expected result in test case	Pass	Fifth run - Plastic as input
6	1	As expected with expected result in test case	Pass	Sixth run - Paper as input
7	1	As expected with expected result in test case	Pass	Seventh run - Metal as input
8	1	As expected with expected result in test case	Pass	Eighth run - Plastic as input
9	1	Aluminum is recognized as glass.	Fail	Ninth run - Invalid input
10	1	As expected with expected result in test case	Pass	Tenth run - Glass as input
Test Case Status	Pass with one failure on invalid input test case.			

In this first iteration, the testing is considered as pass though there is a failure in the ninth run on invalid input test case. The robot should respond to it as error with error message speech. The ninth run is considered to have minimal impact onto the teaching, as the teacher will be using the valid input, which is the same as what being labeled on the bin. Failure is expected, as the robot itself is not that stable when involving speech recognition but still can acceptably be used. Moreover, the likelihood of the teacher to use an invalid input would be minimal or none. Besides that, the reason of having the invalid input test case is just to notify that the input is invalid and not recognizable if an accidental invalid input occurrence happened.

Second Iteration

TABLE 4.4. Second Iteration Sorting Test Result

Test Case Executed	TC09			
Test Case Remark	Second Iteration			
#	**Test Step**	**Actual Result**	**Status**	**Remark**
1	1	As expected with expected result in test case	Pass	First run - Paper as input
2	1	As expected with expected result in test case	Pass	Second run - Invalid input
3	1	As expected with expected result in test case	Pass	Third run - Paper as input
4	1	As expected with expected result in test case	Pass	Fourth run - Glass as input
5	1	As expected with expected result in test case	Pass	Fifth run - Metal as input
6	1	As expected with expected result in test case	Pass	Sixth run - Plastic as input
7	1	As expected with expected result in test case	Pass	Seventh run - Glass as input
8	1	As expected with expected result in test case	Pass	Eighth run - Invalid input
9	1	As expected with expected result in test case	Pass	Ninth run - Metal as input

10	1	As expected with expected result in test case	Pass	Tenth run - Plastic as input
Test Case Status	Pass			

The second iteration is done to ensure the use of speech recognition is stable. The outcome of the result is positive and all the runs had succeeded. As compared to the first iteration, the invalid input test case had shown a positive result. On the other hand, the second iteration indicate that the likelihood of the error to occur is minimal and the valid input test case, which is being treated as critical, had shown no error throughout both of the iterations.

4.2.4 Teaching and Learning Evaluation

The teaching and learning evaluation is conducted in Taska Permata Seri Iskandar in Seri Iskandar, Perak, with the presence of a teacher and ten students that get involve in the evaluation. Ten students were being divided into two groups, consisting of five students of the age between three and four years old respectively. There are ten items provided that compromises of paper, glass, metal and plastic materials, as a constant variable for the students to sort it into three recycle bins, which are labeled accordingly as paper bin, glass bin, and plastic and metal bin. All of the bins are labeled according to the commonly used and available publicly in Malaysia, for simulating the real environment in smaller scale and demonstration purpose in teaching and learning environment. Details of the evaluation are in the following section.

4.2.4.1 First Group Evaluation Result

The first group consist of four years old students, which being group without robot intervention for teaching, as of first run. The teaching session is conducted by explaining to the students about recycling, introducing the recycle bin and how to correctly recycle the item into the proper bin. After the completion of teaching session, the learning session is started by giving the students on the opportunity to sort the given items into the recycle bin with less guidance by the teacher. At the same time, the students' recycling action is recorded on how many items are successfully being sorted into the correct bin and how many unsuccessful sorted items.

The second run is done with the intervention of the robot as assistive teaching tool for the teacher during the teaching session. The robot demonstrates on sorting the item into the correct recycle bin. The second run is done to identify if there is any significant improvement that would impact on their learning process against previous teaching and learning session, which is without the intervention of robot during the teaching session. Similar to the first run, the students were given another opportunity to sort the item into the recycle bin with less guidance by the teacher and the students' sorting action is recorded. The results of both runs are presented on the Table 4.5 and Table 4.6.

FIGURE 4.11. Teaching Session of First Iteration for First Group

FIGURE 4.12. First Iteration Sorting of First Group

TABLE 4.5. First Run of Sorting Action Result for First Group

Student	Recycle Item	Status
A	1	Correct bin
	2	Correct bin
B	1	Correct bin
	2	Correct bin
C	1	Wrong bin
	2	Wrong bin
D	1	Correct bin
	2	Correct bin
E	1	Correct bin
	2	Correct bin

FIGURE 4.13. Teaching Session of Second Iteration for First Group

FIGURE 4.14. Second Iteration Sorting of First Group

TABLE 4.6. Second Run of Sorting Action Result for First Group

Student	Recycle Item	Status
A	1	Correct bin
	2	Correct bin
B	1	Correct bin
	2	Correct bin
C	1	Correct bin
	2	Correct bin
D	1	Correct bin
	2	Correct bin
E	1	Correct bin
	2	Correct bin

4.2.4.2 Second Group Evaluation Result

The second group consists of students with the age of three years old. This group session involves the intervention of the robot in the teaching session. The robot is being used as an assistive teaching tool for the teacher. The teaching session is conducted similarly to the first group, such as explaining about recycling, introducing the recycle and how to correctly sort the item into the proper bin. Besides that, the robot demonstrates on sorting the item into the correct recycle bin. The learning session started after the completion of the teaching session. Similarly, the learning session involves on the students to sort the item into the recycle bin with less guidance by the teacher. The students' sorting action is recorded. The result of the second group is presented on the Table 4.7.

TABLE 4.7. Sorting Action for Second Group

Student	Recycle Item	Status
A	1	Correct bin
	2	Correct bin
B	1	Correct bin
	2	Correct bin
C	1	Correct bin
	2	Correct bin
D	1	Correct bin
	2	Wrong bin
E	1	Correct bin
	2	Correct bin

FIGURE 4.15. Second Group

FIGURE 4.16. Second Group Teaching Session

4.2.4.3 Discussion on the result of teaching and learning evaluation

The result of the first group in the first run shows eight successful items being sorted into the correct recycle bin while having two unsuccessful sorted items that being sorted into the wrong recycle bin. Supposedly, the student should sort the plastic and metal item into the plastic and metal recycle bin or the orange recycle bin. Apparently, the student paid less attention during the teaching session but eager on sorting the item into the bin. However, in the second run of the first group with the intervention of the robot in the teaching session, the result shows a significant improvement compared to the first run. The students have correctly sorted all items into the correct recycle bin.

From the finding of the results, the presence of the robot had significantly improve on the absorption of the understanding on the students about recycling, especially being able to sort the item into the correct recycle bin. Besides that, the students exhibit more interest onto the subject matter with the existence of the robot as assistive teaching tool, which is sorting items into the correct bin and paying more attention onto it. Apart from that, the presence of robot as assistive teaching tool for the teacher had encourage the students to be more participative in the second run, as compared to the first run.

As of the second group, the result had shown that nine items are correctly being sorted into the correct bin while having only one unsuccessful sorted item. Apparently, the unsuccessful sorted item, which is a plastic, should be sort into the plastic recycle bin. Instead, the plastic was being sorted into the glass recycle bin. This is due to the confusion of the student on having to sort the item into the shared bin of different type of materials, which led onto sorting the plastic into the glass bin. Somehow, it indicates that the student is more familiar if the item is to be sort in specific bin without having to share the bin with different type of item, such as separating the plastic and metal bin by distinguishing it. However, the commonly used available bin in Malaysia presented the recycle bin for metal and plastic as one recycle bin, which is presented in orange color.

Comparatively, the intervention of the robot in the teaching session had shown a great improvement in the learning process of the students. The students had shown an interest of learning with the presence of the robot and able to sustain the interest of the students to pay more attention than without the presence of robot as assistive teaching tool for the teacher. Other than that, the students are thought to be more visual-oriented in their learning process as the students' literacy in reading is relatively low.

In contrary of the second group with the first group, the second group had shown only nine successful sorted items compared to the first group that successfully sorted all the items with the presence of the robot in the teaching session. Nevertheless, the relative difference between both of the results are due to the teaching session in the first group is conducted twice compared to the second group.

Besides that, the use of English language as the main language for the communication medium with the robot had influence on the outcome of the sorting demonstration by the robot. The students are not able to understand what the robot had mentioned unless with the teacher’s translation.

Apparently, result of a direct intervention of the robot would improve on the teaching and learning process with the presence of the robot as an assistive teaching tool. On the other hand, the students exhibit more interest with the presence of robot and able to sustain their concentration, as well as their interest on the subject matter, which is recycling.

Moreover, the intervention of the robot as assistive teaching tool would be more effective with the customization of the robot to be able to communicate accordingly to the language used for medium of communication in the teaching and learning session that is based on the preferred language used in the school, such as for this case study, Malay language. Apart from that, the students exhibit on having more interest towards animated movement of tangible things, which is the robot, and interactive approach that promotes on two-way communication in the learning process.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Summary

In conclusion, the finding from the project on the use of the NAO robot as an assistive teaching tool for the teacher in early childhood education, which focuses on pre-school students, is able to sustain the young children or students' attention to become more attentive during teaching session by the teacher, as compared to without the use of the robot as assistive teaching tool.

Besides that, the use of NAO robot, which is also a humanoid robot, is able to capture the interest of the young children to learn and promote on the participation of the young children in learning session due to the interactive features of the robot, such as animated movement and talking feature.

Apart from that, the findings from the project have shown the proposed approach had significantly present improvement on the teaching and learning process in early childhood education. Relatively, it has also shown that the proposed approach is able to positively increase the absorption of knowledge from the teaching and learning session.

Nevertheless, the proposed approach will be able to nurture the interest of the young children to practice recycling and promote the curiosity to understand the importance of recycling. Moreover, the approach is able to promote public awareness on the importance of recycling whereby it is being introduced at young age. In addition, the product is ready to be used in the real environment with the supervision of the teacher.

5.2 Recommendation

It is recommended that the teaching module should be able to fit into the surrounding of the teaching and learning environment in terms of language used as it will provide a better outcome and understanding in delivering the information or message towards the students, as well as ease of use in communication. Relatively, this would be dependent on the locality of the language available in the robot.

Besides that, future improvement could be done on being able to recognize the type of items before proceeding onto sorting the item into the correct bin, in order to make it more interactive and reducing the chances of error in delivering the information to the students which currently depend on speech recognition to sort the item into its designated bin. Moreover, the improvement could also be done on the stability of speech recognition on the robot itself.

Apart from that, it is better to distinctly distinguish the type of items into one bin rather than sharing multiple types of items with the same bin. For example, the plastic and metal bin, which are made as one recycle bin. This is to avoid any confusion by the young children in identifying the recycle bin and to better improve their understanding.

In addition, this project could be extended to focus on special children with extensive and specific module on the program, as well as the approach itself.

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APPENDIX

Appendix 1 – Snapshot of Questionnaire

Greeny : A Robotic Approach As An Aid for Early Childhood Education

This questionnaire is conducted as part of the survey being made for a study to develop a module on teaching aids for the educator to teach the students about recycling and improve the awareness about recycling using NAO Robot. Your participation in this survey is highly appreciated. All informations will be kept confidential.

* Required

I am a ... *

Please specify gender.

◯ Male
◯ Female

I am in the age group of ... *

Please specify age group that you belong to.

◯ Below than 13 years old
◯ 13 - 17 (years old)
◯ 18 - 29 (years old)
◯ 30 - 45 (years old)
◯ Above than 45 years old

I am a/an ... *

◯ Student
◯ Educator
◯ Executive Officer
◯ Self-employed
◯ Unemployed
◯ Other:

Are you familiar with the term 'green' and recycling? *

◯ Familiar
◯ I have heard before
◯ Not familiar with it

How often do you recycle? *

◯ Always
◯ Seldom
◯ Never

Have you ever been involved in a recycling program? *

◯ Yes
◯ No

I have always discussed about the importance of recycling to my family or friends, and even strangers. I think recycling is important. *

- ◯ Highly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Highly Disagree

What are the item(s) mainly being recycled by you? *

- ☐ Paper
- ☐ Plastic
- ☐ Aluminium Can
- ☐ Glass
- ☐ Electronics
- ☐ Other: ______

Do you think in Malaysia, we practice recycling all the time? *

- ◯ Yes
- ◯ No

Do you think early childhood (playschool, kindergarten) exposure to recycling would be good and be able to improve the awareness on the importance of recycling? *

This question explains on the exposure of recycling in the early age.

- ◯ Yes
- ◯ No

I think the use of NAO Robot to teach or learn about recycling would attract children to know more about recycling and practice it. *

NAO Robot is illustrated on the top.

- ◯ Highly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Highly Disagree

Appendix 2 – The Screenshot of The Coding