DESIGN AND ANALYSIS OF CANSAT MODULE FOR EDUCATION

by

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ENDORSEMENT

I, Nur Juliana binti Ahmad Johari hereby declare that all correction and comments made by the supervisor and examiner have been taken consideration and rectified accordingly

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DECLARATION

This thesis is the result of my own investigation, except where otherwise stated and has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any other degree.

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Date:

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DESIGN AND ANALYSIS OF CANSAT MODULE FOR EDUCATION

ABSTRACT

Design and Analysis of CanSat Module for Education is a project focuses on the development of STEM education space-based technology tools for educational purpose initiated by the USM Space System Lab (USSL). A research on CanSat Kit for Education (CakEd) is a way of teaching and learning fundamental of space education to secondary school students using a CanSat or can satellite in soda can size that can be launched from a rocket, drone or a balloon. The system of the satellite including a control system, telemetry system, power system and payload system. This project focuses on integrating of learning and teaching module for CanSat which consist of hardware, software and web based learning system. Improvement for the hardware requires a new structural design of CanSat using design software Solidworks for the latest electronic module packaging. A GUI system for CanSat user with a web based learning system is developed to provide a systematic data collection system from telemetry system of CanSat. The end process of integrating elements of CanSat by fabricating and packaging of CakEd. This study also investigates the effectiveness of CanSat teaching and learning module through outreach program. Improvement can be done afterwards based on the feedback and recommendation from user. At the end of the study, a complete CanSat Kit for Education produced and ready to be commercially used.

REKABENTUK DAN ANALISIS MODUL CANSAT UNTUK PENDIDIKAN

ABSTRAK

Reka Bentuk dan Analisis Modul CanSat untuk Pendidikan adalah projek yang berfokuskan kepada pendidikan STEM menggunakan teknologi angkasa yang diasaskan oleh USM Lab Sistem Angkasa (USSL). Kajian mengenai CanSat Kit for Education (CakEd) adalah satu cara untuk mengajar dan mempelajari asas pendidikan angkasa untuk pelajar sekolah menengah menggunakan CanSat atau satelit dalam ukuran tin minuman soda yang boleh dilancarkan dari roket, drone atau balon. Sistem didalam satelit termasuklah sistem kawalan, sistem telemetri, sistem kuasa dan sistem muatan. Projek ini menumpukan kepada mengintegrasikan modul pembelajaran dan pengajaran untuk CanSat yang terdiri daripada perkakasan, perisian dan sistem pembelajaran berasaskan web. Peningkatan perkakasan memerlukan rekabentuk struktur baru CanSat menggunakan perisian reka bentuk Solidworks untuk pembungkusan modul elektronik terkini. Sistem GUI untuk pengguna CanSat dengan sistem pembelajaran berasaskan web dibangunkan untuk menyediakan sistem pengumpulan data sistematik dari sistem telemetri CanSat. Proses akhir mengintegrasikan kit CanSat adalah dengan fabrikasi dan pembungkusan CakEd. Kajian ini juga mengkaji keberkesanan modul pengajaran dan pembelajaran CanSat melalui program jangkauan. Penambahbaikan boleh dilakukan selepas itu berdasarkan maklum balas dan cadangan daripada pengguna. Pada akhir kajian, Kit CanSat untuk Pendidikan yang lengkap akan siap sepenuhnya dan sedia untuk digunakan secara komersil.

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CHAPTER 1

INTRODUCTION

This chapter gives an overview of the project and introduces the importance and validity of the problem. The research objectives have been derived as a guide to be attained for the project.

1.1 Background study

CanSat Kit for Education (CakEd) is a teaching and learning module initiated by the USM Space System Lab (USSL) in 2017. The main objective for this project is to implement STEM education for secondary school through space technology. This project mainly to enhance secondary school student's interest towards STEM subject.

The term STEM education refers to teaching and learning in the fields of science, technology, engineering, and mathematics. It typically includes educational activities across all grade levels, from pre-school to post-doctorate in both formal and informal setting (Kuenzi, 2012). In line with the Malaysian Blueprint document, the decline of enrolment and quality of the student in STEM are mainly due to several reasons included limited awareness of STEM, value of STEM learning and relevance to daily life, perception of students and parents that STEM subject i.e. Science is harder to excel than Arts stream, current STEM curriculum lack relevance to everyday life, teacher-centered teaching and learning approaches, lack sufficient opportunities to be critical, creative and innovative, limited and outdated resources. (Ismail *et al*, 2017) One of the key elements in STEM education is defined by letter 'E' which means Engineering. There are various ways to apply STEM education through engineering program. One of the most common integration of engineering is by relating it to the technology and its application through the mathematics and science knowledge. Robotics and programming is one of the example of STEM education program that integrated all the STEM elements. Some studies show that through robots, some daily life related problems may be posed, and student may be asked to find solutions to these problems. Through this problem-solution process, student can use different skills that may be attributed to different fields of STEM (Çetin & Demircan, 2018). Internationally, space education also has been part of the alternative to teach and learn of STEM education. The most common is via the outreach program at elementary to secondary school. The most common teaching method for an outreach program is through outdoor activities including an explorace related to space topic, build-up any space technology model such as water rocket and mini satellite, and experiment on the model built and making analysis.

Recently, a popular space based education project known as Can Satellite (CanSat) has been developed globally around the world. CanSat is Soda can size satellite. CanSat is fundamental concept in teaching space engineering to undergraduate students. In CanSat projects, students will be able to design, build and test a small electronic payload that can fit inside a Soda can. The CanSat can be launched and ejected from a rocket or a balloon. By the use of a parachute, the CanSat slowly descends back to earth performing its mission while transmitting telemetry. Post launch and recovery data acquisition will allow the students to analyze the cause of success and/or failure. (Khalil Ibrahim, 2011). Up to now, this pico-satellite has been used for educational purposes and have demonstrates their importance in the academic programs of most of faculties specialized in aerospace and inter-disciplinary areas (Colin, 2017). The CanSat that provides benefits in an affordable way to acquire the students with the basic knowledge to many challenges in building a satellite with low operational cost giving the ideas to develop an educational kit suitable for secondary school. Even though the kit already available overseas, the local-made of CanSat kit is still sought to widen space technology for STEM education in our country.

1.2 Problem Statement

In recent years, STEM education mentioned as one of the main components that shape Malaysian education to serve the goals of 2020. In Malaysia, STEM education still lacking in various way especially in regular school educational system. Thus, this thesis focuses on Malaysian student and educator to enhance their interest in STEM education through space technology. Space technology to be conducted here for the thesis is a pico-satellite which is Can Satellite (CanSat). This thesis also focuses on the developing of CanSat kit for education (CakEd) to be used as one of the space technology product for STEM education in Malaysia. CanSat is a simple satellite project that widely used globally for educational purpose but not in Malaysia. Since there is still no CanSat kit available in Malaysia, the invention of CakEd is to provide an affordable space education kit for Malaysian educational purpose compare to the product from oversea which is higher in cost.

1.3 Objective

The objectives for this research are:

- to integrate learning and teaching module for CanSat consist of hardware, software and web based learning system. The module should comply with the improvement of oldest version to the latest version of CanSat module.
- to assess the effectiveness of CanSat teaching and learning module for secondary school students.

CHAPTER 2

LITERATURE REVIEW

This chapter presents a critical review of literature related to the project. The review includes the information of others' research and studies to the subject related to the project.

2.1 STEM education analysis

The achievement of students in Mathematics and Science is asses based on world knows assessment, Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assestment (PISA). The assessment for TIMSS conducted for every four years to assess student's ability in two aspects such as algebra and geometry, and cognitive skills (thinking process of knowing, applying and reasoning). The score for TIMSS 2011 shows that Malaysia ranked 26^{th} for mathematics and 32^{nd} for science subject among other 59 countries. However, the mean score is below the international average. Figure 2.1 and Figure 2.2 shows the results from TIMSS analysis for mathematics and science respectively for year 1999 to the latest 2011.

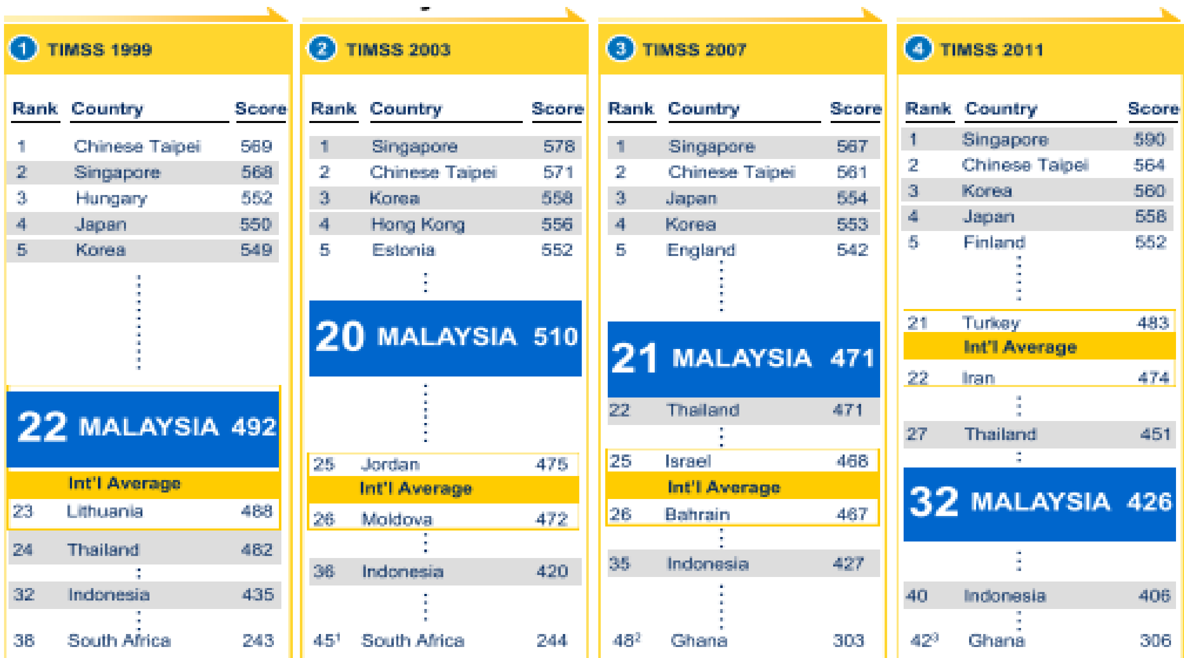

Figure 2. 1: Malaysia's performance in TIMSS for Mathematics against other countries over four cycles (Source: TIMSS 1999.2003,2007,2011)

Figure 2. 2: Malaysia's performance in TIMSS for Science against other countries over four cycles (Source: TIMSS 1999.2003,2007,2011)

As for PISA coordinated by the Organisation for Economic Co-operation and Development (OECD) conducted for every three years to evaluate proficiency in reading, mathematics and science in student aged 15 years old. The focus is on the student's ability to apply their knowledge in real world setting. The result shows that Malaysia has been ranked 57th for Mathematics and 52nd for Science and the score is not achieve the international average. Figure 2.3 shows the outcome from the PISA international ranking among other 74 countries taking part in the most recent assessment in year 2009.

1 Reading

Rank	Country	Mean score
1	Shanghai-China	556
2	South Korea	539
3	Finland	536
4	Hong Kong	533
5	Singapore	526
⋮		
26	Hungary	494
	OECD Average	
27	Portugal	497
⋮		
42	Russian Fed.	459
	International Average	
43	Chile	449
⋮		
52	Thailand	421
⋮		
54	MALAYSIA	414
⋮		
61	Indonesia	402

2 Mathematics

Rank	Country	Mean score
1	Shanghai-China	600
2	Singapore	562
3	Hong Kong	555
4	South Korea	546
5	Chinese Taipei	543
⋮		
24	Austria	496
	OECD Average	
25	Poland	495
⋮		
41	Croatia	460
	International Average	
42	Israel	447
⋮		
52	Thailand	419
⋮		
57	MALAYSIA	404
⋮		
67	Indonesia	371

3 Science

Rank	Country	Mean score
1	Shanghai-China	575
2	Finland	554
3	Hong Kong	549
4	Singapore	542
5	Japan	539
⋮		
20	United States	502
	OECD Average	
21	Republik Czech	500
⋮		
40	Greece	470
	International Average	
41	Malta	461
⋮		
51	Thailand	425
⋮		
52	MALAYSIA	422
⋮		
65	Indonesia	383

Figure 2. 3: PISA 2009+ ranking against other countries (Source: PISA 2009+)

In the PISA assessment, below minimum proficiency means in mathematics, students unable to employ basic algorithms, formulae, procedures or convention. They also not capable to do direct reasoning and literal interpretations even though they can answer clearly the questions involving familiar context. In science, based on PISA means that the students have very limited scientific knowledge that can only be applied to a few familiar situations. They able to present scientific explanations that follow explicitly from the given evidence, but will struggle to draw conclusions or make interpretations from simple investigations (‘Malaysia Education Blueprint 2013 - 2025’, 2013).

Engineering generally is the natural integrator to the STEM education. Learning engineering requires the student to be able to have at least a basic knowledge of science, mathematics and technology. Integrating all the three elements in STEM is the basic component to master on engineering elements. Basic skills in science such as able to understand the science concept behind each scientific situation and able to analyze and apply the knowledge are necessary in engineering. Additionally, skills in mathematics also required to be able to catch up with engineering element which most of the engineering work task related to calculation of some engineering elements. Lacking in science and mathematics skills means that it will obviously effect on the learning progress in engineering. As from the research found by TIMSS and PISA shows that Malaysia still lacking in various way both in teaching and learning method of science and mathematics.

Based on the research data from Ministry of Education (MOE) Malaysia stated that in the year of 2011, only 45% of students graduate from the science stream, including technical and vocational programmes. Decreasing for secondary school students who met the requirement to study science after PMR and not to do so increasing to 15%. The results contrast with the Ministry’s target ratio of 60:40 of Science/Technical: Arts to have secondary school students for related field. Based on the estimation from the National Council for scientific Research and Development that Malaysia will need 493,830 scientist and engineers by 2020.The Ministry of Science, Technology and Innovation (MOSTI) estimates that there will be shortfall of 236,000 people as for the human resources needed for scientist and engineer by 2020 ('Malaysia Education Blueprint 2013 - 2025', 2013). The declining in the number affected by the lack of student's interest in STEM stream. Table 2.1 shows the existing ratio and production rate of Science and Human capital versus target.

Table 2. 1: Existing ratio and production rate of Science and Human capital versus target (Source: Academy of Science Malaysia; Ministry of Science Technology and Innovation (MOSTI))

Level	2012		2020	
	Ratio	Production rate (Quantity/year)	Ratio	Production rate (Quantity/year)
Science student in secondary school	30%	135,000	70%	315,000
Science student in tertiary education	40%	40,000	70%	70,000

Table 2.1 indicates the ratio of science stream student in secondary school and tertiary education which is 30% and 40% respectively in year of 2012. In comparison with the year of 2020 it shows the ratio is 70% which is much higher than 2012. The target seems to be unpromising to be achieve with the declining in student interest in STEM. Studies in 2010 stated that in the industries unskilled workers represent 75% of total workforce and quarter of it have qualification in tertiary education. Only 28% of skilled employee are in high skilled bracket. Shortages in critical profession such as engineers, scientist and research and development (R&D) personnel are limiting

the evolution of current industries. Because of that reason, it is crucial for the educational stakeholder to make sure STEM would be the choice for the students in their studies (Ali, 2018).

The Ministry of Education Malaysia has written in the Malaysia blueprint of education, to ensure to prepares students with the skills required in STEM to able to meet industry and country development requirements. The measures that must be taken include raising student interest through new learning approaches and an enhanced curriculum, sharpening skills and abilities of teachers, and building public and student awareness.

2.2 Space Based Education Program for STEM

Many efforts have been made to increase the awareness on STEM subject among students in school. Advancing STEM education requires collaboration from many parties such as industry players, educators, policy makers and families (Ismail *et al*., 2017)). Aerospace engineering is not a core subject in school, but the elements of astronautic, space technology and space science includes in the syllabus in Malaysian school's textbook. Space based topic usually can be found in physics, pure science and some in mathematics subject. Since, space is not the core subject in school globally, most of the aerospace organization actively participated in most of the STEM program and supporting the STEM education. It is a trend in the world globally to have an outreach program for almost every grade level from elementary school to post-graduate level. Space education are relevant to be implemented in STEM education because of the space education itself able to complete all the STEM element with required skills for the students involved in STEM stream.

There is a program known as Lunar Ecosystem and Architectural Prototype (LEAP 2) and its collaboration space-based STEM program funded by NASA called as Lunar Caves Analog Test

Sites (LCATS) (Ximenes et al., 2018). These program organized to expose to the local community about STEM education through the space-based educational program. In additional, the most popular space-based educational program is High Altitude Balloon also known as HAB. This outreach program is normally conducted in team and reached out to schools and higher education institutions.

2.2.1 LEAP2/LCATS

The Lunar Ecosystem and Architectural Prototype (LEAP2), is a commercial lunar site development program being developed by an international consortium of aerospace industry organizations investigating technologies for lunar settlement (S. W. Ximenes, 2013). This project organized together with the industry, academia and government organization. LEAP2 project in their outreach program highlighted to strives for establishment of an inclusive local community sponsored space program for STEM education, community workforce development and entrepreneurship. They used a project-based learning in their LEAP2 education initiative where focuses on application in advancing the body of knowledge for site development of planetary pits and lava tube (development of Marius Hills Skylight) as a commercial prototype for understanding how to use the planetary features to the benefit of human settlement on distant planets. (Ximenes et al., 2018)

Next, is Lunar Caves Analog Test Sites (LCATS) for Space-STEM Learning Performance is a program funding by NASA. This program is a program developed by a non-profit WEX Foundation organization of San Antonio, Texas. LCATS is a program that provides Space-STEM learning experiences in space exploration using project based learning environment that work within the LEAP2 framework. This program provides the actual technology engineering and science investigation challenges throughout the various LEAP2 site development. The mission objective is to gives the students learning experience for planetary surface systems engineering and mission operations, science experiment and instrumentation, and allows student to freely generate ideas for technology concept investigation. The LCATS program engages of middle and high school students to assist aerospace professional to solve real-world space exploration technology development. A workshop conducted by the educators and undergraduate/post-graduate student acting as team mentor/team leader and supported by professional subject matter expert to guide the students also in innovative hands-on applications that provide practical solutions for LEAP2 mission in architecture challenges. This program requires the students to use their knowledge, critical thinking and problem solving skill while helped by the mentor. (Ximenes et al., 2018)

Hence, the LEAP2 and LCATS outreach program specifically for breadboard development and flight test for space technology implementation using mentor chain of professional such as engineer, scientist with educator, undergraduate, post-graduate students guiding middle and high school students make STEM program be a critical path for technology demonstration and development. (Ximenes et al., 2018).

2.2.2 High Altitude Balloon (HAB)

The outreach program in space education is normally focusing on the low cost project to make it more sustainable. The High altitude balloon is one of the common technology used to run near space experiment or research. In a local outreach program run by a group of undergraduate students from School of Aerospace Engineering, Universiti Sains Malaysia using HAB as the alternative for space based project for STEM education. This project conducted by undergraduate students, divided into two different team. One is from the team Voyage, a group of final year student and the other one is run by the space crew, a student group from Universiti Sains Malaysia space system lab (USSL). (Ismail *et al*, 2017)

The Voyage team HAB have three main objectives which one of it is to deliver a student experiment to the stratosphere. The team has visited to a primary school with student ages range 10 to 12 years old, conducted a talk on High Altitude Balloon, and space experiments. The experiment is to gives understanding of science by the space education. The experiment included build up spacecraft lander and a soda rocket. The next outreach program is at a secondary school with the school's student involvement age range of 14 to 16 years old. The main event of this outreach program is space talk, booth opening and HAB launching. The experiment from the school's student has been brought together to the stratosphere using HAB. (Ismail *et al*, 2017)

The outreach program run by the space crew start with a space talk to the selected schools for an hour also with the overview of the space camp program. Next, a space camp conducted for secondary school students. The camp conducted with objective to encourage the mind of science apprentices in exploring deeper into space environment and technologies. Throughout the camp, students were exposed to problem solving, critical thinking, generating ideas skills also introduced to space technology. Includes in the program that require students to make their own hypothesis for their experiment and analyzing data post-launch using descriptive method of how's and why's. The best four experiment then selected to be flown together with the HAB. The outreach program also provides other activities such as introduction on CanSat technology guided by expert from Space System Lab of USM. They are able to launch their CanSat from the height of 328ft above the ground. (Ismail *et al*, 2017)

Through the program, a survey conducted to the all participated students in the program. Figure 2.4 shows the result from student opinion on the knowledge gain throughout the program.

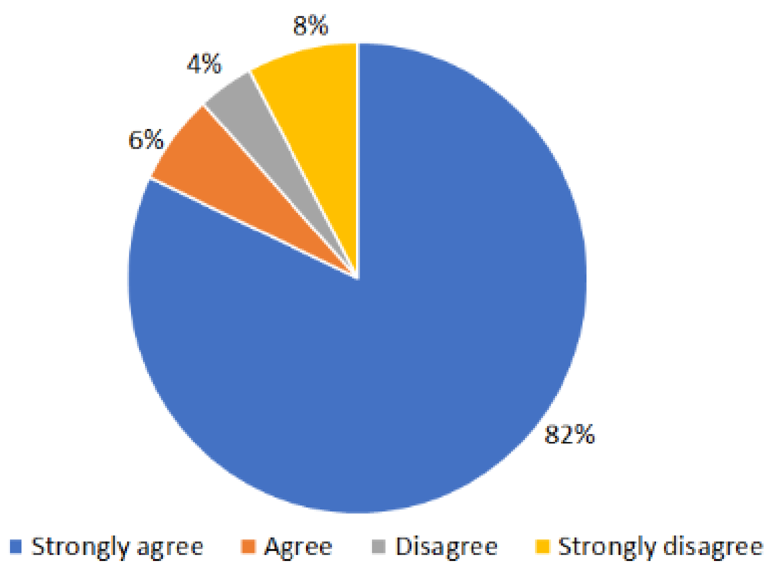

Figure 2. 4: Experience and knowledge gain

Figure 2.4 shows that the program giving a good experience and knowledge with the percentage of 79% and 16% rate for excellent. Another 5% rate for fair and little to none. Figure 2.5 shows the student's rating to the time worthiness for the program. (Ismail *et al*, 2017)

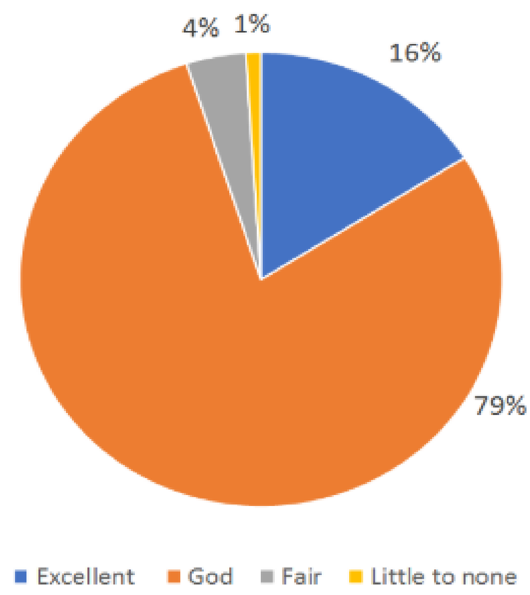

Figure 2. 5: Time worthiness of the program

Figure 2.5 shows that more than 80% of students rated strongly agree the program are time worth. While 6% rated agree. The rest rated 4% of disagree and another 8% strongly disagree that the program is time worth. (Ismail *et al*, 2017)

The study shows that an outreach program is a good alternative to implement space education for STEM education. Student interest in STEM subject can increases with various hands-on activity with new and fun learning environment to let the student experience and enjoy the real implementation of the knowledge they gain in the classroom.

2.3 CanSat for Education

CanSat is a miniature size of satellite that has been suggested by Prof. Bob Twiggs in November 1998 at the University Space System Symposium (USSS), Hawaii to adopt a can sized satellite. This challenge launched the establishment of international workshops and competitions.

In the past decade, CanSat has been used for college students which the program is a student-led satellite development projects, realizing low-cost and short term development program. During the CanSat workshop and competition provides the students with affordable opportunity for educators and student to acquire basic knowledge of space engineering and experience engineering challenges in building satellites (Khalil Ibrahim, 2011).

Study shows that, most of the space based education, specifically for CanSat will organize a workshop and competition as the alternative to promote space education for STEM education. Each year, an annual CanSat competition is arranged in USA. The competition participants are from a group of university students or high school students that will compete with each other in team. They were required to design and build a space type system, according to specifications released by the organizer (Khalil Ibrahim, 2011). The CanSat has took place globally around the world and mostly organize by educational institute and funded by aerospace industry player also the government of the country. There are several CanSat competition in America such as Texas CanSat competition and ARLISS project. In Europe, the competition known as European CanSat competition promoted by European Space Agency and focuses on high school students. In Asia, the country that already organized the CanSat competition such as in Japan organize by University Space Engineering Consortium (UNISEC), South Korea sponsored by their Ministry of Science, ICT and Future Planning, India by ARDL and also in central Asia region such as Iran and Turkey also have their own CanSat competition. Other country also includes Spain, France, Argentina and South Africa.

The CanSat space-based engineering education, challenges innovative students to get hands-on experience in a space related project. As a space engineering project, students will get experience from conceptual design, through integration and test actual operation of the system.

One of the major advantages of CanSat is the very low life cycle cost of the project. Thus, the educational institute could involve more students to space related project (Khalil Ibrahim, 2011).

Besides of competition, in US, there is also a non-government body, the Magnitude.io and UC Davis School of Education that offers an outreach program for CanSat project to any educational institute in the country. These body make use of CanSat to promote STEM education to the students by extend their in-class experience of science and mathematics. The program includes the hands-on experience build up their own CanSat and the curriculum also covers learning about instrumentation of CanSat, mission planning, data analysis, mission hypothesis, science communication and science writing ('STEM education and project based learning in Space for K12, NGSS', n.d.). Not only that, there is also a team from European country developed a CanSat kit or CANduino for ESA European CanSat Competition (ECS). However, there is no official product kit provider available for these kit.

2.4 Mechanical Structure of CanSat

The volume constraints for any CanSat design are either 350ml or 500ml can with maximum mass not exceed 1kg. Considering it is lightweight and small altitude range, a wide range of material can be use. The fabrication of the design can be use different lightweight metal or composite materials such as glass, carbon composite or aluminum (Khalil Ibrahim, 2011). But, the most common manufacturing method is by using a 3D printing method which the material strength is much higher than other materials also the fabrication process of the structure are much easier. A complex design shape also possible if using 3D printing method. This process involves the use of computer and CAD software, which enable a specialized printer to print a specific shape or part. The durability of these part depends on the type of material used to print them. A wide range of plastics, polymers, ceramics, and metals are now available to be chose based on the structure requirements. This method also provides the development of rapid prototyping of a model structure which can save time for mass production ('3D Printing is Creating the Future of Space | The Aerospace Corporation', 2019).

Other consideration of the CanSat design must consider launching method. Not to mentioned, the CanSat system consist of electronic components. The design should protect it from shocks by absorbing some of the energy generated during launch, release, parachute deployment and landing. For a CanSar does not need thermal insulation if the launch altitude not exceed 1000m and the temperature will not drop more than 6-7 degrees. Instead, a CanSat that send to stratosphere must consider thermal system since the temperature different can reach -50 degrees. A proper planning on the CanSat structure and thermal system of CanSat must be done properly. It is to ensure the electronic component can operate in high altitude with low temperature environment (Khalil Ibrahim, 2011).

For the electronic components, the PCB board should not be in direct contact with the outer surface of the CanSat (Khalil Ibrahim, 2011). It is recommended to apply soft materials such as foam or any insulating materials to absorb shock from the motion of CanSat. The space management of CanSat structure also must be done properly. It is to make sure there is space for battery, GPS module and also payload system of the CanSat such as sensors and camera. Identify the requirement for each of the electronic components and plan the positioning for each of the component suitable with their specification. Make sure a ventilation system provided for the mechanical structure of the CanSat to control the temperature of CanSat's the electronic system.

Figure 2.6 and Figure 2.7 shows the example of available 3D printed structure that has been commercially used.

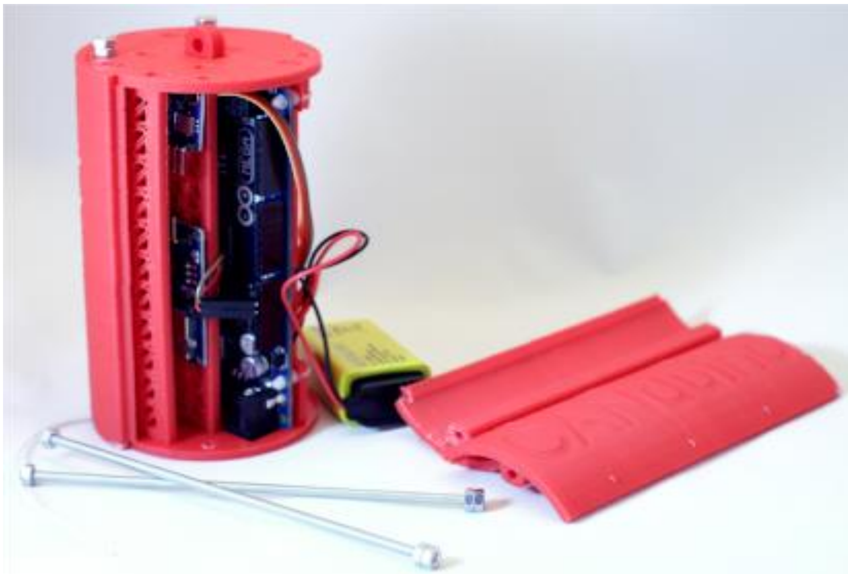

Figure 2. 6: CanSat structural design of CANduino (Source: https://canduino.eu/)

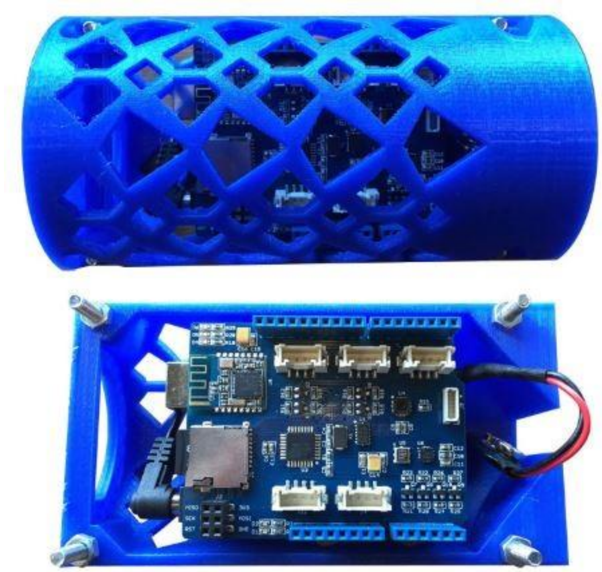

Figure 2. 7: CanSat structural design by Magnitude.io (Source: https://magnitude.io/)

Figure 2.6 is the CANduino design structure of CanSat platform specially design to meet the requirements of ESA European CanSat Competition (ECS). CANduino fabricated using 3D printing machine which the material using ABS plastic which taken about 12 hours of printing time. Figure 2.7 is the CanSat structural design by a company Magnitude.io. This structure used for their CanSat for STEM education program.

CHAPTER 3

METHODOLOGY

This chapter explains about the steps taken to complete the project. Figure 3.1 shows the flowchart for the project. It started with the task of translating teaching and learning video and at the same time, task of designing structural design based on the new electronic device packaging and teaching and module tutorial video can be conducted. Then both teaching and learning module will be uploaded into the official website of CakEd. Upon the completion of structural design, packaging and costing of CakEd will be determined. Workshop and CanSat module analysis can be conducted when the learning and teaching module, hardware and software of CakEd integrated. A modification can be made to the teaching and learning module if the analysis result does not satisfy the user standard.

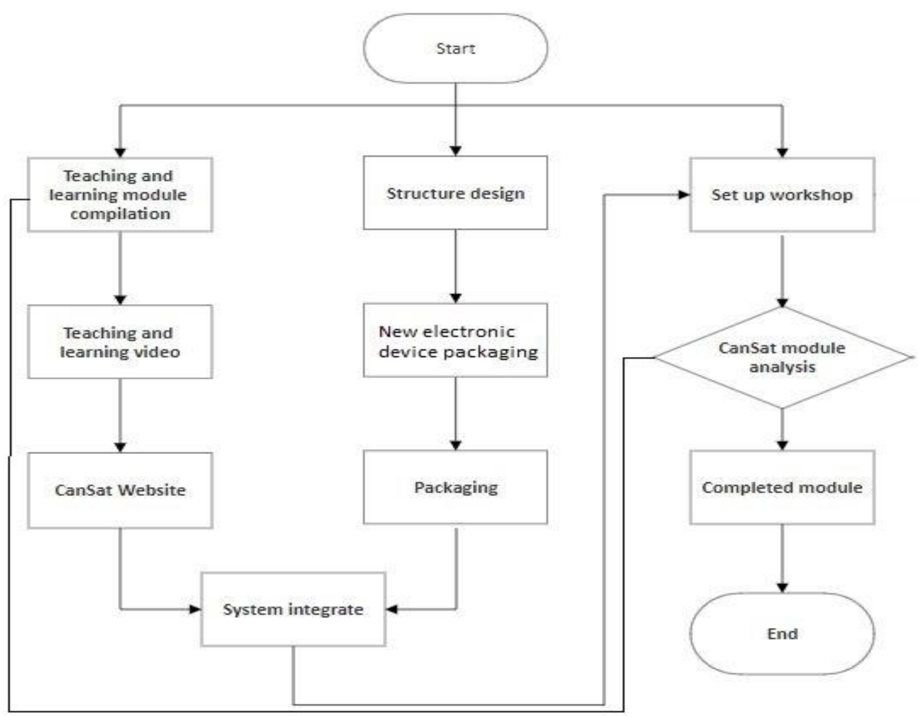

Figure 3. 1: Project's flowchart

3.1 Learning and teaching module compilation

Learning and teaching module has been developed previously in Malay language. There is a need to translate available teaching and learning module to English. The learning module is to explain the basic concept of space, space technology and its system in simplest way to the reader. As for the teaching module used by the educator, instructor or teacher as a guide to teach students about related topic such as basic concept of space and space technology. Manual for CanSat also available to conduct the project. After completing the teaching and learning module translation, the next task is to develop tutorial videos as the alternative to get more information in developing a CanSat. The videos will be uploaded to the CakEd official website at www.caked.space. Registered user will be able to access the module and videos provided. All task related to translation and editing task of the module using an open source software which is Inkscape and Microsoft Words. This work will use for the after product of print out teaching and learning module and CanSat manual will come together with the CanSat kit for education (CakEd).

3.2 Hardware design

Hardware design of CanSat includes the design of the CanSat outer structure. The structure need to be design is for the oldest version (V1) of CanSat PCB board and the latest version (V2) of CanSat PCB board. Designing software of Solidwork used to make the structural design. Before designing the structure, requirements for the CanSat structure need to determine based on the electronic component consist for each version of the CanSat kit. The structure of CanSat may consist of outer structure and internal structure. Internal structure is the primary structure for the CanSat component where all the electronic components will be mounted on it. While the outer structure or secondary structure of CanSat functioned as the casing of the CanSat kit. The method of fabrication of CanSat structure using additive manufacturing method which is the 3D printing method.

The list of electronic component for as listed in Table 3.1 and Table 3.2. The structural design of CanSat must meet the requirement for each of the electronic component such as the component positioning. Table 3.1 shows the electronic component and hardware for the internal structure of oldest version of CanSat (V1):

Table 3. 1: Electronic component for CanSat V1

No	Component	Quantity
1	Microcontroller	1
2	BMP/E 280 sensor	1
3	3dr Telemetry - Receiver	1
4	3dr Telemetry - Transceiver	1
5	600TVL Euchine Camera 5.8GHz	1
6	Euchine Wireless transceiver	1
7	Lithium Polymer battery 3.7V 1300mAh	1

Table 3.2 shows the electronic component for the latest version (V2) of CanSat:

Table 3. 2: Electronic component for CanSat V2

No	Component	Quantity
1	Main PCB (rectangular)	1
2	Top PCB (round)	1
3	Arduino Nano	2
4	3dr Telemetry – Transmitter	1
5	3dr Telemetry – Transceiver	1
6	9V 800mAh USB Rechargeable battery	1
7	9V Snap Battery connector	1
8	Sensor BMP280	1

9	GPS module	1
10	SD Card reader	1

3.3 Software Integration and Web Based Learning System

Next is to develop a GUI system for the CanSat module to provide a systematic data collection system from the telemetry system of CanSat to the user via offline or online access of GUI system. The upgraded version of GUI system enables the data collection from the basic component of CanSat payload from BMP280 and camera also from the navigation system, GPS. The oldest version of GUI system will collect the parameter of temperature, pressure and altitude and image from camera. However, the data only can be seen by the user itself. The upgraded version of GUI system offers additional parameter collected which is location and the data can be seen by the provider also with other CanSat user when it used via the online access.

The web based learning system developed for ease the student or the CanSat user to communicate with developer to discuss any issues related to the CanSat using a discussion room of forum. The content of the web based incudes information about the CanSat kit and provides a platform for the user for self-learning by download manual and learning module.

3.4 Packaging and costing

Packaging of CanSat kit include the task of design the packaging for the CanSat kit materials and making the costing budget for the kit. A packaging design detail and fabrication of packaging are necessary. Preparing overall costing for the kit includes bill of materials and training session cost.

3.5 CanSat module analysis and improvement

The data for analysis will be collected during the outreach program. A questionnaire is prepared and distributed among the students and educator during the CanSat workshop and Space Connect program by the space crew. The effectiveness of the CanSat module and STEM interest among student can be evaluated based on the feedback from the questionnaire. Any improvement can be done for the CanSat module based on the analysis result and recommendation from the user.

3.5.1 Analysis by Survey Form

There are two type of questionnaires. One to evaluate STEM education interest among secondary school students and the other one is for the CanSat kit module evaluation. A quantitative data collection method is used for both survey. It is the method to examine the relationships between numerically measured variables with the application of statistically techniques which the data quantity is the main parameter to making hypothesis out of the survey. Quantitative data collection methods are based on the random sampling and structured data collection instrumentation. The types of questionnaires for this survey is scaling questions. The CakEd survey form is distributed to the participant via online survey. It includes options for respondents to rank the available answers to the questions on the scale of given range value. The structure for the survey form as follows: