Fusion Technology and Visualisation to Share STEM Data Using PETS Robots (i-COMEL) for Open Data Readiness Amongst Primary School Children

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Abstract. The world is seeing rapid and dynamic technological innovations in the form of applications, tools, systems, or software that can help a nation's population, organisations and Government, make their administration and management more effective and efficient and most importantly at a more affordable price. Fusion technology, a hybrid concept practiced in Japan, Germany, which involves the integration of two or more technologies to develop products that can revolutionise the market. Thus, this paper highlights a fusion technology innovation (integration of vision and motion as well as analytical technologies) in the form of Box Robot application or PETS Robots that are programmable, called i-COMEL, to share STEM data in a class activity on a lesson related to Solar Systems. This activity was conducted to help primary school students enhance critical and scientific thinking through the use of Computational Thinking (CT) across STEM. In this activity students share data with other groups of students to prepare them for open data readiness. This was done through the use of PETS Robots that would use both vision and motion technologies to collect data based on the questions set, and these data were uploaded to the ThinkSpeak server on the Internet to visualise the data and displayed for all students to share during the presentation in the classroom. Learning to share data amongst the very young generation of the population, is important as Malaysia reinvents itself and moves towards a smart and digital data driven society, Malaysia 5.0. Findings of the proof of concept (POC) conducted on i-COMEL, showed that fusion technology used in the form PETS Robots and integrated with Computational Thinking (CT) across STEM for primary school students not only was a fun method of learning STEM subjects and acquiring critical and scientific skills but also an effective approach to open data readiness practice amongst primary school students.

Keywords: Malaysia 5.0 · Fusion technology strategy · Fusion technology innovation · Visualisation · Open data readiness · STEM data

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1 Introduction

As is happening globally, the 21st century, especially post-COVID19 pandemic, sees the world accepting the economy of digital innovation as something that needs to continue to happen more rapidly. Malaysia responded to the launching of the Digital Economy Blueprint (MyDIGITAL) [1] initiative. This policy outlines the importance of all sectors and groups of the population to see digitalisation and digital adoption as critical and needs to be improved at all levels: government, businesses and society. This also means that knowledge, data and technology will play a key role in ensuring that all parties: government, business and the general public can obtain, share and use data to improve the country's digital economy for the well-being of the society. To ensure that the government, businesses and the general public are data driven entities, each entity needs to be prepared to share data and use data as efficiently as possible. Therefore, the concept of open data needs to be understood by all levels of the Malaysian society as it moves towards Malaysia 5.0.

In a society such as Malaysia 5.0 [2], fusion technologies that use more than one type of technology can solve problems either in providing specific functions, control systems that can analyse situations, and make data -based decisions are inevitable. Typically, fusion technology involves the transformation of core technologies into hybrid technologies, i.e. combining knowledge from different technologies, different fields, different companies, different industries and different geographies. Research related to fusion technology can be distinguished from technology research that only focuses on one technology or one basic area commonly known as break-through approach, which is a long and horizontal technology development (linear technological development). The fusion technology approach takes over old generation technology methods while focusing on incorporating the technologies needed to build hybrid products that can revolutionise the market in this digital innovation economic era.

2 Fusion Technology and Visualisation in Digital Innovation Economy

In this digital innovation economy era, fusion technology and visualisation has become inevitable. Organisations can invest in research (R&D) based on a 'breakthrough' approach or focus on the existing fusion technology with visualisation approach. The first approach uses a sequential approach (linear), a step-by-step strategy, while the second approach is non-sequential (nonlinear), complementary and collaborative. It mixes additional technical improvements from a variety of different technology fields to create products that can revolutionise the market. For example, combining optics with electronics to create optoelectronics, which has successfully produced optic-fiber communication systems with visualisation; fusing mechanical and electronic technologies to give birth to the mechatronic revolution and visualisation, which has transformed the machine-tool industry in Japan [3, 4]. Similarly, a smart factory in Germany (which has a branch in Kulim Hitech Park, Kedah, Malaysia) produces integrated microwave chips. The process involved in producing microwave chips is extremely complicated and time

consuming. The steps involved are also too many. Thus, the plant has used fusion technology and visualisation [5–7]: augmented reality technology, virtual reality and robotic technology as well as data analytics technology that is able to visualise and determine the microwave chips in the oven are ready to be produced and packaged for marketing.

In this era of digital innovation economy too, the old adage "one technology-one industry" is no longer appropriate because breakthrough strategies are not comprehensive; companies need to combine both approaches i.e. breakthrough approach and fusion approach in the technology strategy adopted. Relying only on breakthrough approaches fails because the focus on R&D efforts is too narrow (for example, within one specialised field of electronics), ignoring the possibility of combining technologies to produce innovations in more than two areas of technology. In this paper, the emphasis is on the fusion of motion and vision-based technologies and analytical technology using PETS Robots called i-COMEL through the process of collecting, visualising and sharing STEM learning data in primary schools in Malaysia. Technology fusion application built and described in this paper, is an application that combines technology fusion in helping primary school students collect, visualise and share data based on the concept of Computational Thinking (CT) and open data for learning purposes.

The justification for the fusion of motion and vision as well as analytical technologies used in this study is to ensure that the programmable PETS Robot (i-COMEL) can see its surroundings and move as programmed and collect data as it moves and visualise it through a visualisation server to be shared by the groups in the classroom for discussion.

3 Open Data and STEM in the Digital Innovation Economy

Primary school students who are the future generation of a smart society (Malaysia 5.0) need to be a generation that is not only savvy (has digital skills), but also has knowledge of STEM in addition to the arts, and has the skills to think logically, critically, creatively and scientifically. To solve problems effectively, they need to be trained with the skills of computational thinking (CT) across STEM [8–10]. To ensure that results of problem solving are effective, primary school students also had to share as much information and data with other students. This means, open data practices should be practiced amongst students and it must begin in primary schools.

Open data (OD) in this era of digital innovation economy, includes three (3) important elements, namely: use (use), share (share) and reuse (reuse) [11, 12]. Use involves the user obtaining information or data from an authentic source and using it for a specific purpose. Sharing involves users sharing information or/and authentic data obtained with other users to solve complex or complex problems. Reuse, on the other hand, involves users using information or/and authentic data obtained to produce a new digital innovation.

STEM data was shared amongst primary school students through an activity conducted based on Computational thinking (CT). CT is a concept that was initially created to help students who are studying computer science to be able to think logically, scientifically, critically and creatively before implementing programming and coding that showed more effective results [13, 14]. However, various studies have shown that students can benefit from CT in any subject in addition to computer science subjects such as STEM subjects or literature such as Language, Geography and History. Computational

Thinking (CT), is a concept that includes elements such as logic, algorithms, composed, abstraction, plotting, visualization, evaluating and presenting [15].

4 PETS Robot Application (i-COMEL) for Open Data Readiness

As mentioned earlier, the i-COMEL application-based fusion technology strategy is a Box Robot application called PETS Robot, which was designed and built to help primary school students code and program to solve problems, whilst preparing them to practice open data readiness. This is important to prepare young students to be aware that problem solving in the present and the future is data-driven. The availability of open data for future generations is the only way that will be accepted as an authentic method and will be believed as truth [16, 17]. Thus, a validation based on a proof of concept study (POC) on the use of i-COMEL robot was implemented to ensure that primary school students can solve problems based on fusion technology strategies using COMEL teaching and learning modules to train them coding and programming using i-COMEL and at the same time encouraging them to share data.

4.1 Reengineering Design of PETS Robots: i-COMEL

PETS Robot is a Robot Box used by many overseas schools such as Taiwan, USA and Japan to teach primary school students to learn to code and program through a fun gaming approach [18, 19]; with some integrating AI technology in solving complex problems [20]. For the purpose of this study, the design of i-COMEL was reengineered to meet the objectives of the study. Figure 1 shows the re-engineered exterior design of the i-COMEL from the top view. Figure 2, on the other hand, shows the redesigned i-COMEL from the bottom view. The visible wheels allow i-COMEL to move and be controlled based on the programming done by the primary school students.

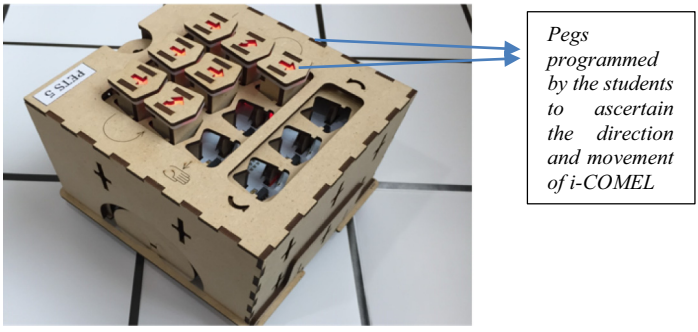

Fig. 1. Top view of the reengineered i-COMEL

To ensure that i-COMEL can move smoothly, stably, be able to collect data, able to be linked to databases in the internet, and to ensure that the data can then be visualised using online visualisation tools, it was necessary to re-engineer i-COMEL, in order to implement specific functions. For that purpose, some hardware were loaded on the Robot as follows:

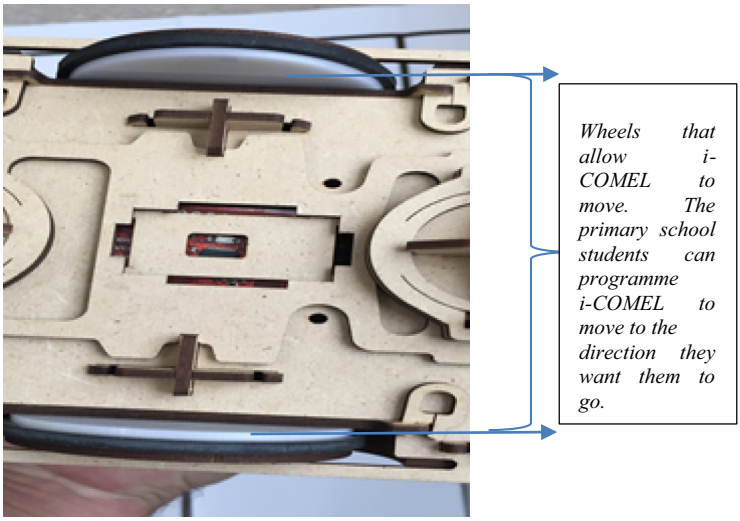

Fig. 2. Bottom view of the reengineered i-COMEL

a. Near Field Communication (NFC) card reader
b. Board ES8266
c. Rechargeable battery

The reader board on the original Robot was augmented with a Near Field Communication (NFC) card reader, plus an ES8266 board and a rechargeable battery. This allowed i-COMEL to function more efficiently and effectively. The program in the main board that existed, was modified to allow i-COMEL to detect and collect data from NFC cards using an NFC card reader. The main board on the Robot was added with an ES8266 board to enable i-COMEL to connect to the Internet via WiFi. The data collected by i-COMEL was sent to an IoT server on the internet called ThinkSpeak. The server is a visualisation tool that can visualise the data collected by i-COMEL.

The original battery was replaced with a rechargeable battery because the replaced battery had more electrical power. The combination of technology to ensure that i-COMEL can implement the fusion technology strategy on i-COMEL is very important. This is because it enabled the primary school students to perform coding and programming activities, while solving problems based on cross - STEM teaching and learning modules for open data readiness. Figure 3 shows a simple sketch showing the changes that have been implemented to i-COMEL through the reengineering process.

4.2 Design Reengineering Sketch from Internal Perspective of i-COMEL

To understand the reengineering that has been implemented on PETS Robot, i-COMEL to achieve the objectives of the study, a sketch of the design engineering from an internal perspective as shown in Fig. 4, 5, 6 and 7.

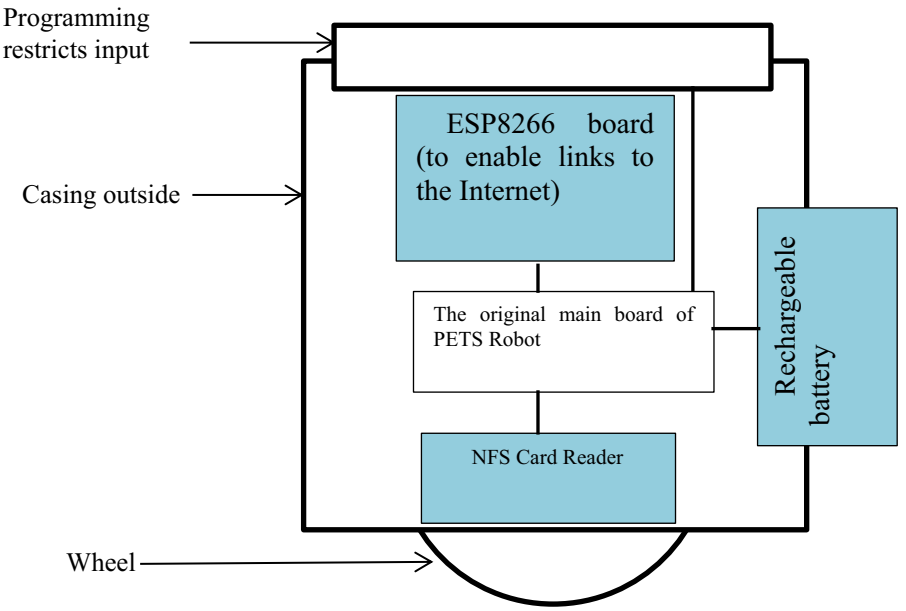

Fig. 3. Simple sketch showing the reengineering of i-COMEL.

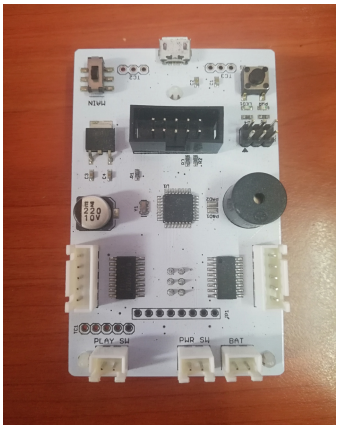

Fig. 4. PETS Robot sub-board (i-COMEL) before being reengineered

Fig. 5. NFC reader card connected to PETS Robot sub-board (i-COMEL)

Fig. 6. ESP8266 board added to PETS Robot sub-board (i-COMEL)

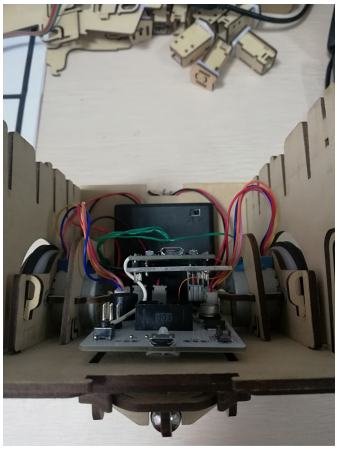

Fig. 7. Sub-board augmented with ESP8266 and NFC card reader mounted on PETS Robot casing (i-COMEL)

5 POC of PETS Robot Application (i-COMEL) for Open Data Readiness

Proof of the concept (POC) of PETS Robot application, i-COMEL for open data readiness is implemented to enable students to make simple coding and programming to move the robot in order to solve a problem and achieve a specific goal. In addition, data is collected and visualised and then shared with other students for open data readiness. Fusion technology strategies combined with analytical technology, visualization and movement technology are being extensively studied, suitable for 21st century teaching and learning use. PETS Robot also known as robot box is widely studied for primary school teaching and learning use. However, its use in the teaching and learning of coding and programming, especially in the context of CT across STEM has never been implemented both nationally or globally.

This study observed how i-COMEL was integrated with fusion technology strategy, moved, collected, visualised and shared STEM data with other students using an online visualisation server. Through i-COMEL Robot, STEM-themed data and information were shared by primary school students who contributed to the practice of open data readiness. This is a very important effort in the digital innovation economy era towards the formation of a technological smart society (Malaysia 5.0).

5.1 POC: Programming Activities Based on CT Across STEM Using i-COMEL

Teaching and learning activities using i-COMEL were implemented based on the teaching of English (Unit 9: Solar System) at a primary or elementary school called *Sekolah Kebangsaan Sri Jelok, Kajang, Selangor, Malaysia.* Five (5) PETS Robots, i-COMEL, were used in the activity implemented in a classroom at the selected school. The students were divided into five (5) groups (five (5) persons in each group). Due to the fact

that the POC needed to be implemented in detail, the detailed observational study was implemented based on only one group from Grade 4. These students were categorised as students with high academic achievement.

The students were given two sets of problems to solve using i-COMEL. Both of these problems required them to create a programming program. For both tasks, they needed to discuss in groups (using CT and TRIZ skills) and plan before programming the robot together.

The decision made must be the group decision. The first task (T1) required them to solve a given problem using linear programming and the second task (T2) required them to solve a given problem using a loop programming function. In both tasks, students had to move the i-COMEL robot on a display (board) specially designed for the movement of the robot. The display should be smooth, but can be detected by the app to stop at a specific pit stop, where students were instructed to collect as much data (points) as possible on the display. Then the students had to direct i-COMEL to move to a pit stop to upload the obtained data to the ThinkSpeak server in the internet, to visualise the data. Figures 8, 9 and 10 show a CT-based across STEM teaching and learning process session, based on fusion technology strategy and visualisation using i-COMEL.

5.2 POC: Results of Task Based Activities Using i-COMEL

Observational Results of the POC conducted on primary school students in a selected school, based on task - based activities using i-COMEL were as follows:

i. All the students (100%) acquired coding and programming skills quickly. It is assumed that they have implemented the activity based on an interesting theme and students found the theme undertaken as relevant to their lives.
ii. All the students (100%) were active and they seemed to have fun working and playing with the PETS Robot, i-COMEL. This is important because the COMEL teaching and learning model created (model has already been published earlier) based on Computational Thinking (CT) across STEM was intended to make the learning process active and fun.
iii. Majority of the students in the group (80%) learned that in the process of programming, they needed to plan the programming in advance. This involved a process of thinking as well as a process of systematic, logical and scientific discussion with peers in the group.
iv. All students in the group (100%) learned to work as a team through the division of tasks (planning, programming, re-analysing data calculations) made with those downloaded by i-COMEL online. This is a skill that is to be taught to students through the COMEL model based CT across-STEM.
v. All students (100%) successfully completed both assigned tasks in one (1) hour. This had met the expectations of the researchers. Thus, indicated that the fusion technology strategy and visualisation, through the use of i-COMEL successfully helped primary school students performed the tasks given based on the CT across STEM COMEL model.
vi. All the students (100%) appreciated how data could be shared from one device to the Internet and that the data collected can then be visualised using the online server,

ThingSpeak. This simple fusion technology strategy and visualisation, demonstrated that fusion technology and visualisation, can be applied in; a more sophisticated and complex contexts at the industry level. This had helped young students to practice open data readiness and data sharing.

5.3 POC: Improvements of Future i-COMEL

The use of fusion technology strategy through the use of PETS Robot called i-COMEL which has been validated through a Proof of Concept, found that the strategy successfully helped primary school students to learn English based on a computational thinking (CT) across STEM model. However, based on the findings, future i-COMEL can be further improved as follows:

i. The speed performance of the future i-COMEL robot needs to be improved. Four (4) out of the five (5) students (80%) in the group, indicated they felt it was a bit long waiting for the first move to be made by i-COMEL when the programmed distance was quite far.
ii. All the students, five (5) out of five (5) students (100%) in the group had agreed that the battery power used in i-COMEL should be increased so that there is no need to frequently charge the battery while performing the tasks.
ii. All the students, five (5) out of five (5) students (100%) in the group agreed that the display that can be recognised by the robot needs to be enlarged so that the robot route is more interesting and it is easier to plan the i-COMEL route in order solve the problem.
vi. The researchers realised that the databases and visualization tools need to be created on a regular basis and placed in a cloud server for use so that data can be collected and reused for other students not just from day to day, but from year to year for many years to come.
v. The researchers also realised that adding AI to the PETS Robots would make the problem solving approach more exciting and effective. Thus, future i-COMEL could be improved with the integration of AI technology (Fig. 11).

Fig. 8. Primary school students conducting T1 using i-COMEL Robots

Fig. 9. Primary school students conducting T1 using i-COMEL Robots

Fig. 10. Primary school students conducting T2 using i-COMEL Robots

Fig. 11. Primary school students conducting T2 using i-COMEL Robots

6 Conclusion

The Proof of Concept (POC) conducted on the application called i-COMEL based on fusion technology and visualisation for STEM data sharing to facilitate practice on open data readiness, was implemented amongst primary school students in a school in Malaysia. Findings of the POC showed that the strategy used was positive and the students had successfully performed the tasks assigned to them. The i-COMEL Robots successfully helped primary school students to code and do programming effectively. At the same time, these young students also acquired computational thinking (CT) across STEM skills. The fusion technology and visualisation strategy through i-COMEL Robots also made it easier for the students to share STEM data for learning purposes an exciting and innovative way. This strategy not only strengthen their STEM knowledge, but also prepares the young students to deal with data, for the future modern and smart society (Malaysia 5.0) which will be a data driven society. Therefore, the observational POC based on the task-based activities using PETS Robot, i-COMEL, implemented on year 4 primary school students, had successfully proven that the strategy used can prepare

students for open data readiness. The problem solving functionalities of i-COMEL can be further improved in the future by integrating fusion technology with AI technology.

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