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PREFACE

First and foremost, it is my honour to announce that the **Malaysian Journal of Innovation in Engineering and Applied Social Sciences (MyJIEAS)** will be starting its first publication in August 2022. **MyJIEAS** provide a platform for the discussion and knowledge-sharing on innovation in engineering and the applications of social science theories related to the livelihood and welfare of humans, particularly in engineering, environmental, mathematics, computer sciences, and social sciences issues.

MyJIEAS strives to attract and engage an international readership and authorship primarily from academic sector. **MyJIEAS** welcomes high-quality articles, either written individually or co-operatively, which will substantially contribute to the journal's development and success. Please do not hesitate to contact us for any uncertainties or inquiries.

I wish to take this opportunity to thank all the individuals involved in this publication, particularly the editorial and technical boards, for their tireless efforts in ensuring the continued success of **MyJIEAS**. Moreover, my gratitude is extended to all contributors.

Best wishes,

Dr. Marlina binti Ramli

Chief Editor, **MyJIEAS**

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Development of Short-Range Wireless Energy Transfer Module (Y-Less) for TVET Education

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ABSTRACT – One of the new developing technologies that will bring significant change to human existence is wireless power transmission using inductive coupling. The Wireless Energy Transfer Module (Y-Less) is developed as teaching and learning trainer to provision in understanding the basic concepts of wireless communication and able to support the syllabus available in educational institutions. This Y-Less design based on inductive-coupling technology, which employed two coils induce a current in the receiving circuit from transmitter coils that could be converted to usage energy reveals to the students the basic idea of what is meant by wireless communication. It demonstrates energy transfer of power supply from one point to another without any connecting cable that uses the concept of wireless. Output with $12V_{DC}$ and $5V_{DC}$ is shown in charging the phone or turning on the lamp/fan at a distance between the receiver and the transmitter up to 10 cm. The usage of inverter and USB is included in the resulting output application to enhance the technical knowledge.

KEYWORDS : energy transmission, wireless energy transfer, induction-coupling

1.0 INTRODUCTION

Teaching theories and concepts in a practical way to undergraduate students requires both a teaching and learning modality with a laboratory infrastructure. It is a general knowledge that laboratory based activities form a critical component of the overall support for teaching and learning. It would be better if students were given exposure in practical learning activities that illustrates the theoretical concepts [1]. This paper outlines the development of Y-Less module prototype based on a cheap, readily available IC component and coils that introduces the latest applications of wireless power transmission in life. Y-Less module focuses on fabricating a relatively simple, inexpensive, and reliable wireless energy transfer kit that can be used to support the teaching of communication fundamental and wireless communication. The both courses are included in the Technical and Vocational Education and Training (TVET) education level in Malaysia, which emphasizes students to have a practical skill [2].

Understanding wireless communication is a mandatory and basic thing in the field of telecommunications. It is contained in most of Engineering Course Information in Electrical Engineering field. However, the introduction to the concept or method of transmitting information wirelessly and without real medium practically makes it difficult for students to describe the processes. On this initiative, the research is done to develop the trainer to help students in understanding the concept of wireless communication. The development of a simple module but achieving the goal is necessary in mastery of the concept. The Y-Less Module is the teaching and learning trainer that can demonstrate a method of wireless energy transfer to obtain useful electricity supply from one place to another without the need of electricity transmission medium. This wireless energy transfer reveals to the students the basic idea of what is meant by wireless communication that will be learned further. This process of energy transfer involves a phenomenon known as electromagnetic induction. Microwaves can move at greater distances than simple induction coils. The receiving antenna collects the transmitted microwave energy and the converter circuit (receiver) converts the microwave energy into usable electrical energy.

Due to its rapid speed and dependable operation, wireless power transfer has made tremendous progress in its effective transferring approach. Wireless transmission is employed in cases where instantaneous or continuous energy transfer is needed, but interconnecting wires

are inconvenient, hazardous, or impossible. Wireless energy transfer technology has attracted much attention nowadays because of the capability to transfer energy from one place to another place without using any contacted wire [3]. Since the 19th century, research has been conducted in order to attain the goal of delivering power wirelessly. Wireless transmission has been used in the telecommunications industry for a long time, with various transmission methods. Radio waves, cellular broadcast, and Wi-Fi are all instances of wireless transmission [4]. Inductive coupling between transmitter and receiver, which are only a few millimetres away, is an efficient technique of delivering electricity wirelessly.

The technology of sending power wirelessly via inductive-coupling has been deemed the most effective and dependable means to transmit power across an air gap utilising weak magnetic coupling in research work over the past decade [5]. It has a high efficiency of 80-90 percent, as well as a high level of resilience and reliability. The system's main circuitry is based on the Primary and Secondary sides. Over an air gap, the power created in the primary side copper tube is inductively connected to the secondary side copper tube. The secondary coil's induced power is then redistributed to loads across it. As it provides electricity along a path of a few millimetres, distance and voltage are inversely linked. With more distance between the primary and secondary sides, the voltage starts to drop. This study focuses on the ground-breaking idea of transmitting electricity without requiring wires via inductive coupling and the behaviour of various loads.

2.0 WIRELESS POWER TRANSFER

Wireless power transmission is a technology that utilizes radio to transmit power energy, mainly through electromagnetic induction, electromagnetic resonance, RF, microwave, laser to realize non-contact power transmission [6]. The wireless power transmission illustrates a good prospect in the medical, transportation, military, aerospace, communications, industrial, electric power, energy environmental protection and other areas. The wireless power transfer is to transmit electrical energy from one point (transmitter) to another point (receiver) through the air, vacuum or other environment without the use of wires (intermediate materials) [7]. Wireless power transmission can be broadly divided into short-range wireless power transmission, medium-range wireless power transmission and remote wireless power transmission due to the different power distance that wireless power transmission can achieve. The equivalent circuit of Wireless Power Transfer system can be seen in Figure 1.

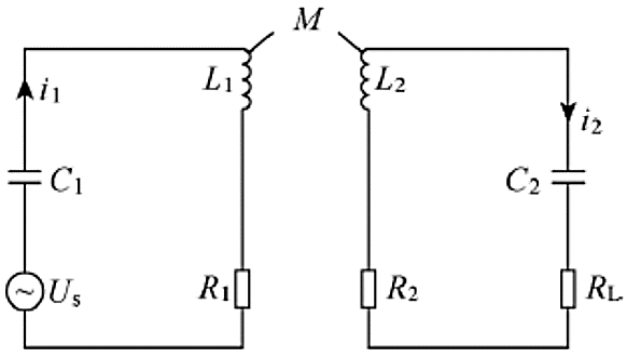

Figure 1. Equivalent circuit of Wireless Power Transfer [5]

Wireless electricity proposed in Y-Less module is based on short-range concept that work on the mutual electromagnetic induction. This inductive-coupling technology [8] of electromagnetic induction is usually used for power supply of small electronic equipment because of the limit of transmission distance. The idea of mutual induction can be used to transfer electrical power without any physical contact between the coils [9]. The simplest example of how mutual induction works is the transformer, where there is no physical contact between the primary and the secondary coils. Using a transformer coupling, the primary and secondary coils can generate induced currents which may form an alternating electric field in the medium, so that power can be transmitted via the most non-metallic materials and the energy can be transferred from the

transmitter to the receiver, enabling wireless transmission of electricity. The transfer of energy takes place due to electromagnetic coupling between the two coils as shown in Figure 2.

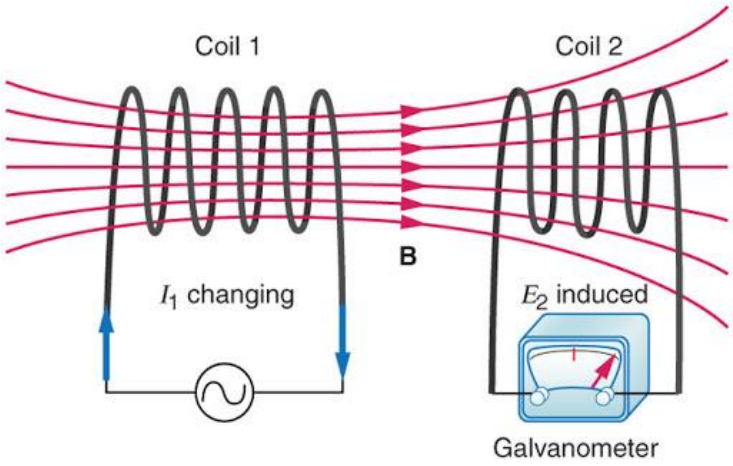

Figure 2. Mutual Induction [10]

Mutual inductance occurs when an emf is formed in a coil as a result of a change in current in a connected coil. Faraday's law describes the emf, and its direction is always in opposition to the change in the magnetic field produced by the connected coil (Lenz's law). Self inductance L causes the induced emf in coil 1. The shift in current I1 induces an electromotive force (E.M.F) in coil 2. Mobile devices or smart phone that is capable to take charge from wireless charger is also a great use of this technology. The principle can be shown in wireless telephone charger, the Splashpower recharging mat as shown in Figure 3 and Edison Electric's Power desk to recharge several devices at once [4]. The chargers use coils to create a magnetic field. Electronic devices use corresponding built-in or plug-in receivers to recharge while resting on the mat. These receivers contain compatible coils and the circuitry necessary to deliver electricity to devices' batteries.

Figure 3. A Splashpower mat uses induction to recharge multiple devices simultaneously [3]

3.0 WIRELESS ENERGY TRANSFER MODULE (Y-LESS) DESIGN

The Y-Less module is applied for short distance range, reaching at most a few centimetres up to 10 cm only [11]. Common applications include inductive charging of electric toothbrush, mp3, universal wireless power pad and other small power electronic devices. The action of an electrical transformer is the simplest instance of wireless energy transfer. The module is developed for transmitting the electrical power from a transmitting source to load wirelessly using

coils. Two coils are used, one on the transmitter side called as primary coil and another at the receiver side called as secondary coil as shown in Figure 4. The primary and secondary circuits of a transformer are electrically isolated from each other. The circuit windings, sensitively dependent upon the position of the coils relative to each other, perform ideally when the distance between the primary and secondary winding is no greater than the thickness of the primary [12].

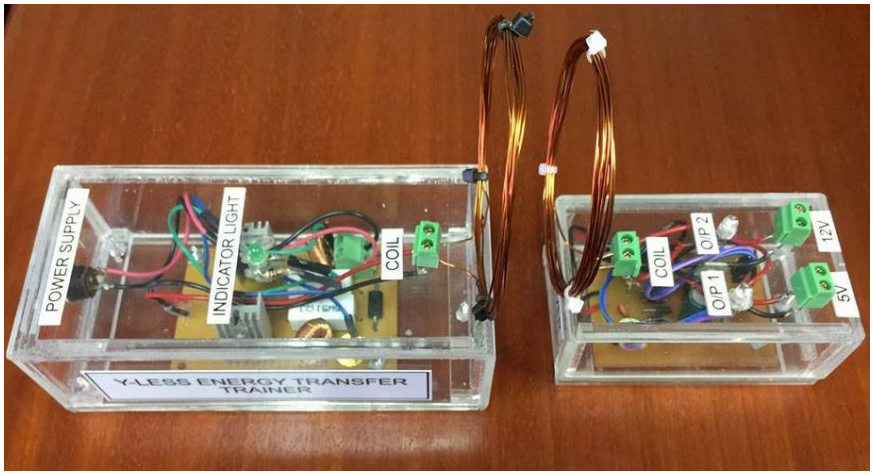

Figure 4. Y-Less Module

The transfer of energy takes place by electromagnetic coupling through a process known as mutual induction between coil. The AC power is supplied to the transmitting circuit which converts the AC Power into magnetic flux using primary coil. When secondary coil interacts with this flux, an E.M.F. will be induced in the secondary coil. In this way, electrical power will be transmitted without using wires. A larger distance between coils, stronger field could induce current from farther away, but the process would be extremely inefficient. Since a magnetic field spreads in all directions, making a larger one would waste a lot of energy. The output of the module can be connected to optical mouse for 5 V_{DC} dan to inverter and fan for 12 V_{DC} output as shown in Figure 5.

Figure 5. Output connected with 5 V_{DC} and 12 V_{DC}

The transfer of energy takes place by electromagnetic coupling through a process known as mutual induction between coil. The AC power is supplied to the transmitting circuit which converts the AC Power into magnetic flux using primary coil. When secondary coil is connected to the appliance/device at the receiving end. When the power is turned on, the transmitting coil converts the supplied input power to magnetic flux, which oscillates at specific frequency. This

magnetic flux gets induced into the coil at the receiver in the proximity to the transmitting coil, which in turn induces E.M.F. in the receiving coil. This induced E.M.F. can be used to supply power to electrical and electronic devices. The circuit diagram of the transmitter and receiver is shown in Figure 6 and 7 respectively.

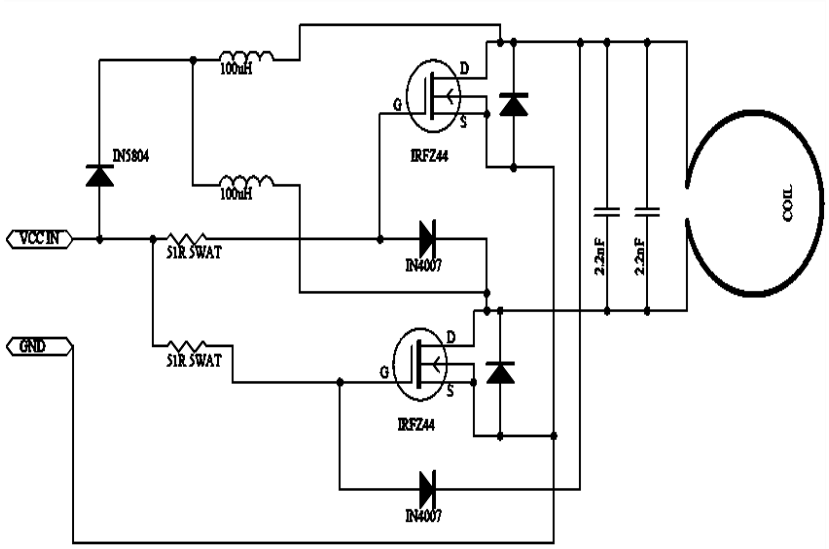

Figure 6. Transmitter Circuit

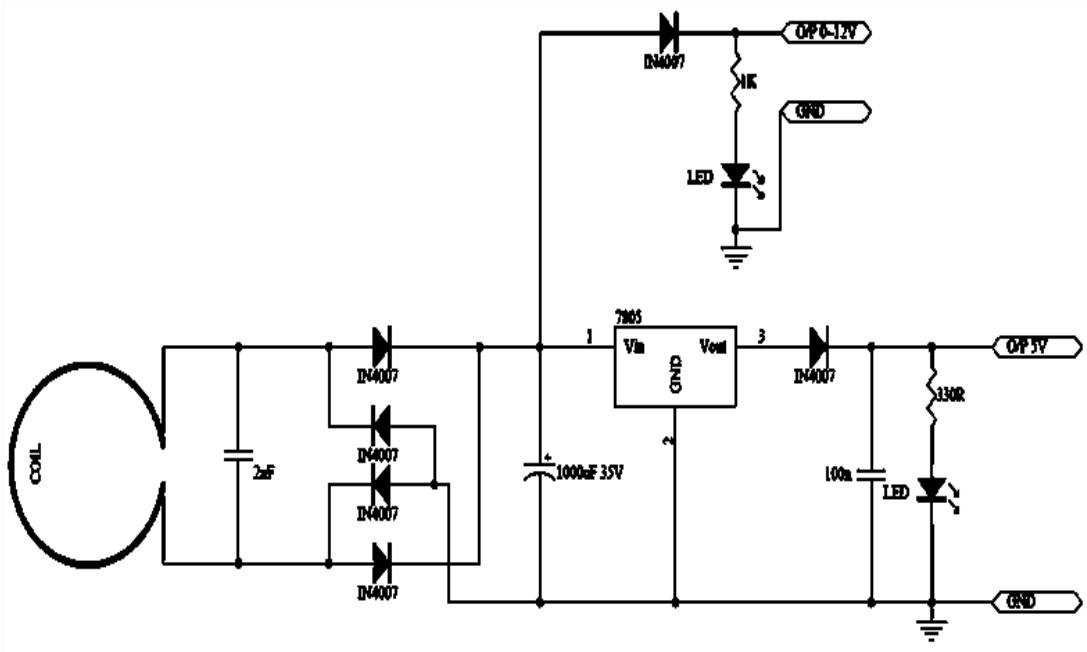

Figure 7. Receiver Circuit

5.0 MODULE EVALUATION

The development of Y-Less module is evaluated in terms of response from users such as lecturers and students. The evaluation of the module is tested the all functions specified and personal sense based on laboratory manual distributed to the experts and students, who have been involving and teaching an engineering course to answer the questionnaire of the module. The collected data were analysed through Mean Score application of required statistical techniques. The first objective was to study the response of students and lecturer towards the

development of Y-Less module in increasing the understanding of student in wireless communication. The result has been shown in the following Table 1.

Table 1: Response of Users in Mean Score

Item	Question	Likert Scale (Number of Respondents)						
		1	2	3	4	5	Mean Score	
1	Easy to use and operate	0	10	30	70	10	3.67	Student
		0	2	3	10	5	3.90	Lecturer
2	Standard of Procedure (SOP) clear and easy to understand	0	10	15	80	15	3.84	Student
		0	1	1	12	6	4.15	Lecturer
3	Labelling on trainer	0	5	5	90	20	4.05	Student
		1	1	1	10	6	3.80	Lecturer
4	Block diagram clear and easy to understand	0	10	16	85	5	3.59	Student
		2	2	3	12	3	3.90	Lecturer
5	Attractive design	2	10	25	76	7	3.63	Student
		1	3	5	9	2	3.40	Lecturer
6	Helps in understanding concept	0	0	24	90	6	3.85	Student
		1	1	3	11	4	3.80	Lecturer
7	Stimulate interest	1	4	25	76	14	3.82	Student
		0	0	0	15	5	4.25	Lecturer
8	Results of experimental are useful in improving knowledge	0	7	14	76	23	3.95	Student
		0	0	2	14	4	4.10	Lecturer
9	Suitable for individual/group	0	1	40	65	14	3.77	Student
		0	0	0	17	3	4.15	Lecturer
10	Recommended in Teaching and Learning activity	2	2	16	78	22	3.95	Student
		0	0	0	10	10	4.50	Lecturer

The interpretation of the mean score for this research is based from [13] . Referring to the data obtained from Table 1 with respect to the comment and recommended of using the trainer as a teaching aid in communication system fundamentals and wireless communication course, it was shown that most of the score for each question shows the high range value which is 3.67 to 5.00. It can be concluded that most respondents agree that the trainer developed by thorough research is benefit the students a deeper understanding in wireless communication.

5.0 FUTURE DEVELOPMENT

Induced voltage at secondary coil is inversely proportional to the distance between primary coil and secondary coil so by increasing distance E.M.F become low so we have to increase the primary coil. For future development, the module will be embedded with variable numbers of coil turns for increasing voltage with selecting high rating transformer. Besides, the advancement to the module is intended for one coil could send electricity to several receiving coils, as long as they all resonate at the same frequency. This non-radiative energy transfer involves stationary fields around the coils rather than fields that spread in all directions.

6.0 CONCLUSION

Based on the result on developing the trainer for teaching aid, it shows that the research is needed in all field especially in education for all educators. The use of trainers in teaching and learning process is welcomed by students and lecturers because it can improve student's understanding of the concept of wireless communication . By research on the content of the syllabus, existing facilities with the expertise and capabilities of lecturers, a promising result in developing the hardware/trainer for teaching, research papers, videos and so on can be produced for the use of students and lecturers.

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Development on Smart Killer Bacteria

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ABSTRACT – Nowadays, in globalization era there is always the foundation of the new technologies features every year. Smart Bacteria Killer (SBK) become the most popular features which rapidly gaining its popularity due to its importance to certain applications. The lack of system of cleanliness among doctors, nurses and visitors which expose the patients to illness have been an idea to create the device. The device is designed to create a more attractive and appealing design with low cost and affordable.. The SBK development is to kill bacteria on hands of users. This tool is designed to help doctors, nurses, patients and visitors to feel comfortable and clean while visit patient, friends or relatives. The lack of system of cleanliness among doctors, nurses and visitors which expose the patients to illness have been an idea to create the device. The device is designed to create a more attractive and appealing design with low cost and affordable. The SBK required a safety ultraviolet lamp with a wavelength of 246nm to kill bacteria. The SBK can be used to all the users such as doctors, nurses, patients and visitors at the hospital for hygiene and cleanness and also free from bacteria.

KEYWORDS : Electromagnetic, radiation, wavelength, ultraviolet, bacteria.

1.0 INTRODUCTION

Ultraviolet (UV) light is an electromagnetic radiation in 400 nm to 100 nm wavelength. It is state between visible light and X-rays [1]. The source of UV radiation was present in sunlight with 290 to 400 nm wavelength range that reaches on the surface of the earth. Electric arcs like tanning lamps, mercury-vapor lamps and black light also produced UV light [2].

Long-wavelength UV radiation can cause chemical reactions, and causes many substances to glow or fluoresce that effect on human health and environment [3]. Consequently, biological effects of UV are greater than simple heating effects, and many practical applications of UV radiation derive from its interactions with organic molecules. Though usually invisible, under some conditions children and young adults can see ultraviolet down to wavelengths of about 310 nm [4], and people with aphakia (missing lens) can also see some UV wavelength while near-UV is visible to a number of insects and birds.

UV radiation can classify into three (3) types. There were Ultraviolet long wave (UV-A), Ultraviolet medium wave (UV-B), Ultraviolet short wave (UV-C). 99% of the UV radiation was reached to the earth was UV-A. UV-A and UV-B contribute to the health hazard that because of over exposure to the sun and the most harmful was UV-C. Filtered ozone layer was UV-B. Germicidal UV-C lamps kill up of most viruses, airborne bacteria and mold spores and also mold and help prevent future mold growth [5]. Time and intensity were contributed to the exposure of germicidal UV. Fundamentally equal in lethal action on bacteria, low intensities was for a long period while high intensities for a short period [6]. Killing power decreases as the distance from the lamps increases was apply to germicidal UV regarding on the inverse square law.

i) UV-C

UV-C was suggested in this research. The beneficial of using the UV-C were efficient and safe, filters and coils, Germicidal Lamp Technology and high output Lamps. Appropriate exposure time with direct exposure to 254nm was for UV-C sterilization. As a result the RNA and DNA of microorganisms like viruses bacteria, protozoa, yeast and mold spores were in inactivate [7]. By rendering them sterile or dead the microorganism are unable to reproduce. The intensity of UV-C radiation knows as dosage with microwatts per square centimetre unit is and fluency by exposure time to that radiation [8]. It is a tool measure to determine the acceptance kill rate by measuring the total amount of UV-C energy that indicate by spectrum colour and the percentage of microorganism see. Were easier to kill compare to the Mold spores hardly to kill compare to

Viruses and microorganisms, as a result much higher dosage of UV light were required. The reading of the result was in the percentage kill of microwatts per square centimetre. Table 1 shows the dosage mold spores with percentage of microorganism sees with the different spectrum colour [9].

Table 1. Mold Spore

MOLD SPORES	Color	Microorganisms see (90%)	Microorganism see 90%
Aspergillius glaucus	Bluish green	44,000	88,000
Aspergillius niger	Black	132,000	330,000
Aspergillius flavis	Yellowish green	60,000	99.000
Mucor racemosus A	White gray	17,000	352,0000
Mucor racemosus B	White gray	17,000	352,000
Oospora Lactis	White	5,000	11,000
Penicillium expansum	Olive	3,000	22,000
Penicillium roqueforti	Green	13,000	26,400
Penicillium digitatum	Olive	44,000	88,000
Rhisopus nigricans	Black	111,000	220,000

ii) Types Of Lamp

Germicidal UV-C lamps were divided to three common types [10]. Table 2 describe the characteristic of the types of the Germicidal UV-C lamp.

Table 2. Germicidal UV-C characteristic

TYPE	CHARACTERISTIC
Slim line lamps	a. Instant-start b. Low, high- and very high-ozone types. c. Life time base on the electrode life and number of starts. d. air cooling and heating systems, conveyor lines, water sterilization e. not need to be turned off
Cold Cathode	a. instant-start b. large cylindrical cathode coil filament, c. long life unaffected by frequency of starting
Hot Cathode	a. Preheat / hot cathode b. lamps generally use standard, off-the-shelf fluorescent ballasts c. Economy and space d. Four electrical connections per lamp. e. Life time base on the frequent starts/stops.

The implementation of this project requires two phase, which is hardware and software development. Hardware development includes Smart Bacteria Killer design and how to measure the bacteria that been killed and LCD display. In software development involves the application of Proteus, PIC controller and MPLAB software in this project. There are use of hardware motion sensor. The motion sensor on the circuit will detect the present of hands in specific distance. When the sensor detect motion above of 30cm the UV lamp will light up and start killing the bacteria. Ultraviolet (UV) light is all around us even though our eyes can't detect it. Our bodies use it to make vitamin D, but too much exposure can cause painful burns and even cancer. Although UV light can be dangerous, it is also very valuable and is used in many ways. UV light is used to identify biological materials, like blood, at crime scenes and in places where sanitation is important. Because it can kill viruses and bacteria, it is also used to sterilize medical and biological research facilities and to sanitize much of our food and water.

Ultraviolet light is one type of electromagnetic wave. Electromagnetic waves are different than waves on a string or waves that you see in water because they don't need anything to travel through. They are waves of pure energy and because of this, they can travel through empty space. They also move really quickly, traveling through space at the speed of light. All visible colors of light, as well as microwaves, X-rays, and radio waves, are also electromagnetic waves. The only difference between these types of electromagnetic waves is their frequency and wavelength. Ultraviolet waves, with wavelengths from 40-400 nanometers (nm), are those that fall between visible light and X rays on the electromagnetic spectrum. Because ultraviolet light has a frequency higher than that of visible light, it carries more energy and has the ability to penetrate our skin. Prolonged exposure to ultraviolet light can cause sunburns and DNA damage, which can contribute to the development of skin cancer.

Sunlight is the greatest source of UV radiation. Man-made ultraviolet sources include several types of UV lamps, arc welding, and mercury vapor lamps. UV radiation is widely used in industrial processes and in medical and dental practices for a variety of purposes, such as killing bacteria, creating fluorescent effects, curing inks and resins, phototherapy and suntanning. Different UV wavelengths and intensities are used for different purposes.

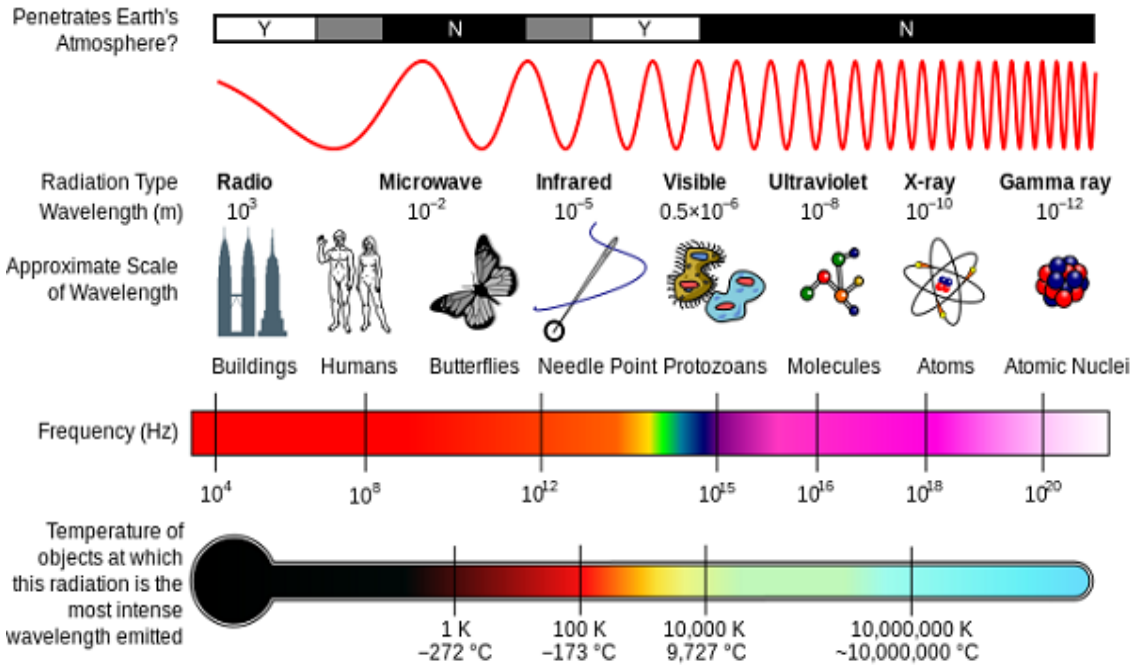

Figure 1. UV wavelengths and intensities

Effect of the UV light exposure

Some UV exposure is essential for good health. It stimulates vitamin D production in the body. In medical practice, UV lamps are used for treating psoriasis (a condition causing itchy, scaly red patches on the skin) and for treating jaundice in new born babies. Excessive exposure to ultraviolet radiation is associated with different types of skin cancer, sunburn, accelerated skin aging, as well as cataracts and other eye diseases. The severity of the effect depends on the wavelength (see Figure 1), intensity, and duration of exposure.

Effect on the skin

The shortwave UV radiation (UV-C) poses the maximum risk. The sun emits UV-C but it is absorbed in the ozone layer of the atmosphere before reaching the earth. Therefore, UV-C from the sun does not affect people. Some man-made UV sources also emit UV-C. However, the regulations concerning such sources restrict the UV-C intensity to a minimal level and may have requirements to install special guards or shields and interlocks to prevent exposure to the UV. The medium wave UV (UV-B) causes skin burns, erythema (reddening of the skin) and darkening of the skin. Prolonged exposures increase the risk of skin cancer.

2.0 METHODOLOGY

This chapter will discuss in detail on the process of the Smart Bacteria Killer development and Sensor detector Standard of Operation (SOP). The implementation of this project requires two phase, which is hardware and software development. Hardware development includes Smart Bacteria Killer design circuit and how to measure the bacteria that been killed and LCD display. The software development involves are of Proteus, PIC controller and MPLAB software in this project.

Figure 2 illustrates the flowchart of SOP procedure for detecting the percentage of bacteria. First is screening the sample under the UV lamp, if the percentage of bacteria detected. Figure 3 illustrated the block diagram of SBK. The processes were started with the motion sensor which is in direct contact to relay. When the current percentage of the bacteria above limit of 80%, the relay will turn from normally close to normally open and will send signal to A/D converter in PIC16F876A. The output will turn on the LCD 16X2 to show the current percentage of the bacteria and will turn on the UV lamp at the same time. When the percentage of bacteria is below 80%, the sensor will automatically turn the relay from N/O to N/C and the UV lamp and the LCD 16X2 will also turned off automatically.

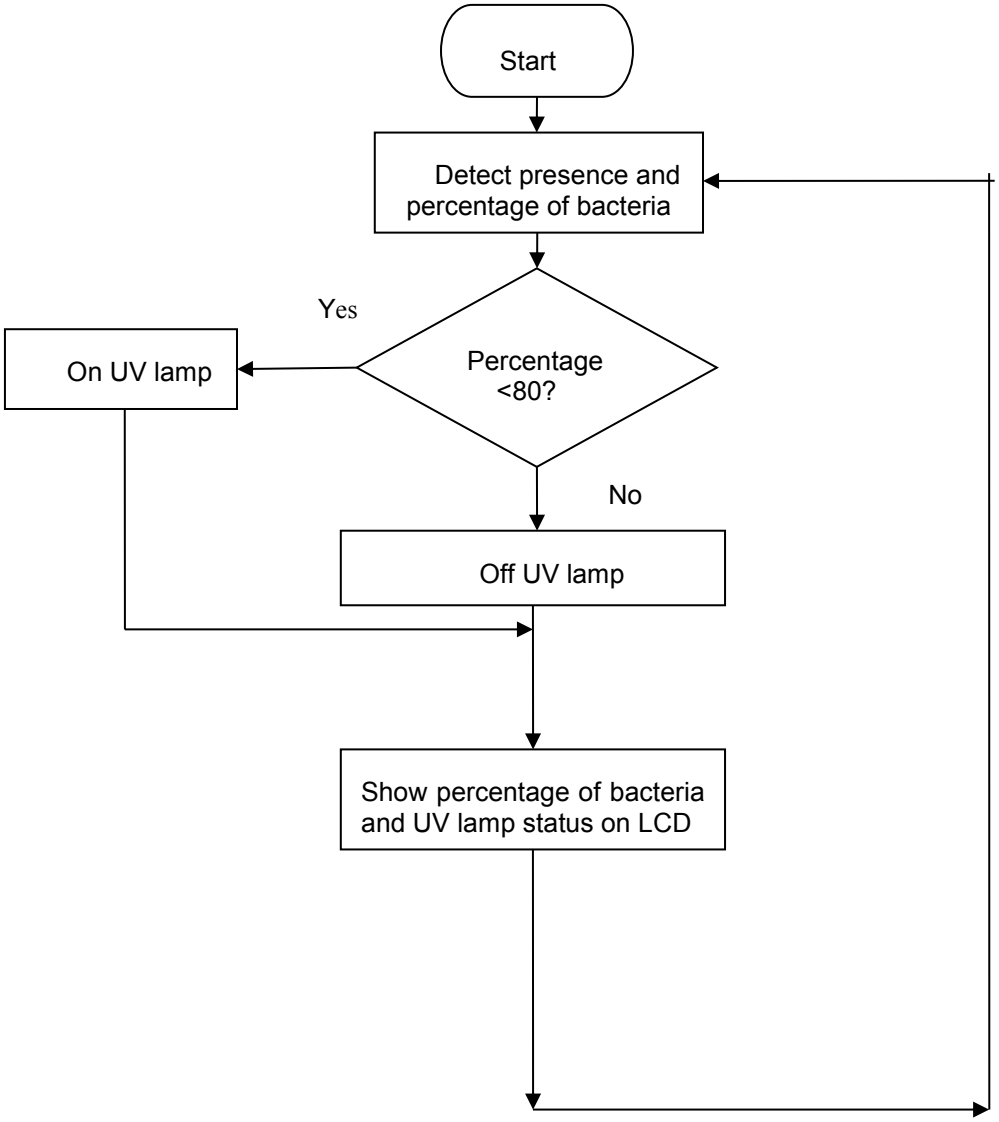

Figure 2. Flowchart of sensor detector Standard of Operation

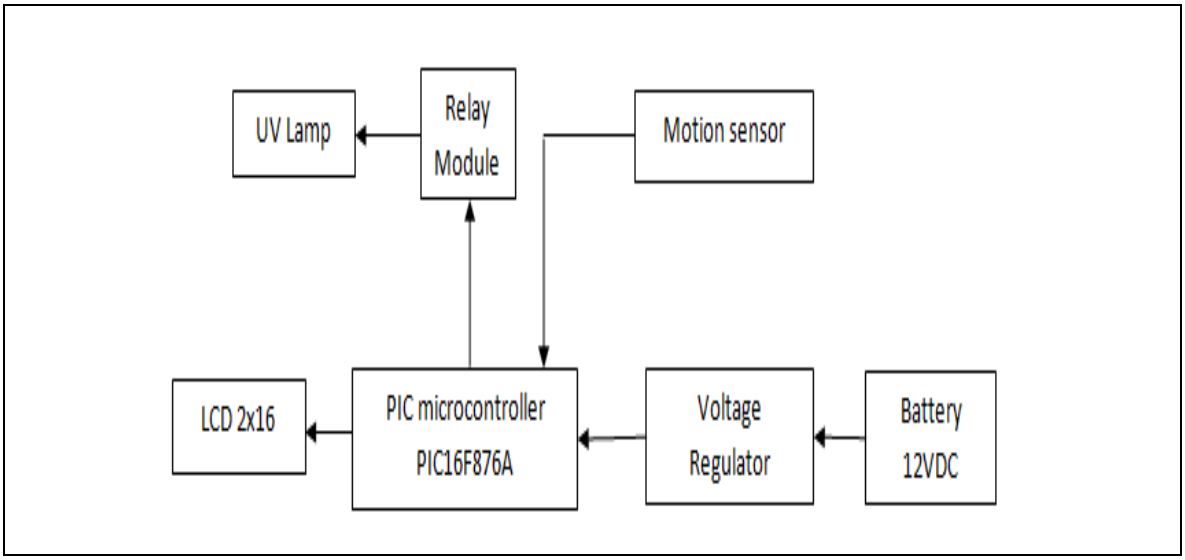

Figure 3. Block diagram of SBK

3.0 RESULT

This SBK may help people to feel comfortable and clean when entered hospitals. Besides, it can help hospital authorities to increase level of cleanliness among staffs and visitors. In addition, this project can also help to protect patients from infected by a serious disease as shown in figure 4 & 5.

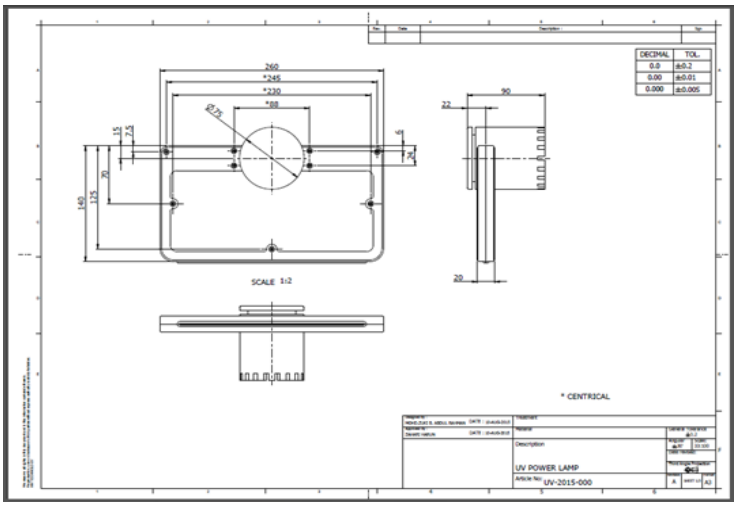

Figure 4. Design SBK

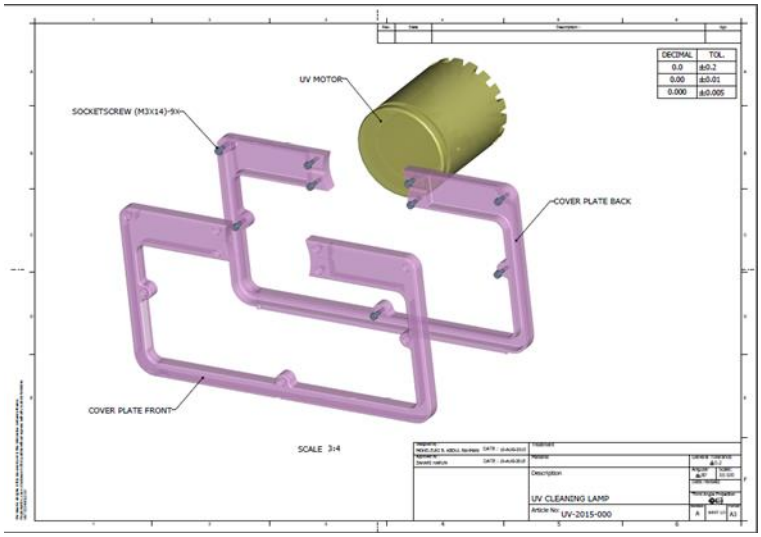

Figure 5. Development SBK

4.0 CONCLUSION

Smart Bacteria Killer (SBK) is design to detect and than kill the bacteria when the percentage of bacteria is below 80%, screening microorganisms and viruses exposure through ultraviolet that will fluencies of time and intensity. It is recommended especially in the intensive care unit (ICU) need to practices in order to make safer and maintaining health and preventing disease, especially through cleanliness means free from bacteria and so that he disease does not spread. Finally, this project gives benefit for hospital and industries because it was an innovation of something that expensive and able to reduce the cost.

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Gretel.ai: Open-Source Artificial Intelligence Tool To Generate New Synthetic Data

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ABSTRACT – Nowadays, machine learning is widely employed to solve real-world problems, particularly in medical and diagnostics fields. However, to trained a machine learning model required a massive amount of data making it challenging due to the demand access of medical data is rigid since the data is kept confidential, secure, and difficult to obtain. Therefore, this paper introduces Gretel.ai, an artificial intelligence tool for generating synthetic data that related to Autism Spectrum Disorder (ASD). The results demonstrate the proposed framework for generating synthetic data using the Autism Quotient 10 (AQ10) screening instrument growth from 1054 original records to 5000 synthetic records while preserving the primary characteristics of the originals dataset's features. Additionally, the Gretel.ai also provide a quick synthetic report that quantifies the utility on exploratory data analysis by presenting data summary statistics comparing the synthesized and the original training data comparisons.

KEYWORDS: Synthetic data, Machine Learning, Synthetic Report, ASD dataset, Synthetic tool

1.0 INTRODUCTION

Artificial Intelligence (A.I.) and machine learning solve real-world problems, particularly in the medical industry and diagnostics. This is employed to access an enormous amount of high-quality data to develop successful A.I. and machine learning models, especially for medical data. However, gathering such data is difficult due to the sensitive nature of the data, and Personal Health Information (PHI) cannot be obtained easily without permission [1]. To solve this issue, a new technology known as Synthetic Data was implemented. Synthetic data are used in many A.I. projects and machine learning models. According to [2] on the Gartner blog, by 2024, 60% of data utilized for developing A.I. and analytical projects will be synthetically generated, and consumption for A.I. projects will increase by 2030, whereby synthetic data would eventually supplant actual data in A.I. models as shown in Figure 1.

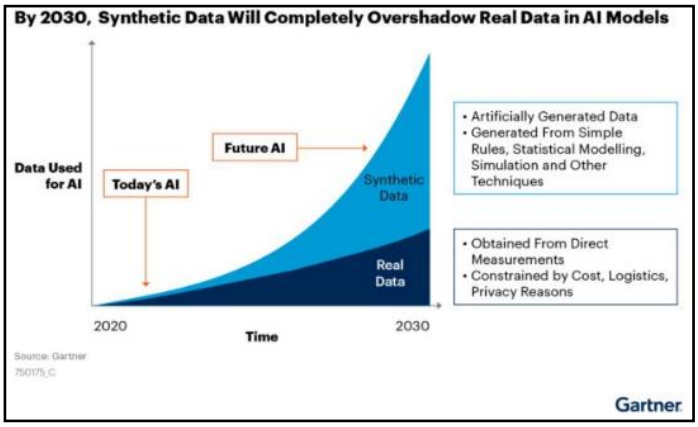


Figure 1. Synthetic Data will replace actual data in A.I. models by 2030 [2]

Synthetic data are generated artificially by A.I. algorithms rather than by actual events [3]. The synthetic data preserve the inclusive properties and characteristics of the original data [4]. Thus, the synthetic data are easily shared while preserving the privacy and security of the actual data. In 2021, more than one synthetic data vendor had advanced because of the demand for synthetic data and offering services through their platforms and APIs [5]. Figure 2 shows the list of data vendors divided into companies that offer synthetic data for structured data and others for unstructured data. In addition, more than one open-source tools are available online to produce synthetic data, for example, GenerateData [6], Synth [7], Sdv [8], Mostly A.I. [9], and Wakefield [10]. However, utilizing an open-source project may demand additional technical skills to install and utilize the library.

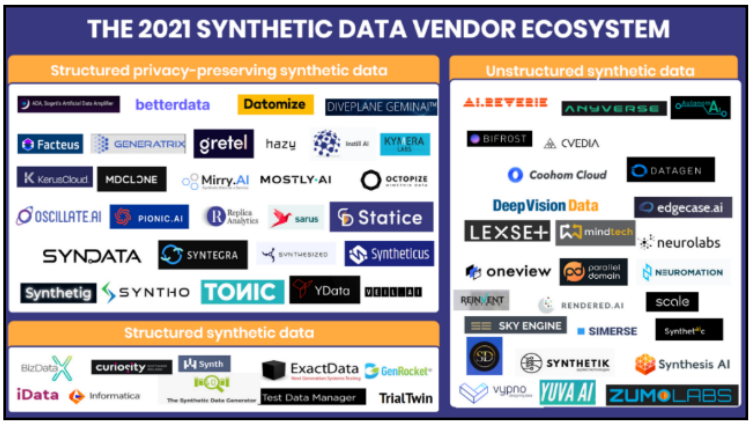


Figure 2. The 2021 Synthetic Data Vendor Ecosystem [5]

Machine learning has become a trend to solve real-world problems, especially in the medical field and disease diagnosis. Machine learning requires a massive amount of data to train a machine learning model, especially in medical data; however, the main challenges in the medical domain are how to cope with the small datasets and the limited amount of annotated records[11]. Even though there is an online data repository with many medical datasets hence, there are still small and only valid for some medical issues. In order to meet the machine learning requirements of a large dataset, the small dataset must be transformed into a massive amount dataset so that the process can be applied and transformed into useful and ageable output.

Therefore, this paper focused on Autism Spectrum Disorder (ASD) medical dataset using the Autism Quotient 10 screening tool (AQ10). The AQ10, on the other hand, has only 1054 records, and synthetic application tools can help generate and optimize datasets while keeping the original dataset features and properties unchanged. This study also shows how to use the Gretel [12], an open-source synthetic program that can conduct and generate both an original and synthetic report.

2.0 METHODOLOGY

The framework of the methodology is illustrated in Figure 3. It consists of the original input dataset with 1054 records, synthetic open-source applications, and the synthetic dataset's output. The synthetic application processes the original input data using applications algorithms and validates the training data to have a confidence quality to be used. The output is synthetic 5000 data records.

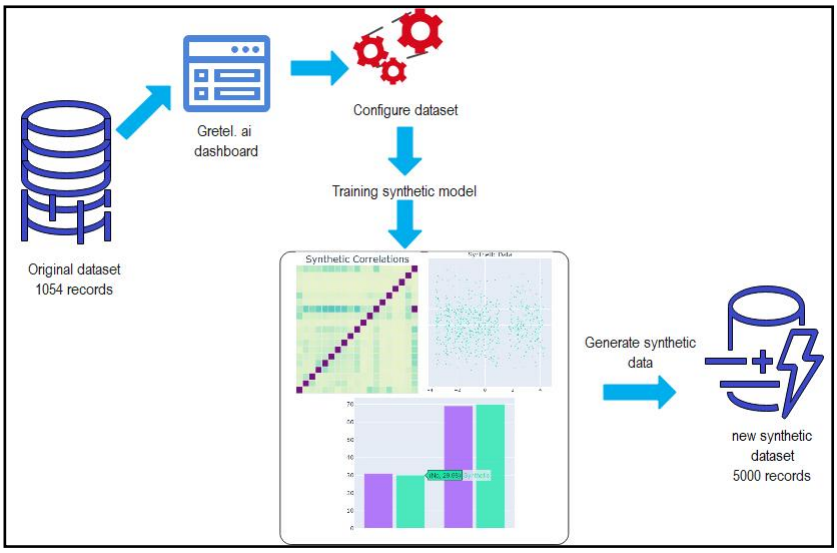


Figure 3. The framework of synthetic application

2.1 Dataset

The dataset used in this study was generated and made publicly available on the website https://www.kaggle.com/fabdelja/autism-screening-for-toddlers [13]. In addition, the website is verified and permitted to use the dataset for research context only. The detailed data description is summarized in Table 1.

Table 1. Attribute List Summary.

Attribute No	Attribute	Value
1	Case No	Number (1-1054)
2-11	A1 -A10	Binary (0,1)
12	Age_mons	Number between 12-36
13	Qchat-10-Score	Number between (1-10)
14	Sex	String
15	Ethnicity	String
16	Jaundice	Boolean (True or False)
17	Family_mem_with_ASD	Boolean (True or False)
18	Who completed the test	String
19	Class/ASD Traits	ASD / Non ASD class (String)

Table 1 summarizes the detailed description of the dataset. The name of the dataset is “Toddler Autism dataset July 2018”, which contains 1054 records and 19 variables indicating various features, ten of which are questions used to establish whether a toddler has ASD, denoted by items A1 through A10 in the table above. These ten questions are taken from the clinically validated Autism Quotient 10 (AQ10) for toddlers. The toddlers are considered positive for ASD if the score is six or above [14]. Figure 4 shows a sample of 10 records in comma-separated values (CSV) format of the Toddler dataset.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Case_No	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Age_Mons	Qchat-10-Score	Sex	Ethnicity	Jaundice	Family_mem_with_ASD	Who completed the test	Class/ASD Traits
2	1	0	0	0	0	0	0	1	1	0	1	28	3	f	middle eastern	yes	no	family member	No
3	2	1	1	0	0	0	1	1	0	0	0	36	4	m	White European	yes	no	family member	Yes
4	3	1	0	0	0	0	0	1	1	0	1	36	4	m	middle eastern	yes	no	family member	Yes
5	4	1	1	1	1	1	1	1	1	1	1	24	10	m	Hispanic	no	no	family member	Yes
6	5	1	1	0	1	1	1	1	1	1	1	20	9	f	White European	no	yes	family member	Yes
7	6	1	1	0	0	1	1	1	1	1	1	21	8	m	black	no	no	family member	Yes
8	7	1	0	0	1	1	1	0	0	1	0	33	5	m	asian	yes	no	family member	Yes
9	8	0	1	0	0	1	0	1	1	1	1	33	6	m	asian	yes	no	family member	Yes
10	9	0	0	0	0	0	0	1	0	0	1	36	2	m	asian	no	no	family member	No
11	10	1	1	1	0	1	1	0	1	1	1	22	8	m	south asian	no	no	Health Care Professional	Yes

Figure 4. Sample of 10 ASD records in CSV format

2.2 The Gretel Dashboard

In this step, the Gretel tool is used to generate synthetic data. The application is at https://gretel.ai/. To get started, sign in or sign-up email is compulsory. Figure 5 illustrates the gretel.ai dashboard.

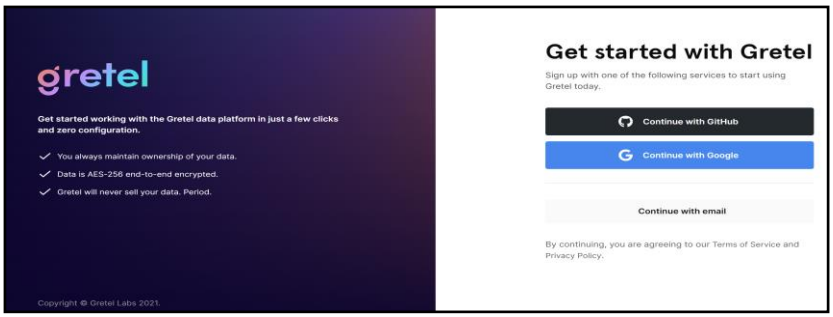


Figure 5. The gretel.ai dashboard

2.3 Generate Synthetic Data

The Gretel tool trains the data and generates synthetic data. The original data source is configured since there are no missing values in the dataset, as shown in Figure 6. Each activity states the status configured from the model created until results are generated via report form. Figures 7 and 8 depict the log activity in the gretel.ai tool application.

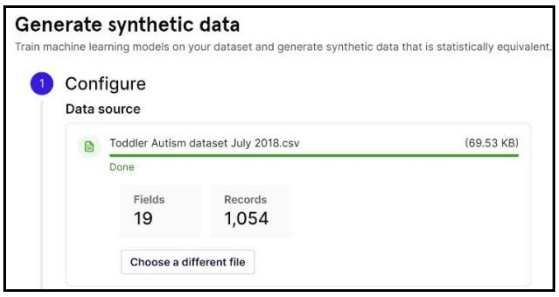


Figure 6. Configuration of synthetic data

Figure 7. The activity in the gretel.ai

Figure 8. Configuration of synthetic data

3.0 RESULT

The Gretel application produced a report, namely Gretel Synthetic Report, consisting of sections of Synthetic Data Quality Score, Privacy Protection Level, Data Summary Statistics, Privacy Protection Summary, Training Field Overview, Training, and Synthetic Data Correlation, Principal Component Analysis and Field Distribution Comparisons. Each of the sections compares the synthesized and the original training data. The report is attached with the question mark symbol for a detailed explanation of the report. Figure 9 shows the score of the Synthetic Data Quality Score that measures how well the generated synthetic data maintains the original dataset's statistical features. The statistics show that the confidence score is 97 percent, and the synthetic data is a nail for quality confidence. On the other hand, the Privacy Protection Level measures protect synthetic data against adversarial attacks, which shows a suitable protection level.

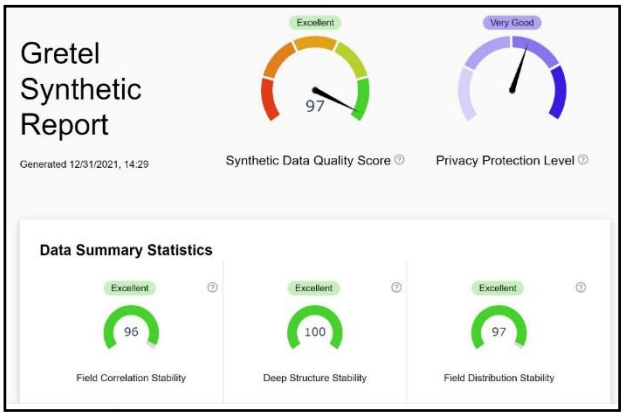
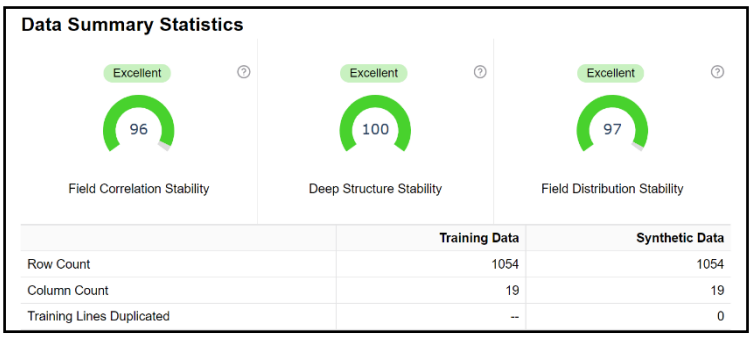


Figure 9. Gretel Synthetic Report

As shown in Figure 10, the Data Summary Statistics section includes scores for Field Correlation, Deep Structure, and Field Distribution Stability. The summary also includes the row and column counts, which are the same for training and synthetic data and have no duplicate training lines.



	Training Data	Synthetic Data
Row Count	1054	1054
Column Count	19	19
Training Lines Duplicated	--	0

Figure 10. Data Summary Statistic

Gretel's effect on the original data yielded the following data files: training and synthetic data. The synthetic data files calculated average, and the results are closer to the original dataset. The report includes a heatmap that depicts the relationships contributing to a 96 per cent score. The X-axis of the heat map is Class/ASD Traits, and the Y-axis is A9, which shows a correlation difference of 0.03, the train correlation is 0.31, and the synthetic correlation is 0.28. The higher the score shows the stability of the data to aid in the comparisons. Figure 11 shows the heat map of the Toddlers dataset.

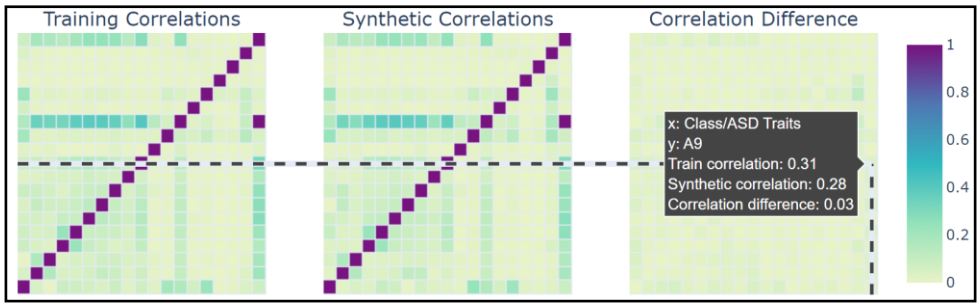


Figure 11. Heat map for the Toddlers dataset

The Deep Structure Stability checks the relationships between attributes through Principal Component Analysis (PCA). Gretel compares PCA by computing first on the original data, then comparing the distribution dependence again on the synthetic data. As a result, the 100% statistical integrity in the synthetic score given the higher score of the quality, confidence, and data distributions. Figure 12 illustrates the distribution dependence relationship between attributes.

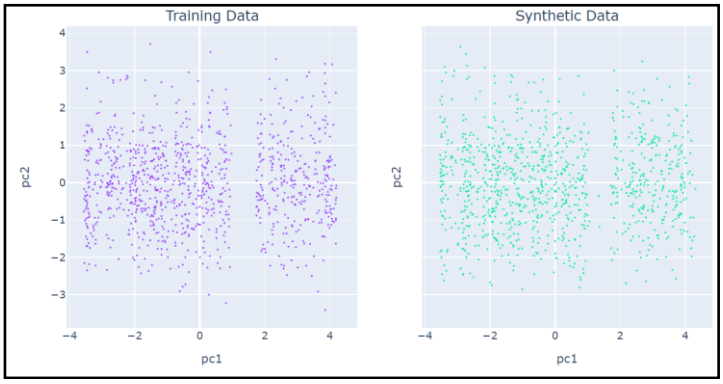


Figure 12. Distribution dependence relationship between attributes

The Field Distribution Stability statistic quantifies how the synthetic data replicates the original data. Gretel constructed a marginal histogram with a 97 percent distribution on synthetic data. As illustrated in Figure 13, the purple histogram represents the differences of original data, whereas the green histogram represents synthetic data.

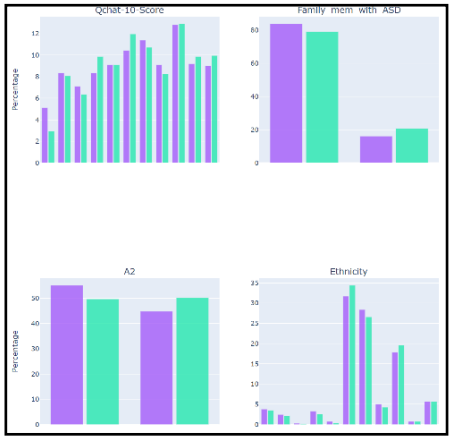
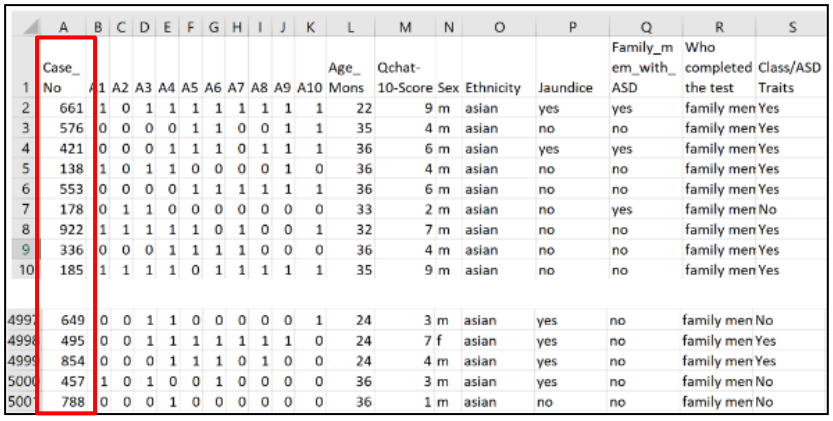


Figure 13. Marginal Histogram

The Gretel tool transformed the original data of 1054 records into synthetic data of 5000 records with 19 attributes, as shown in Table 2. Figure 14 shows the synthetic data with randomized Case No attribute displayed after training in the gretel.ai application.

Table 2. Comparison of Original and Synthetic Data Attribute.

Attribute No	Attribute	Original data	Synthetic data
1	Case No	Number (1-1054) Ascending	Number (1-5000) Randomized
2-11	A1 -A10	Binary (0,1)	Binary (0,1)
12	Age_mons	Number between 12-36	Number between 12-36
13	Qchat-10-Score	Number between (1-10)	Number between (1-10)
14	Sex	String	String
15	Ethnicity	String	String
16	Jaundice	Boolean (True or False)	Boolean (True or False)
17	Family_mem_with_ASD	Boolean (True or False)	Boolean (True or False)
18	Who completed the test	String	String
19	Class/ASD Traits	ASD / Non ASD class (String)	ASD / Non ASD class (String)



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Case_No	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Age_Mons	Qchat-10-Score	Sex	Ethnicity	Jaundice	Family_mem_with_ASD	Who completed the test	Class/ASD Traits
2	661	1	0	1	1	1	1	1	1	1	1	22	9	m	asian	yes	yes	family mem	Yes
3	576	0	0	0	0	1	1	0	0	1	1	35	4	m	asian	no	no	family mem	Yes
4	421	0	0	0	1	1	1	0	1	1	1	36	6	m	asian	yes	yes	family mem	Yes
5	138	1	0	1	1	0	0	0	0	1	0	36	4	m	asian	no	no	family mem	Yes
6	553	0	0	0	0	1	1	1	1	1	1	36	6	m	asian	no	no	family mem	Yes
7	178	0	1	1	0	0	0	0	0	0	0	33	2	m	asian	no	yes	family mem	No
8	922	1	1	1	1	1	0	1	0	0	1	32	7	m	asian	no	no	family mem	Yes
9	336	0	0	0	1	1	1	1	0	0	0	36	4	m	asian	no	no	family mem	Yes
10	185	1	1	1	1	0	1	1	1	1	1	35	9	m	asian	no	no	family mem	Yes
4997	649	0	0	1	1	0	0	0	0	0	1	24	3	m	asian	yes	no	family mem	No
4998	495	0	0	1	1	1	1	1	1	1	0	24	7	f	asian	yes	no	family mem	Yes
4999	854	0	0	0	1	1	1	0	1	0	0	24	4	m	asian	yes	no	family mem	Yes
5000	457	1	0	1	0	0	1	0	0	0	0	36	3	m	asian	yes	no	family mem	No
5001	788	0	0	0	1	0	0	0	0	0	0	36	1	m	asian	no	no	family mem	No

Figure 14. Synthetic Data with Randomized Case No Attribute

4.0 CONCLUSION

This paper investigated the existing artificial intelligence tool, the Gretel.ai, for generating synthetic data and intelligent data analysis and applications. Using the ASD Toddler dataset, which is publicly available, the proposed framework can generate synthetic data ranging from 1054 to 5000 records without changing the original features. By viewing the graphics using the ASD dataset, the tool also provides a quick report, namely the Gretel Synthetic Report, which can help quantify their utility on exploratory data analysis. With these benefits and the availability of synthetic data, it will likely become the future of Artificial Intelligence. In due course, the synthetic data will replace actual data to become primary data generation for future references.

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IOT based Non-Invasive Transcutaneous Bilirubinometer for Jaundice Prediction

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ABSTRACT – IOT based Non-Invasive Transcutaneous Bilirubinometer is the device that measures the yellowness of the skin (jaundice) by analysing the spectrum of the light reflected from the newborn's skin based on transcutaneous bilirubin (TcB) where the amount of bilirubin is measured. Jaundice is always occur in infants or newborn where the condition of the infants or newborn like the skins, eyes and other tissues of the baby becomes yellowish. The overall process involved are development of non-invasive bilirubin meter device, the method of non-invasive test conducted for transcutaneous bilirubin then the monitoring process of bilirubin level with automatic data storage of patient in smartphones. This IOT based Non-Invasive Transcutaneous Bilirubinometer device also used infrared (LED green and blue 455-575nm), photodiode (BPW21R) and colour sensor (TCS3200) that can detect the bilirubin level in the blood through the surface skin of the newborn without giving them any discomfort and pain. This device has a new upgradation system by using the MIT software application and IOT Android system that can give the result of the test conducted. The data from the test will be stored on the phone automatically and the user can keep monitoring the condition of the newborns via the phone continuously.

KEYWORDS : Jaundice, Transcutaneous Bilirubin, Colour Sensor (TCS3200), Photodiode Sensor (BPW21R), MIT Software, IOT

1.0 INTRODUCTION

The development of new technology that introduce the different method and product to detect jaundice or hyperbilirubinemia in newborns is by using non-invasive technique. Hyperbilirubinemia or jaundice occurs in 60% of healthy infants and 80% of premature infants due to elevation of unconjugated bilirubin in red blood cells [1]. Jaundice in a newborns happens due to the increased production of bilirubin and limited ability of the undeveloped liver to collect and excrete bilirubin and normally it occurs during the first week after birth. Although jaundice is not painful, serious complications may occur if elevated bilirubin level is not treated in a timely manner. The worst case that may happen to jaundice infants is severe hyperbilirubinemia that causes toxicity to the nervous system and potentially causing kernicterus or brain damage [2].

Non-invasive, transcutaneous, point of care measurement of transcutaneous bilirubin (TcB) pre discharge by multi wavelength spectral analysis, using a portable devices is clinically equivalent to measurement of TsB in a diverse, multiracial term, and near-term newborn population and predictive of subsequent hyperbilirubinemia. Hence, non-invasive bilirubin meter can overcome the problem which is the pain inflicted and discomfort to the newborns through needle prick when withdrawn the blood from the newborns. Besides, non-invasive transcutaneous bilirubinometer measures the yellowness of the skin by analysing the spectrum of light reflected by the newborn's skin using blue and green LED (455 nm & 575 nm), photodiode sensor, and RGB colour sensor with IR filter. The measurement of the bilirubin level is based on transcutaneous bilirubin (TcB) where the amount of bilirubin is measured at two different wavelength that are first, at the wavelength of 455 nm which is the maximum absorption amount of bilirubin and the absorption of haemoglobin at both wavelength, 455 nm and 528 nm.

By non-invasive transcutaneous bilirubinometer that connects via smartphone, the result of the test can be displayed instantly and it can avoid delay with discharge and indicate the need for formal SBR testing. However, this non-invasive transcutaneous bilirubinometer must be calibrate to avoid from false readings and wrong indicator.

2.0 JAUNDICE PHENOMENAL TO NEWBORN

Hyperbilirubinemia is also known as jaundice among people nowadays. Jaundice is a common problem in the first week of life to the newborn infants. This phenomenal increase in the anxiety of the parents. Haemoglobin, the red pigment in red blood cells, must undergo a succession of changes before the body can dispose of it. Specific enzymes from the body in human great processing centre, the liver, carry out each step. Bilirubin which is the yellow pigment responsible for jaundice, is a normal component in the breakdown of haemoglobin. Adults often turn yellow when they have hepatitis because their livers aren't able to process the bilirubin. The presence of enough bilirubin for the yellow pigment to be visible is called jaundice [7].

Jaundice occurs in about 60% of healthy term infants and 80% of those born prematurely. Jaundice has two different types which are physiological jaundice and pathological jaundice [6]. By definition, physiological jaundice appears between 24 to 72 hours of age, peaks by 4 to 5 days in the term and 7th day in preterm neonates and then, disappears by 10 to 14 days of life. Approximately, the level of bilirubin of newborn infants does not exceed 15 mg/dL but in some cases, if the newborn infants have 17 to 18 mg/dL of serum bilirubin, they still considered as healthy newborn. In this regard, physiological jaundice disappears spontaneously without having any special treatment. Pathological or also known as non-physiological jaundice appears in the first 24 hours and serum bilirubin is rising beyond 5 mg/deal per day. The peak level might be greater than the expected normal range. Thus, the higher readings of jaundice can lead the infants to a severe hyperbilirubinemia and can affect the newborn's health in a long period of time. They can be exposed to a liver failure problems and cerebral palsy.

Jaundice occurs due to breakdown red blood cells, the breakdown process is known as hemodialysis. If the cell breakdown rate occur at faster rate than usual, it increased the level of bilirubin in the body and causes jaundice to the infants [8]. Bilirubin concentration can be detected by using two different techniques which are invasive method and non-invasive method. Bilirubin is the yellowish pigment that is the byproduct of heme catabolism. Bilirubin is responsible for the yellow colour of the urine. When the cell is died, haemoglobin is release from the cell, which is breakdown into heme and globin, Heme is finally converting into bilirubin, an orange yellow pigment. Bilirubin is an endogenous anion derived from haemoglobin degradation from the red blood cell [3]. Bilirubin is altered by exposure to light so serum and plasma samples must be kept in dark before measurements are made. When the liver function tests are abnormal and the serum bilirubin levels more than 17 μmol/L suggests underlying liver disease.

Total bilirubin is also known as total serum bilirubin. In other words, total bilirubin also termed as any form of a yellowish pigment made in the liver when red blood cells are broken down and normally excreted with the bile. Total bilirubin is measured as the amount, which reacts in 30 minutes after addition of alcohol. Normal range is 0.2-0.9 mg/dl (2-15μmol/L). It is slightly higher by 3-4μmol/L in males as compared to females. Other than that, total bilirubin and direct bilirubin levels are measured directly in the blood of the newborn baby [9]. Direct bilirubin or also known as conjugated bilirubin is a bilirubin that is made by the liver from indirect bilirubin and can be dissolve in water. It is also measured directly in the blood. This is the water soluble fraction. Besides that, a small portion, termed delta bilirubin is the covalent conjugated bilirubin that bound to albumin. The measurement of direct bilirubin estimated the total concentration of the conjugated bilirubin and delta bilirubin [10]. This is measured by the reaction with diazotized sulfanilic acid in 1 minute and the normal range obtained is 0.3mg/dl (5.1 μmol/L). Indirect bilirubin also known as unconjugated bilirubin or hyperbilirubinemia (albumin bound) which usually results from increased production, impaired hepatic uptake, and decreased conjugation of bilirubin [11]. This fraction is calculated by the difference of the total and direct bilirubin and is a measure of unconjugated fraction of bilirubin. Unconjugated hyperbilirubinemia will arises in newborn if one of the three major pathophysiologic conditions or a combination of them occur. The three major pathophysiologic conditions are the increased bilirubin production, impaired bilirubin uptake, and impaired bilirubin conjugation.

3.0 METHODOLOGY

IOT based Non-invasive Transcutaneous Bilirubinometer design has been made in obtaining the proper accurate readings of hyperbilirubinemia. In this section, several components of the device and more detail explanation about the design and flow of constructing the IOT based Non-invasive Transcutaneous Bilirubinometer are discussed. The device's design is based on two aspects that are hardware and software. For the software part, there will be a system that will be built by using Massachusetts Institute Technology (MIT) Software [12] which is the MIT software will be the main part that will connect and synchronize the hardware and software. Besides, this device also will be connected wirelessly to the phone and the programming for data storage will be add on in this device for the upgraded point. For the hardware part, the Arduino Nano, will integrate with the software and hardware part to make sure that the both parts is connected so that the input can communicate and program to the output application.

The hardware part of the device that contain infrared sensor (blue and green LED 455 nm – 575 nm), color sensor TCS3200, photodiode sensor (BPW21R) with Arduino Nano will be tested on the newborn with jaundice. Then, the reading of the bilirubin level will be displayed on the smartphone via wireless connection. Figure 2 shows how the Recent Intelligence Non-Invasive Transcutaneous Bilirubinometer is functioned. The battery act as the source that connect with Arduino Nano. The input is LED with two different wavelengths, 455nm and 575nm, photodiode sensor and color sensor will be attached to the skin. The Arduino Nano that indicate with the input will process all the data receive from the input like the wavelength of the bilirubin level through the skin reflectance. The result then will be displayed at the LCD and also the smartphones where the smartphones will connect wirelessly with the Arduino Nano and the data of patient will be storage at cloud storage.

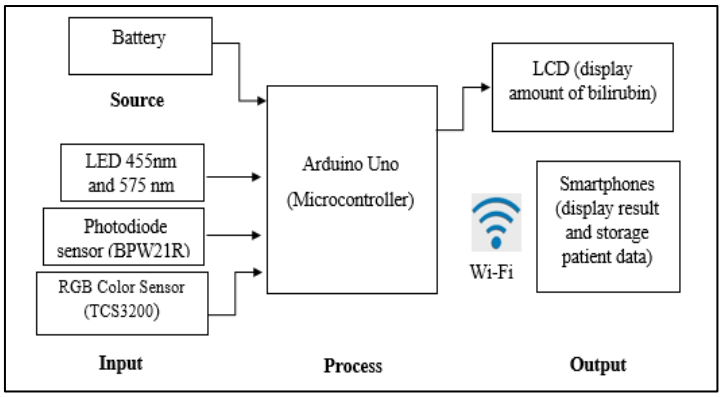

Figure 2. Block diagram of IOT based Non-Invasive Transcutaneous Bilirubinometer

Figure 3 shows the design of the IOT based Non-Invasive Transcutaneous Bilirubinometer. The design shows the picture on how the IOT based Non-Invasive Transcutaneous Bilirubinometer device will be tested on the patient and the result then will appear on the smartphone. With the use of IOT, all of patient's data will appear and can be save automatically in the smartphone.

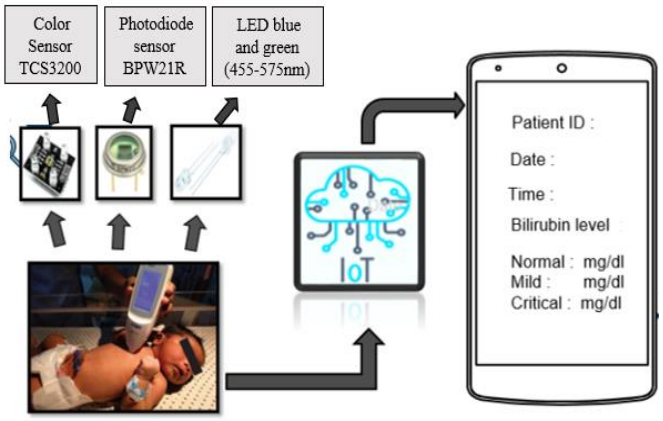

Figure 3. Design of IOT based Non-Invasive Transcutaneous Bilirubinometer

Table 1 shows the reading parameter of bilirubin level in newborns as reference for the result of IOT based Non-Invasive Transcutaneous Bilirubinometer device when being tested to the newborn in different area of the body and classified in five level for each range of bilirubin.

Table 1. Reading of bilirubin in newborns

Area of the Body	Level	Range of Serum Bilirubin	
		µmol/L	mg/dL
Head and Neck	1	68-133	4-8
Upper trunk (above umbilicus)	2	85-204	5-12
Lower trunk and thighs (below umbilicus)	3	136-272	8-16
Arms and lower legs	4	187-306	11-18
Palms and soles	5	≥306	≥18

3.0 RESULT AND ANALYSIS

The analysis of device is by referring to the research [13] that using a colour detection to detect jaundice in newborn which is the concept is similar to IOT based Non-Invasive Transcutaneous Bilirubinmeter device. The result from the research is taken as a reference for this project in testing section. Based on the research, the device is being tested on the colour sample of jaundice and each colour sample has different value of bilirubin. Thus, through the result, the amount of bilirubin in newborn and the condition of the newborn whether it is normal, severe or critical can be known. Table 2,3 and 4 are used as references and describe the level of bilirudin and jaundice. Table 2 shows the range of bilirubin level in newborn that determine whether the newborn is in normal condition or having a jaundice. The table is used as a reference to determine the bilirubin level in newborn by using the IOT based Non-Invasive Transcutaneous Bilirubinometer device. Table 3 and Table 4 each shows the result of bilirubin level based on jaundice and non-jaundice colour sample. Through this result, the stage of jaundice in newborn can be predicted and determined by referring to the Table 2.

Table 2. Reading of bilirubin level and the stage of jaundice in newborn.

Bilirubin level (mg/dL)	Stage of Jaundice
Bilirubin level < 4	Normal
4 < Bilirubin level ≤ 10	Mild
10 < Bilirubin level ≤ 20	Severe
20 < Bilirubin level	Critical

Table 3. Response for jaundiced sample.

Sample No.	Extracted skin colour of jaundiced sample	Estimated bilirubin level (mg/dl), State of Jaundice
1		17.36 Severe
2		15.23 Severe
3		9.92 Mild

Table 4. Sample colour of non-jaundice and the scale of jaundice for normal condition.

Sample No.	Extracted skin colour of jaundiced sample	State of Jaundice Estimated bilirubin level (mg/dl)
4a		Normal (<4mg/dl)
4b		
5		

The IOT based Non-Invasive Transcutaneous Bilirubinometer device readings is based on bilirubin level in range form. For IOT based Non-Invasive Transcutaneous Bilirubinometer device, the output is based on the value of intensity of blue LED and green LED of TCS3200 RGB color sensor. The value is measured and collected in the form of range to represent the range of value measured using IOT based Non-Invasive Transcutaneous Bilirubinometer device is equivalent to the range of bilirubin level (mg/dl). The stage of jaundice that are normal, mild, severe, and critical can be recorded based on the value of the intensity of blue and green LED appeared during testing the device that fits into the range of bilirubin level that had been measured. Table 5 shows the value obtained the IOT based Non-Invasive Transcutaneous Bilirubinometer device testing compared to the bilirubin color card. The device is tested at least 3 times for each color of bilirubin color card and from the result, the average value is obtained. Comparison analysis between the average value for each color of bilirubin color card is equivalent to the estimated range of bilirubin level tested by IOT based Non-Invasive Transcutaneous Bilirubinometer.

Table 5. Sample colour of non-jaundice and the scale of jaundice for normal condition.

Jaundice Colur of Newborn Image	Estimated Range of Bilirubin Level using Recent Intelligence Non-Invasive Transcutaneous Bilirubinometer	Stage of Jaundice
	29853	Mild
	43524	Severe
	53442	Severe

4.0 CONCLUSION

The IOT based Non-Invasive Transcutaneous Bilirubinometer design aims to be easy to use, efficient, economical and most importantly, not giving any pain or discomforts to the patient. Invasive method is a good technique in measuring and detecting the jaundice in early age of newborn. However, due to the risk factor on doing the blood test on the baby, the new device using latest technology and without painful is designed in determined jaundice which is by using the Intelligence Non-Invasive Transcutaneous Bilirubinometer that is more preferable and painless for testing the newborn with jaundice. By using this IOT based Non-Invasive Bilirubinometer, it can save time, user friendly, painless without any pricking needle (blood test) is needed to determine the level or readings of the jaundice among baby. The proposed device shows excellent results, generating control with a low computational cost.

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The Study of Incorporation of Fly Ash and Lightweight Expanded Clay Aggregate (LECA) in Mortar

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ABSTRACT – The utilization of supplementary cementitious material as a cement replacement has become essential for providing sustainability to concrete. Fly ash is a by-product of coal combustion in thermal power plants and contributes significant waste generation annually. Moreover, improper disposal of fly ash in landfills has resulted in environmental concerns. Due to this obstacle, fly ash is used as a recycling material for substantial modification. This study is aimed to use fly ash as a cement replacement with percentages of 0%, 5%, 10%, 15%, and 20% of fly ash by weight of cement. In the study, LECA was also introduced as a partial replacement of sand for determining the final density of lightweight mortar. The percentages of LECA used were 0%, 5%, 10%, 15%, 20%, 25% and 30% of LECA in sand. The chemical composition for both cement and fly ash using XRF testing. Four types of trial mixes were used in the study. The mortar strength was investigated at room temperature and after exposure to water curing at 7, 14, and 28 days. The results indicated that cement replacement with 5% fly ash showed an optimum strength compared to the control sample. The incorporation of 10% LECA as a replacement of sand increased the compressive strength value compared to the control sample. Both optimum results gained from those trials were used to confirm the best combination mixes for achieving mortar strength. The final trial mix showed that the final compressive strength results in brick, achieving the strength according to MS 76: 1972. It can be concluded that the application of both fly ash and LECA can be used as a partial replacement for cement and sand. These combination percentages have resulted in good strength and reduced final product density.

KEYWORDS: Fly Ash, LECA, Mortar, Strength, Density, Lightweight Aggregate

1.0 INTRODUCTION

The consumption demands of cement and fine aggregate in the construction industry increase every year in Malaysia. The Malaysian construction market is expected to register a CAGR of 4.7% over the forecast period, 2019–2024. The Malaysian construction industry registered an average annual growth rate of 7.9% in 2010–2016 [1]. Due to these developments, the demands of cement and fine aggregate have become essential to meet the demands of the construction industry. Urbanization and land development have led to increased cement production and sand mining. According to J. Muller [2], cement production is approximately 19.5 million metric tons in Malaysia. The annual production of sand and gravel was 40 million tons in 2012, and most were found in Johor, Kedah, Perak, Sarawak, and Selangor [3]. Higher consumption of these materials leads to environmental problems and human health. Manufacturing the stone-like building material is responsible for 7% of global carbon dioxide emissions, more than what comes from all the trucks in the world [4]. The pollution caused by this mass production impacted the environment and health. Recycling is an optional method for reducing waste.

Nowadays, the application of lightweight concrete has become demanding. The application of lightweight aggregates used to produce lower density concrete has advantages in reducing the self-weight of structures and provides better thermal insulations than normal-weight concrete. According to the types of aggregates, lightweight aggregates concrete can be divided into full lightweight concrete (both the coarse and the fine aggregates are light aggregates) and sand lightweight concrete (all or part of the fine aggregate is the ordinary cement). The lightweight aggregate used in this kind of concrete has high porosity, small apparent density, higher water

absorption, and lower strength. Lightweight aggregates can be divided into three types by their sources; industrial waste lightweight aggregate, natural aggregate and artificial lightweight aggregate [5]. Among artificial lightweight, the light expanded clay aggregate (LECA) is manufactured from clay as a widely available raw material that allows a process to manufacture lightweight pebbles with uniform density and better quality. It can be considered one advantage that makes it suitable for structural and non-structural lightweight concretes.

Numerous publications related to using LECA as a construction material are due to its unique properties and many applications. Most research focuses on applying LECA as a partial or complete substitution of normal weight concrete [6]. However, there is little information regarding LECA as a part of fine aggregate in mortar. Together with this study, supplementary cementitious material is also used to reduce the carbon footprint due to lesser used cement content. In this work, the research aims to utilise fly ash as cement replacement and lightweight expanded clay aggregate to produce lightweight concrete brick. The supplementary cementitious such fly ash is a waste material of coal firing In thermal plants, and its production in Malaysia was around 8.5 million tons annually [7]. This material can replace or minimise the use of cement in concrete work. The use of fly ash in brick properties provides many advantages such as being lightweight, less heat absorbed, high compressive strength and environmentally friendly [8].

On the other hand, the sand was partially replaced by lightweight expanded clay aggregate called LECA. This material is a special type of clay that has been pelletised and fired in a rotary kiln at very high temperatures [9]. LECA has been introduced instead of course aggregate for its lightweight property. The advantages of LECA include high fire resistance, relatively low water absorption, high resistance to pressing, and good sound absorption. Combining these materials with exact percentages in lightweight concrete brick is hoped to achieve sustainable compressive strength and durability for eco-friendly concrete brick.

2.0 EXPERIMENTAL PROGRAMME

2.1 Research design

The study conducted the experimental programme, as shown in Figure 1.

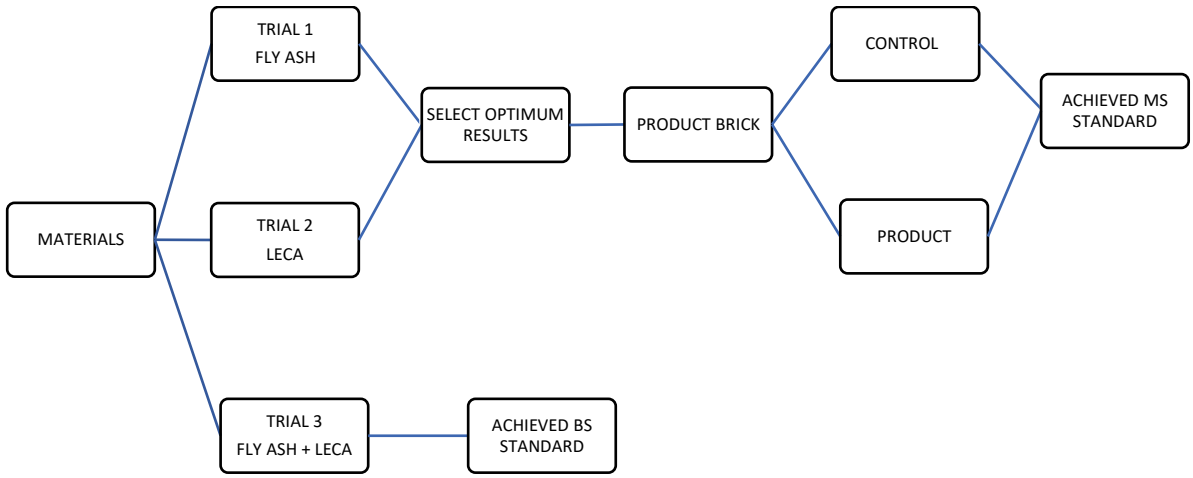


Figure 1: Research Workflow Chart

2.2 Material

Ordinary Portland Cement (OPC) complying with BS EN 197-1: 2011 was used throughout the experiment. Fly ash, a by-product of burning pulverised coal in a thermal power plant obtained from Kapar, Selangor, was used as a supplementary cementitious material. Both OPC and fly ash were sieved by 75 μm for fineness, respectively. The fly ash sample is shown in Figure 2. All samples were tested for chemical composition using Epsilon3-XL EDXRF

spectrometer. The application of the EDXRF technique is fast, economical and fully suitable for the determination of many matrix elements [10]–[12]. The chemical composition is shown in Table 1.

Table 1: Concentration of elements with EDXRF analysis

Major Element	Portland Cement (%)	Fly ash (%)
Si	2.1	12.129
Al	0.497	6.285
Fe	2.476	5.321
Ca	49.01	4.814
Mg	0.201	0.165
S	0.496	658.4 (ppm)
K	0.384	0.921
Ti	0.123	1.808
P	-	0.412
Mn	973.2 (ppm)	545.7 (ppm)
Sr	-	0.521

Figure 2: Fly Ash

Figure 3: Lightweight Expanded Clay Aggregate (LECA)

2.3 Fine Aggregate

Natural river-washed quartz sand complying with BS 882: 1992 was used as fine aggregate. The sand grading is shown in Table 2, and the fine modulus of sand is 3.31.

Table 2: Grading of fine aggregate

Sieve size (mm)	Mass of each sieve (g)	Weight retained (g)	Net weight (g)	Cumulative net weight retained (g)	Cumulative net weight percentage retained (%)	Cumulative net weight passing (g)	Cumulative net weight percentage passing (%)
4.75	460	480	20	20	5.56	340	94.44
2.36	440	460	20	40	11.11	320	88.89
1.18	390	430	40	80	22.22	280	77.78
0.60	350	430	80	160	44.44	200	55.56
0.30	330	420	90	250	69.44	110	30.56
0.15	320	360	40	290	80.56	70	19.44
0.075	310	370	60	350	97.22	10	2.78
Pan	290	300	10	360	100	0	0

2.4 Light Expanded Clay Aggregate (LECA)

LECA, as shown in Figure 3, is the abbreviation of lightweight expanded clay aggregate. LECA is produced from special plastic clay with no or very little content of lime. The clay is dried, heated, and burned in rotary kilns at 1100–1300 °C. LECA is a porous ceramic product with a uniform pore structure with almost potato shape or round shape due to the kiln circular movement. The abundant numbers of small, air-filled cavities in LECA give its lightweight, thermal, and sound isolation characteristics [6]. LECA size used was below 10mm. The grading of LECA aggregates is tabulated in Table 3.

Table 3: Grading of LECA aggregate

Sieve Size	Mass of each sieve (g)	Weight Retained (g)	Net Weight (g)	retained weight	passing weight	cumulative percentage passing (%)
28	1354	1354	0	0	500	100
25	1360	1360	0	25	475	95
20	1312	1312	0	192	308	62
10	1229	1672	443	286	214	43
6.3	1268	1326	58	453	47	9
5	1165	1165	0	493	7	1
pan	903	904	7	500	0	0

2.5 Mix Proportions

Determination of compressive strength using fly ash and LECA in mortar mixes is investigated. Three mixes determine the optimum values of fly ash and LECA in mortar. The mixed proportion of bricks is to achieve the final strength products. The mix ratio used was 1:3, and the water to cementitious ratio was maintained constant at 0.5 for all mortar mixes.

2.5.1 Trial Mix 1

Table 4 shows the mortar mixes as a partial replacement of cement with fly ash. The mortar samples used are 100mm x 100mm x100mm. The percentages of replacement used are 0%, 5%, 10%, 15%, and 20% of fly ash in cement.

Table 4: Mix proportion of fly ash in mortar cube

Specimen	0%	5%	10%	15%	20%	25%
Cement (g)	6900	6555	6210	5865	5520	5175
Sand (g)	20700	20700	20700	20700	20700	20700
Water (ml)	4000	4000	4000	4000	4000	4000
Fly Ash (g)	0	345	690	1035	1380	1725

2.5.2 Trial Mix 2

Table 5 shows the mortar mixes as a partial replacement of sand with LECA. The mortar samples used are 100mm x 100mm x 100mm. The percentages of replacement used are 0%, 5%, 10%, 15%, 20%, 25% and 30% of LECA in sand.

Table 5: Mix proportion of LECA in mortar cube

Specimen	0%	5%	10%	15%	20%	25%	30%
Cement (g)	2300	2300	2300	2300	2300	2300	2300
Fly Ash (g)	0	0	0	0	0	0	0
Sand (g)	6900	6555	6210	5865	5520	5175	5175
LECA (g)	0	345	690	1035	1380	1725	1725
Water (ml)	1150	1150	1150	1150	1150	1150	1150

2.5.3 Trial Mix 3

From the trial mixes 1 and 2, the final optimum results for fly ash and LECA were used to cast the trial for mix 3. Trial mix 3 was made by combining the fly ash and LECA in one mortar mixture. There are 5 batches of the mixes, as shown in Table 6. This mixture is produced by maintaining the value of 5% fly ash as partial cement replacement, and the value of LECA used were 0%, 3%, 7%, and 10% by weight of sand. The value of 5% fly ash and 0% was used as control samples. After casting the mortar cube, all the samples are sent to a compression strength test.

Table 6: Mix proportion of Fly Ash and LECA in mortar cube

Specimen	0%	3%	5%	7%	10%
Cement (g)	2185	2185	2185	2185	2185
Sand (g)	6900	6693	6555	6417	6210
LECA (g)	0	207	345	483	690
Fly Ash (g)	115	115	115	115	115
Water (ml)	1150	1150	1150	1150	1150

2.5.4 Mix Proportion of Brick

Table 7 shows the brick mixes as a partial replacement of sand with LECA. The samples use standard brick sizes. Comparisons are made in terms of strength and density properties

Table 7: Mix proportion or brick

Specimen	Control 0%	Product: 5% Fly Ash & 10% LECA
Cement (g)	3300	3135
Sand (g)	9900	8910
Fly Ash (g)	0	6555
LECA (g)	0	165

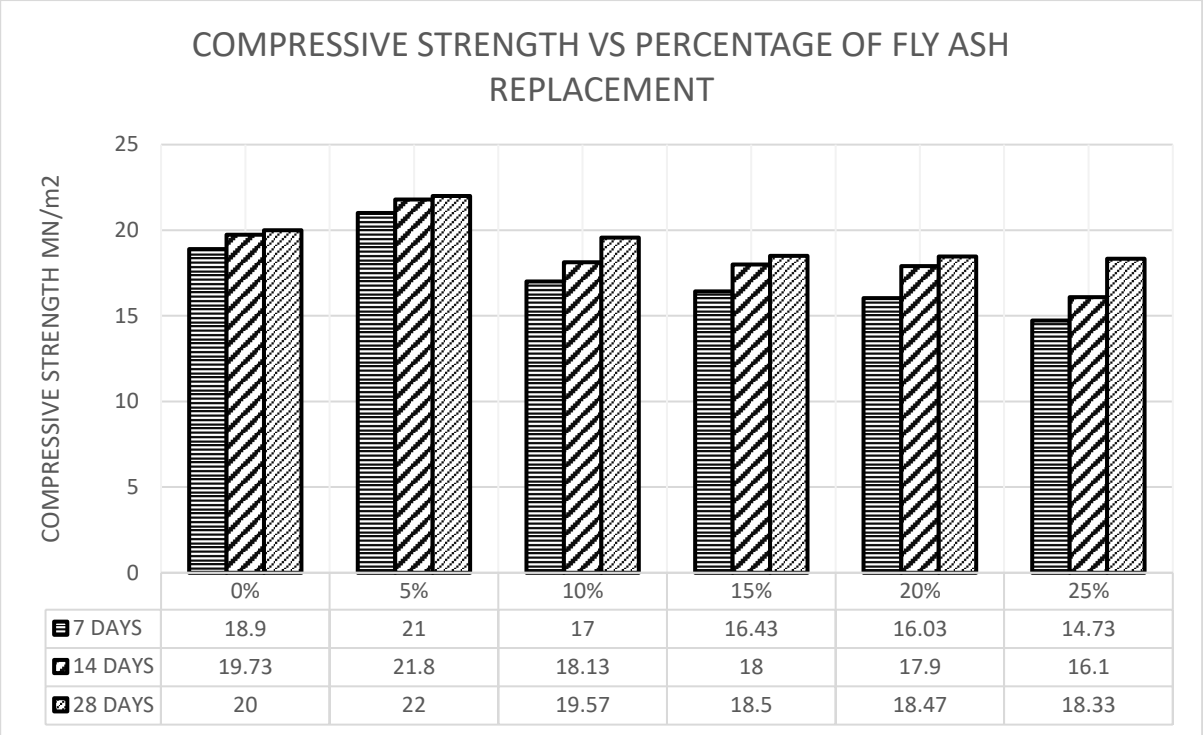
2.6 Compressive Strength Test

The trial mix of mortar cubes with 100mm x 100mm x 100mm was prepared for compressive strength testing. The test was carried out according to BS EN 12390-3: 2009. The samples were tested at 7,14, and 28 days for the fly ash cube and 7 and 28 days for the LECA cube. On the other hand, the brick product was tested at 7 and 28 days.

3.0 RESULT AND DISCUSSION

3.1 Effect of fly ash on mortar strength

Figure 4 shows the results of the compressive strength test conducted for mortar cubes by using fly ash as a cement replacement at 7, 14, and 28 days of curing period. In compressive strength test, 5% fly ash as a cement replacement attains the highest strength result for 7 days curing period with the value of the strength of 18.93 Mn/m^2 compared to other percentages of fly ash and 25% of fly ash as a cement replacement with a lower result of compressive strength with the value of the strength of 14.73 Mn/m^2 for 7 days curing period. This trend shows the decrease in compressive strength after using 10% fly ash until the last proportion for 7 days curing period. For 14 days curing period, the graph shows that 5% of fly ash obtains the highest strength with 21.8 Mn/m^2, and 20% of fly ash has the lowest strength value of 12.9 Mn/m^2. For 28 days curing period, the graph shows that 20% of fly ash promotes a high strength value of 19.67 Mn/m^2 and 5% of fly ash gains the lowest strength value of 16.33 Mn/m^2. The compressive strength of 5% for 14 days has the highest strength of fly ash as a cement replacement and shows an increase for 14 days curing period compared to 7 days and 28 days curing period. From these results, 5% fly ash improved the mortar strength in this first trial mixed. The fly ash is a pozzolanic and amorphous material. When mixed with cement and water, it reacts with the calcium hydroxide released from the hydration of portland cement to produce calcium silicate hydrates (CSH) and calcium aluminate hydrates. These pozzolanic materials reactions are beneficial to concrete, improving strength and durability [8], [14].



	0%	5%	10%	15%	20%	25%
7 DAYS	18.9	21	17	16.43	16.03	14.73
14 DAYS	19.73	21.8	18.13	18	17.9	16.1
28 DAYS	20	22	19.57	18.5	18.47	18.33

Figure 4: Graph of Compressive Strength for Concrete Cubes of Fly Ash mixture

3.2 Effect of LECA in mortar strength

Figure 5 shows the result of the compressive strength test conducted for cubes by using LECA as a sand replacement for 7 and 28 days of the curing period. The results showed that incorporating 10% LECA gave higher strength at 7 days of age with the value of 18.05 Mn/m2 compared to the control sample. However, the increased percentages of LECA until 30% showed reducing the strength of mortar. After curing at 28 days, the 10% LECA showed strength degradation. More percentages LECA in mortar showing reduction strength values. The effect of lower strength is due to water absorption by LECA according to the curing conditions. The strength value was reduced, which could be due to lightweight particle coarse aggregate particles being relatively weak[15]. Particle shape and surface texture might also influence factors that contributed to the reduction strength [16], [17].

Furthermore, It is also observed that incorporating the higher percentages of LECA in mortar presents a rough surface texture, as shown in Figure 6. It is noted that LECA in water curing absorbs more water in conjunction with the curing period. These phenomena create pores in the mortar and reduce the compressive strength at 28 days.

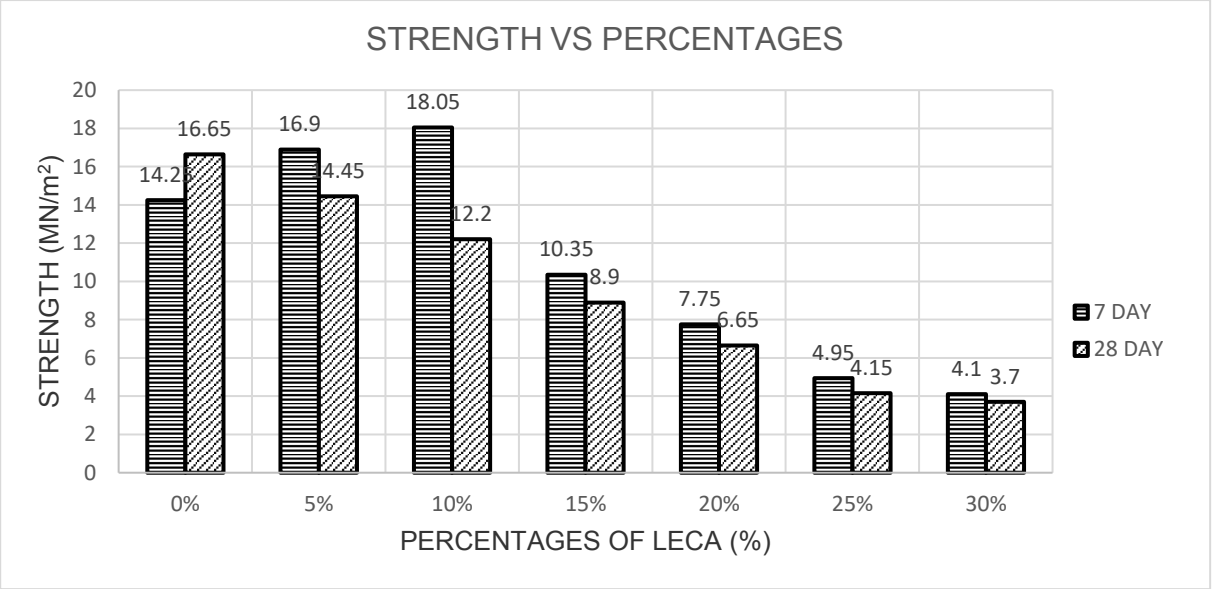


Figure 5: Graph of Compressive Strength for Concrete Cubes of LECA Mixture

Figure 6: The surface texture of mortar cube of LECA mixture

3.3 Effect of optimum percentages of Fly Ash and LECA in mortar strength

Based on trial mix 3, the result is shown in Figure 7. The percentages of LECA used were 0%, 3%, 5% and 10% by weight of sand. The graph shows that substitution of 3% LECA show strength increases compared to the control sample at 7 days. However, at 5%, 7% and 10% of LECA showed degradation in strength. At 28 days, the compressive strength values increased from LECA mortar samples compared to the control samples. The increases in strength are possibly due to the effect of fly ash as filler and improved the particle bonding between sand and cement. The addition of fly ash in a mixed design leads to a change in the rate of hydration [14]. Partial replacement with fly ash generates retardation of hydration cement at the initial stages. This behaviour reflects the strength values at 7 days. Fly ash is a pozzolanic material that can react with calcium hydroxide and can be assessed by the extent and rate of the pozzolanic reaction to gain strength over time [18].

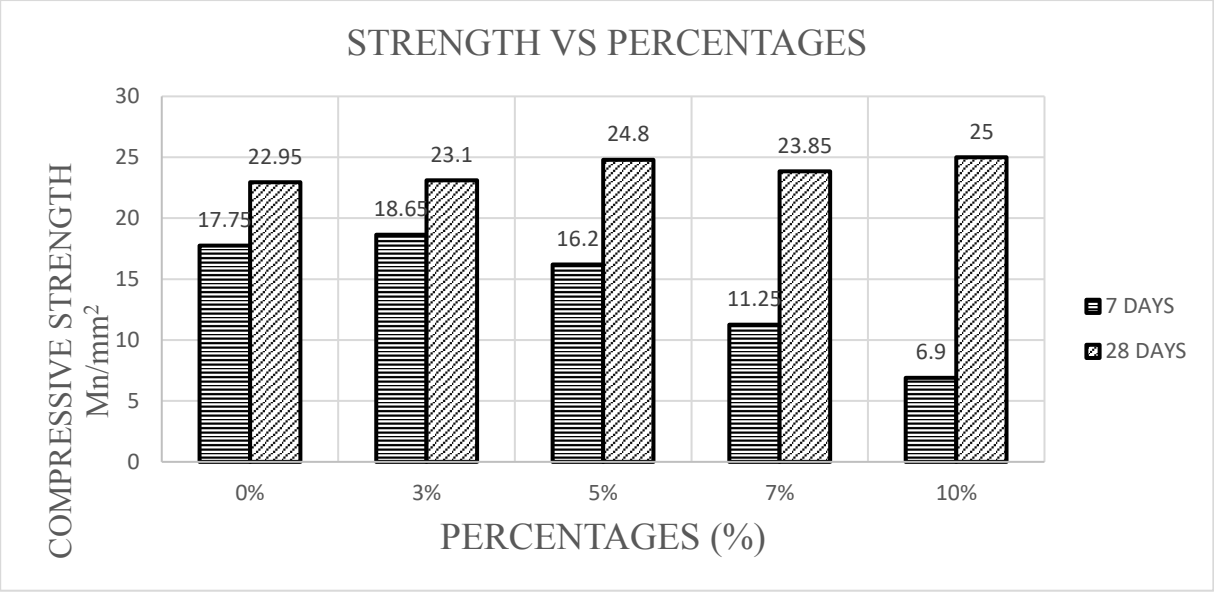


Figure 7: Graph of Compressive Strength for Mortar Cube Test 3 (Fly Ash + LECA)

3.4 Performance brick in strength

Table 8 and Table 9 show the comparison results of the control sample and modified sample. After obtaining compressive strength value of mortar cube of cement and fly ash mixture and mortar cube containing LECA, the value of 5% fly ash as cement replacement produces the highest strength value than control sample while mortar cube with LECA produces the highest strength value compared to control cube at 10%. This finding shows that the best percentage values are used as the final percentages for making bricks. The optimum values of fly ash and LECA in percentages were mixed, and the result is tabulated as indicated above. Performance strength in brick at 7 and 28 days is achieved following MS 76:1972 standards. The final product is shown in Figure 8.

It was found that using LECA as partial replacement sand reduces the density of the final product compared to the control sample.

Table 8: Result of comparison between control and product brick at 7 days.

No.	Sample	Age (days)	Initial Weight (Kg)	Weight (Kg)	Initial Density (Kg/m^3)	Density (Kg/m^3)	Strength Mn/m^2	Standard Brick Compressive Strength MS 76: 1972	Achievement Status
1.	0% Control	7	3.010	3.065	2081	2119	17.8	7 N/mm^2	Achieve
2.	0% Control	7	2.960	3.000	2046	2075	17.3	7 N/mm^2	Achieve
1.	Product	7	2.410	2.375	1666	1642	7.1	7 N/mm^2	Achieve
2.	Product	7	2.460	2.440	1701	1687	7.0	7 N/mm^2	Achieve

Table 9: Result of comparison between control and product brick at 28 days

No.	Sample	Age (Days)	Initial Weight (Kg)	Weight (Kg)	Initial Density (Kg/m^3)	Density (Kg/m^3)	Strength Mn/m^2	Standard Brick Compressive Strength MS 76: 1972	Achievement Status
1.	0% Control	28	2.990	3175	2067	2304	17.4	7 N/mm^2	Achieve
2.	0% Control	28	2.980	3165	2060	2297	21.9	7 N/mm^2	Achieve
3.	Product	28	2.420	2550	1673	1851	10.5	7 N/mm^2	Achieve
4.	Product	28	2.400	2570	1659	1865	9.8	7 N/mm^2	Achieve

Figure 9: Final brick product with dimension 216mm x 103mm x 65mm

4.0 CONCLUSION

The following conclusions are drawn from this investigation: 1) Cement replacement with fly ash increases the mortar's compressive strength at optimum percentages. 2) LECA is utilised as partial replacement sand, showing increasing strength in the mortar at 10%. 3) The modification of mortar sample using fly ash and LECA shows better strength when used 5% fly ash and 10% LECA. 4) The compressive strength of the product brick achieves the minimum standard compressive strength based on the Malaysia standard. 5) The density of the final product shows a little decrement compared to the normal density control sample.

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