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Integration of Microbial Fuel Cell (MFC) in Secondary School: An Approach of Environmental Education to Improve Students' Knowledge on Green Technology and Manipulative Skills in Biology Subject

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Abstract: Green technology is one of the environmental education approaches that can be implemented among students in secondary school. In addition, green technology can be applied in the science curriculum to encourage students' interest in appreciating the environment. It is also useful in curbing the negative human involvement on nature. This preliminary research looked at the need to implement green technology module by integrating Microbial Fuel Cell (MFC) in Biology syllabus. This research assessed the current understanding of Biology form five students on environmental education topic in Biology syllabus and knowledge on Microbial Fuel Cell (MFC). A survey and assessment using multiple choice questions (MCQ) has been conducted on 40 students and 59 students respectively via online. Data obtained were analysed descriptively using SPSS. The results showed a normal distribution graph for MCQ assessment and moderate level of understanding about MFC among form five students. Additionally, the needs for implementing microbial fuel cell (MFC) in Biology curriculum were investigated by conducting interviews among experts in MFC and Biology teachers. By using thematic analysis, opinions of teachers and experts in MFC were grouped into several categories: 1) Inadequate Content Related to Environmental Education and Green Technology in Biology Curriculum; 2) Level of Teachers' Knowledge of Green Technology in Biology Subject Need to Be Improved; 3) Level of Teachers' Knowledge On Pedagogical Methods Need to Be Improved. The results of this study suggests that utilising green technology approach which is MFC is very important to improve the level of understanding on green technology and manipulative skills among secondary school students. The findings also can be used for designing and developing the module related to MFC.

Keywords: Green technology, Microbial Fuel Cell (MFC), environmental education, sustainable development, Biology curriculum

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INTRODUCTION

The development of the science and technology education system for the 21st-century has altered the paradigms of teaching and learning all over the world, where a focus on the 21st-century pedagogy approach is increasingly implemented to produce students with high marketability in the STEM field. In line with that, Malaysia's education system changed from Integrated Based Curriculum for Secondary Schools (KBSM) to Standard Based Curriculum for Secondary Schools (KSSM) (Farihah Mohd Jamel et al., 2020) gradually starting from 2017

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to meet the new policy requirements according to Malaysia Education Blueprint (2013-2025) (MOE, 2018). The transformation of STEM education, including Biology subject starting from 2020 has bring the syllabus direction towards integration of cross-curricular elements and topics related to environmental education, which is green technology (MOE, 2020; Mohd Wira Mohd Shafiei & Hooman Abadi, 2017).

Green technology can be considered as an approach to educate students about environmental education and impart students' interest in appreciating environment (Nor Farahin Jasmi & Arasinah Kamis, 2019) through outdoor, classroom, and nature-centered education programs (Fang et al., 2023; Luna-Krauletz et al., 2021). Additionally, environmental education is very important to create quality human capital because this field is not a distinct branch of science, but also a means of achieving environmental protection objectives (Ardoin et al., 2020) and a lifelong interdisciplinary subject of study. It aids in developing in people the required awareness, abilities, attitudes, knowledge, and capacity for participation so that they may modify their daily actions in a way that avoids conflict with the environment (Mushtaq et al., 2020). The transformation of education system in Malaysia aims to produce sustainable citizens, but the level of knowledge towards environmental education and practices towards sustainable development still at a low level (Amarumi Alwi et al., 2017; Azlinawati Abdullah et al., 2018; Siti Khatijah Zamhari & Christopher Perumal, 2016; Wan Ahmad Suhaidi et al., 2019).

Government should move in the direction of a more sustainable development in order to achieve towards sustainable direction (Arasinah Kamis et al., 2016). Sustainable development practices are required to ensure environmental sustainability for current and future generations in order to minimise the detrimental effects of development on the environment (Hanifah Mahat et al., 2018). This in line with Sustainable Development Goals (SDG), because green technology that promotes sustainable development which entails locating eco-friendly sources of expansion, building new eco-friendly sectors, and generating eco-friendly employment and technology (Guo et al., 2020). Environmental education has been recognised as a way to inculcate and educate students to be more responsible towards environment in order to achieve sustainable development (Nor Farahin Jasmi & Arasinah Kamis, 2019; Robina-Ramirez et al., 2020). Through official education system, the younger generations especially secondary school students can be encouraged to combat issues regarding sustainable development (Per Sund & Niklas Gericke, 2020), for example solid waste management by integrating of green technology into Biology curriculum. The connection between environmental education and sustainable development is very complex; but the key to accomplishing sustainable development is adequate policy formulation, effective curriculum design, and teacher orientation in teaching environmental education (Yadav et al., 2022) (Diagram 1).

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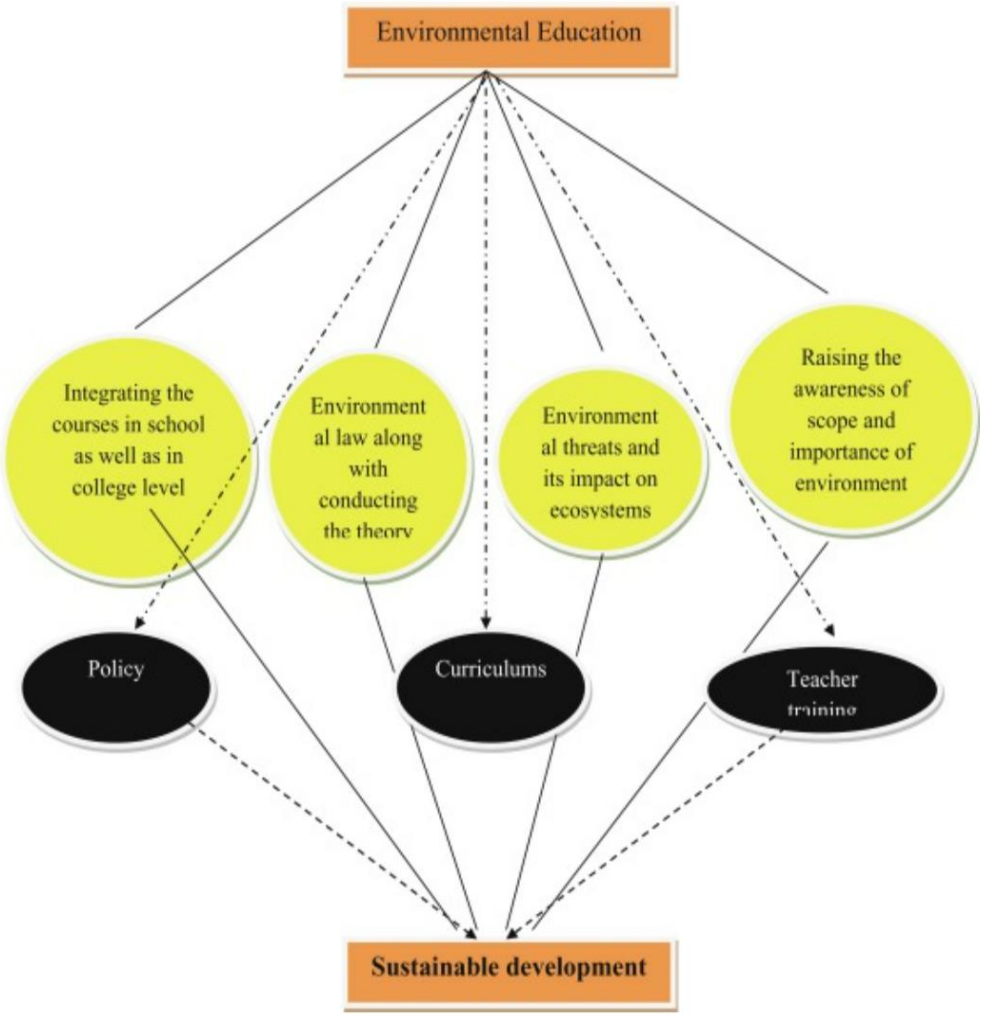

Diagram 1: Sustainable development through environmental education
Source: Yadav et al. (2022)

In line with development of Biology curriculum, integration of green technology elements which is Microbial Fuel Cell (MFC) seems to be effective in educating secondary school students about environmental education because MFC is a sustainable green technology that can generate electricity from chemical energy produced from organic substrates (Khairul Baqir et al., 2018) and inorganic substrates (Mohd Imran Ahamed & Naushad Anwar, 2022). This is supported by Norhafizah Karim et al. (2022), where implementation of environmental education is more comprehensive in Biology curriculum compared to other subjects. Students will learn on how to manage solid waste from environment, especially from schools and learn how solid waste can be recycled to produce electricity. This approach able to increase active participation of secondary school students in environmental management (Ibanez et al., 2020). Previous study shows that students are not exposed on how to manage solid waste, so they unable to understand about sustainable waste management properly (Zurainy Rahman et al., 2019). Eventhough MFC have a great potential to control these problems, the implementation in education is still limited due to lack of teacher readiness and an appropriate niche in the school curriculum (Tan & Lee, 2022).

Starting 2021, transformation of Biology curriculum also lead to full implementation of practical work in Biology to assess students' manipulative skills and science process skills to increase active participation of students so that teaching and learning process will be more

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comprehensive and effective (Nur Zaitul Akmar et al., 2022). All students should be required to engage in hands-on practical learning in order to help them achieve their career goals (Ihejiamazu at al., 2020). Various pedagogical methods can be implemented to expose students with green technology, including practical works to assess their psychomotor ability in handling laboratory apparatus (Hidayah Mohd Fadzil & Rohaida Mohd Saat, 2014; Summayyah Aimi Mohd Najib et al., 2020) systematically. Manipulative skills also important to determine and recognise students' capability to get accurate data during practical works (Lok & Yau, 2020; Hidayah Mohd Fadzil & Rohaida Mohd Saat, 2013). Apart from this, previous study shows that students' engagement in practical works are still low (Hidayah Mohd Fadzil & Rohaida Mohd Saat, 2020) causing lack of manipulative skills enforced among secondary school students. Most of the research related to manipulative skills focused on primary and secondary school students (Hidayah & Rohaida, 2013, 2014a, 2014b, 2017; Zainudin Abdul Razak, 2015), but research on manipulative skills regarding integration of green technology to enhance their manipulative skills is still limited.

The solved of these problems, it takes a teaching material that is able to increase students' knowledge on green technology and manipulative skills in learning Biology. One of them is learning module besides using textbooks and digital materials supplied by MOE (Ahmad Adnan Mohd Shukri et al., 2020; MoE, 2013). Learning module is seen as teaching aids (Mustika Nuramalia Handayani et al., 2021) in Biology to integrate MFC by using practical activities in order to improve students' knowledge on green technology and manipulative skills during experiment. Based on past studies, the use of module as teaching and learning materials will facilitate teacher when delivering biology material to students where students can learn on their own (Ahmad Adnan Mohd Shukri et al., 2020; Amarumi Alwi & Arasinah Kamis, 2019; Farihah Mohd Jamel et al., 2020; Haka et al., 2020).

In the context of this study, the needs analysis study was conducted at the beginning of the module development to determine the level of understanding in learning environmental education topic in Biology syllabus among form five students, to determine the level of knowledge on Microbial Fuel Cell (MFC) among form five students, and to investigate the needs for integration of Microbial Fuel Cell (MFC) into Biology curriculum.

LITERATURE REVIEW

Green Technology

Environmental problems such as pollution, climate change, and the scarcity of natural resources have become global concerns. As a result, the Ministry of Energy, Green Technology and Water (KeTTHA) has created Green Technology Policy to encourage the adoption of green technology in Malaysia. Green technology can be defined as the development and use of products, equipment and systems used to preserve the environment and resources, which can reduce the negative impact of human activities (KeTTHA, 2017; Monu Bhardwaj & Neelam, 2015; Nor Farahin Jasmi & Arasninah Kamis, 2019). Green technology also considered as environmental friendly because less carbon released compared to existing technology (Aizatul Adzwa Mohd. Basri, 2018; Ruzian Markom & Norizan Hassan, 2014; Shan et al., 2021). Most of the environmental problems presently plaguing our society can be resolved effectively through the use of green technology (Anusuya Kaliappan & Hashima Hamid, 2021).

According to National Green Technology Policy (NGTP), there are five strategic thrusts with the aim to: (i) To minimize growth of energy consumption while enhancing economic development, (ii) To facilitate the growth of green technology industry & enhance its contribution to national economy, (iii) To increase national capability and capacity for innovation in green technology development & enhance Malaysia's competitiveness in global arena; (iv) To ensure sustainable development & conserve environment for future generations;

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and (v) To enhance public education & awareness on green technology and encourage its widespread use. By referring to the fifth objective, improvement on green technology through education is very important to inculcate students in appreciating environment. More teaching and learning activities need to be implemented regarding green technology approaches in education. This is supported by Anusuya Kaliappan & Hashima Hamid (2021), where green technology should be integrated into curriculum so that teaching and learning processes on environmental education will be more efficient.

Microbial Fuel Cell (MFC)

Microbial Fuel Cell (MFC) is a branch of green technology and emerging technology in the modern era, including Malaysia. MFC also is a bio-electrochemical device that produce electricity by tapping on the biological processes of microorganisms. MFC is an alternative method of renewable energy because its capability to generate electricity and treat wastewater (Khairul Baqir Alkhair et al., 2018; Shah et al., 2019), by using electrogenic bacteria (Chen et al., 2018; Naureen et al., 2016). Studies made by researchers showed that MFC can be applied in wastewater treatment, bioelectricity generation, hydrogen production, environmental sensors, seawater desalination, bioremediation, and microbial electro-synthesis and energy recovery (Khairul Baqir Alkhair et al., 2018; Logan, 2008; Roy et al. 2017; Shah et al., 2019).

In line with that, transformation of Biology curriculum by integrating green technology as an approach of environmental education is seen as a good initiative by Ministry of Education to educate and create awareness among students in appreciating environment (Nor Farahin Jasmi & Arasinah Kamis, 2019; Anusuya Kaliappan & Hashima Hamid, 2021). Recent emerging technology such as MFC is suitable to be integrated into Biology curriculum because students not only will learn the concept of respiration in microorganisms, but also how electricity can be generated from biomass using bacteria (Khairul Baqir Alkhair et al., 2018). Through MFC activities, students will be exposed with new branch of green technology by generating clean energy efficiently without toxic residues (Chaturvedi & Verma, 2016; Logan, 2004). In addition, MFC can be considered as the knowledge for conserving natural environment because MFC can operate in diversified areas such as renewable energy and solid waste management (Mohd Wira Mohd Shafiei & Hooman Abadi, 2017).

Manipulative Skills in Biology Practical

Students' positive attitudes and motivation for effective science learning have been promoted by practical activity. Implementation of green technology which are MFC activities in Biology syllabus is one of the effective pedagogical teaching and learning strategy in order to produce students with various science skills including manipulative skills. Manipulative skills is one of the scientific skills emphasised during biology practical work Hidayah & Rohaida (2014b). Manipulative skills can be defined as psychomotor skills that relate individual cognitive function with corresponding physical movement (Hidayah Mohd Fadzil & Rohaida Mohd Saat, 2014a). While the Curriculum Development Division of Ministry of Education Malaysia (2016) defined manipulative skills as psychomotor skills that enable students to perform specific task (Table 1). Manipulative skills are very important during practical works (Hidayah Mohd Fadzil & Rohaida Mohd Saat, 2013, 2014a, 2014b, 2017) because students manage to handle and manipulate laboratory apparatus (Lok & Yau, 2020) as well as observing real objects and materials (Abrahams et al., 2013).

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Table 1: Science manipulative skills

Science Manipulative Skills
i. Use and handle science apparatus and substance correctly
ii. Handle specimens correctly and carefully
iii. Draw specimens, apparatus and laboratory substances accurately
iv. Cleans science apparatus correctly
v. Store science apparatus and laboratory substances correctly and safely

Source: Curriculum Development Division (2016)

Biology practical work encourage students to become active learners and engage them in their teaching and learning processes during Biology lessons. Current green technology activity in Biology Form Five syllabus only focus on how to produce eco-enzymes, and no activities regarding solid waste management (MOE, 2020). By integrating MFC into green technology activities, students will be exposed on how to use various materials and apparatus, for example graphite electrodes, anode and cathode, plastic containers, alligator clips, digital multimeter, resistors (Muhammad Izzat Nur Ma'arof et al., 2018) and different type of substrates (Logan, 2008) thus, increase their manipulative skills during Biology practical work.

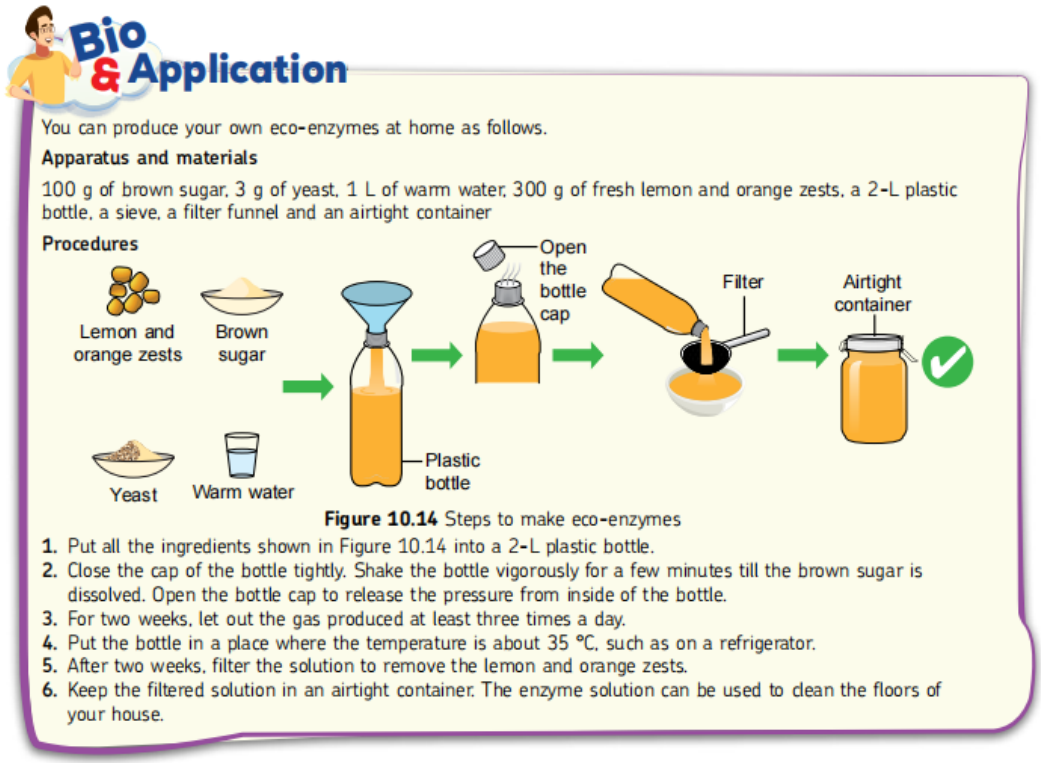

Diagram 2: Green technology activity in Biology Form Five textbook
Source: Ministry of Education (2020)

METHODOLOGY

This research used both quantitative and qualitative research which employs questionnaire, multiple choice questions (MCQs) assessment, and semi-structural interview methods. The stages conducted in this study are necessary to analyse the students and teachers' needs for green technology (MFC) module that will be developed. The sample involved in this study was 59 students for MCQ assessment and 40 students for questionnaire, three expert Biology

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teachers, and three experts in green technology including lecturers in MFC field. Instruments used consist of questionnaire to determine the level of knowldege on current green technology approach which is microbial fuel cell (MFC), multiple choice questions (MCQs) to determine current understanding of Biology form five students about environmental education topic, which is Environmental Sustainability, and semi-structured interview to investigate the needs for implementing MFC in Biology syllabus.

The questionnaire used in this study was created by researcher based on Logan (2008). This survey has been conducted involving Form Five students via online by using Google Form. Researcher selected respondents who had the same characteristics as the actual study samples that will be involved in the next stage. The selection of respondents for questionnaire and MCQ assessment are based on their prior knowledge on topics related to environmental education in Biology Form Five syllabus. The questionnaire is divided into two parts, Part A and Part B. Part A consists of information about respondents' demography, including their email address, gender, race, and religion. While Part B consists of 20 items regarding statements about Microbial Fuel Cells (MFC). The questionnaire also employed five point Likert scale as shown in Table 2.

Table 2: Likert scale

Score	Level of agreement
1	Strongly Disagree
2	Not Agree
3	Slightly Agree
4	Agree
5	Strongly Agree

A learning area was chosen from Biology Form Five syllabus before conducting assessment to the students. This is done to determine the level of students' understanding of learning area which is Environmental Sustainability. Multiple choice questions (MCQs) consisting 40 objective questions was created and selected according to Malaysian Examination Board format (2021), with the ratio 5:3:2 which are Difficult:Moderate:Easy. According to Lee et al. (2021), multiple choice questions (MCQs) have been widely used in online assessments because MCQ are economical and time efficient. Students must choose A, B, C or D from Google Form conducted via online. Researcher also conducted semi-structured interviews with three Biology expert teachers, three experts in green technology including MFC field. Two different semi-structured interview protocol was adapted from Rashidah Begum Gelamdin (2016) to conduct interviews among expert teachers and experts in green technology respectively. When the process of interviewing was done, the the researcher completed the transcript and analyse the transcript thematically.

RESULTS AND DISCUSSION

The Level of Understanding in Learning Environmental Education in Biology Syllabus Among Form Five Students

Diagram 3 shows the results of MCQ assessment that were performed by the students. The graph obtained show a normal distribution graph. Based on Diagram 3, only 3 students (7.5%) manage to get low marks (0-20), 37 students (62.7%) manage to get moderate marks (21-30) and 19 students (32.2%) manage to get high marks.

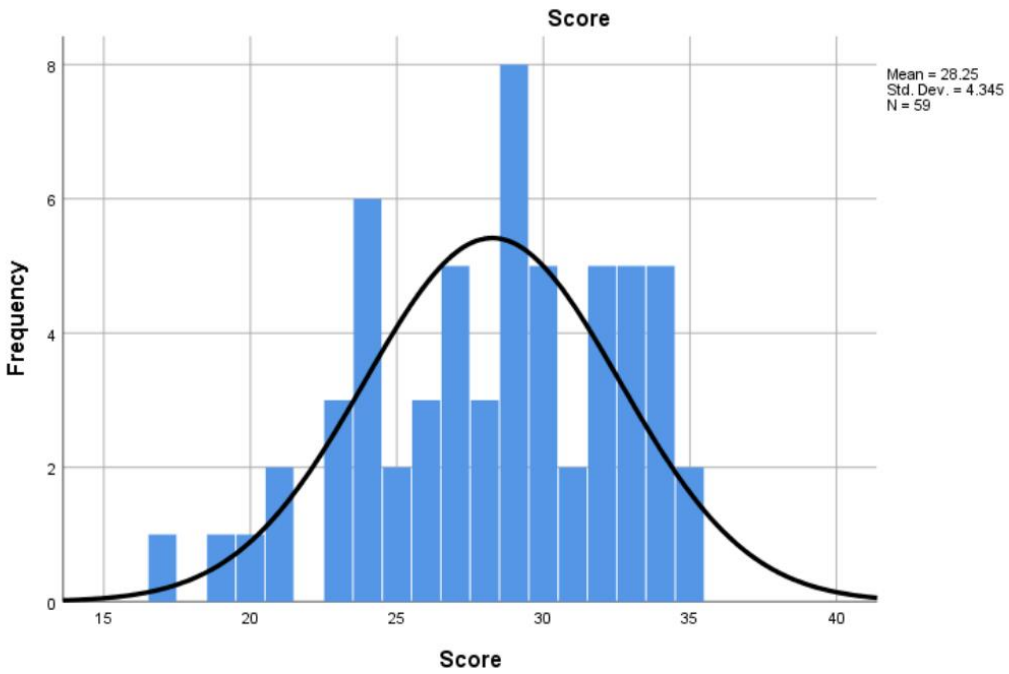

Diagram 3: Graph of Results on Environmental Sustainability Topic

On the average, most of the students manage to score moderate marks for Environmental Sustainability topic. According to Doughlas et al. (2012), MCQs are not only suitable for evaluating first level cognitive skills which is knowledge/remember, but also the next two levels of cognitive skills which are comprehension/understand and application/apply.

The Level of Knowledge on Microbial Fuel Cell (MFC) Among Form Five Students

The researcher also has conducted a survey among Form Five students using questionnaire involving 75 Form Five students taking Biology subject. Data obtained were analysed descriptively to determine mean and standard deviation. Mean obtained were analysed according to interpretation of mean score (Sumarni, 2000; Jamil, 2002) as shown in Table 3.

Table 3: Interpretation of Mean Score

Mean Score	Interpretation
1.00-2.33	**Low**
2.34-3.66	**Moderate**
3.67-5.00	**High**

Source: Sumarni (2000) and Jamil (2002)

Based on Table 4, item 3 shows the lowest mean score which is 2.13. Item 1,2,4,8,9,11,14 and 16 shows moderate mean scores which are 2.70, 2.70, 3.65, 3.20, 3.33, 2.83, 2.83, and 3.18 respectively. Item 5,6,7,10,12,13,15,17,18,19, and 20 shows high mean score which are 3.85, 4.00, 3.83, 3.90, 4.08, 3.98, 4.00, 3.93, 4.00, and 3.93. The average mean score is M=3.48 while average standard deviation, SD=1.018.

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Table 4: Mean Scores on Questionnaires Regarding MFC

Item	Mean	Standard Deviation	Level
1	2.70	1.154	Moderate
2	2.70	1.114	Moderate
3	2.13	1.042	Low
4	3.65	0.975	Moderate
5	3.85	0.939	High
6	4.00	1.001	High
7	3.83	0.864	High
8	3.20	0.906	Moderate
9	3.33	1.010	Moderate
10	3.90	1.181	High
11	2.83	1.228	Moderate
12	4.08	0.871	High
13	3.98	1.196	High
14	2.83	0.944	Moderate
15	3.98	0.891	High
16	3.18	1.196	Moderate
17	4.00	0.891	High
18	3.93	1.152	High
19	4.00	0.906	High
20	3.93	0.888	High
Total	**3.48**	**1.018**	**Moderate**

Table 5 shows the findings of the level of knowledge on Microbial Fuel Cell (MFC) among Form Five students. Based on Table 5, the percentage of students who strongly disagree, disagree, slightly disagree, agree, and strongly agree were recorded. The findings showed that the level of students' knowledge on Microbial Fuel Cell (MFC) is at moderate level.

Table 5: The Level of Knowledge on Microbial Fuel Cell (MFC) Among Form Five Students

Statements	Strongly Disagree (%)	Disagree (%)	Slightly Disagree (%)	Agree (%)	Strongly Agree (%)
I have knowledge regarding Microbial Fuel Cell (MFC).	20.0	17.5	37.5	20.0	5.0
I get knowledge on Microbial Fuel Cell (MFC) from school.	17.5	25.0	30.0	25	2.5
I can build Microbial Fuel Cell (MFC) set up without teacher's guidance.	32.5	35	22.5	7.5	2.5
Microbial Fuel Cell (MFC) consist of anode, cathode, membrane, substrate, electric circuit, and microorganisms such as bacteria.	5.0	7.5	17.5	57.5	12.5
Microbial Fuel Cell (MFC) able to generate chemical energy continuously from organic waste.	5.0	5.0	10.0	65.0	15.0
Microbial Fuel Cell (MFC) able to treat dewatered sludge.	7.5	2.5	20.0	57.5	12.5
Products formed from wastewater treatment by Microbial Fuel Cell (MFC) can be used as fuels.	2.5	5.0	15.0	60.0	17.5

Microbial Fuel Cell (MFC) able to convert chemical energy to electrical energy.	2.5	5.0	10.0	55.0	27.5
Microbial Fuel Cell (MFC) use various types of electrogenic bacteria.	5.0	5.0	15.0	52.5	22.5
Emission of gas by Microbial Fuel Cell (MFC) is very high.	7.5	25.0	20.0	35.0	12.5
Microbial Fuel Cell (MFC) unable to reduce air pollution.	7.5	20.0	25.0	27.5	20.0
Sources used to produce Microbial Fuel Cell (MFC) come from renewable sources.	2.5	5.0	12.5	60.0	20.0
Microbial Fuel Cell (MFC) is not involve in energy recovery.	12.5	32.5	25.0	20.0	10.0
Microbial Fuel Cell (MFC) is a branch of green technology.	2.5	5.0	10.0	47.5	35.0
Microbial Fuel Cell (MFC) set up use bacteria to break down organic wastes.	2.5	5.0	10.0	57.5	25.0
Application of Microbial Fuel Cell (MFC) in organic waste treatment cannot increase the quality of environment.	12.5	30.0	32.5	12.5	12.5
Application Microbial Fuel Cell (MFC) helps in reducing global climate change.	2.5	5.0	10.0	57.5	25.0
Microbial Fuel Cell (MFC) cannot replace existing fuels.	7.5	17.5	42.5	15.0	17.5
Microbial Fuel Cell (MFC) helps in bioremediation to recover and clean polluted medium.	2.5	5.0	10.0	55.0	27.5
Microbial Fuel Cell (MFC) able to oxidise various types of organic wastes to produce electrons for energy generation.	2.5	5.0	12.5	57.5	22.5

Based on Diagram 3, it is showed that more than 50% students able to score above 25 out of 40 questions. This indicate that they are able to understand the concept on environmental education in Biology curriculum, but it does not reflect overall understanding on environmental education among Form Five students. Based on item analysis, 98.3% students able to answer questions based on human activities, for example global warming, excessive use of fertilisers, deforestation, and burning of fossil fuels. The questions are classified as easy level. Otherwise, the students unable to relate the effects of those activities to the environment although their level of understanding in learning environmental education is at moderate level. This is because they cannot answer questions regarding the effects and consequences of human activities to the environment. All these questions are classified as moderate and difficult level. Previous studies focused on knowledge, attitudes, and practices among students (Hanifah Mahat et al., 2019; Misbahul Jannah et al., 2013; Jessica Dato et al., 2020; Wan Ahmad Suhaidi Wan Yunus, 2019). By using questionnaire, most of the students in their findings showed low and moderate level of knowledge, attitudes and practices on environment. One of the key elements influencing the success of sustainable waste management is through education. The National Association of Biology Teachers suggests that the environmental concept is relevant to students' everyday lives. Based on current Biology syllabus, the concept of sustainable waste management has been integrated in Green Technology subtopic, through the study of Environmental Sustainability. Early exposure towards environmental education in Biology syllabus is very important, so the students able to understand about sustainable waste management through green technology concept properly.

Solid waste is the major contributor to pollution and a major environmental concern worldwide (Licy et al., 2013; Hanifah Mahat et al., 2012). By focusing on new approach of environmental education, MFC is one of the effective ways to educate students about solid waste management through green technology. Based on Table 4, the findings showed that the

students have moderate level of knowledge towards green technology which is MFC. Similar study conducted by Anusuya Kaliappan and Hashima Hamid (2022) among vocational colleges students, where the findings showed that knowledge of the respondents towards green technology is at moderate level. Apart from that, findings from several studies (Nur Elma Kordi et al., 2018; Norhayati Ngadiman et al., 2017) showed that the level of knowledge towards green technology among respondents in their studies are low. Lack of teaching and learning activities regarding green technology in schools is one of the factors. In order to produce students with high knowledge on green technology, various approaches through environmental education is very crucial. MFC is suitable to be integrated into current environmental education because students will be encouraged to involve with composting project activities, for example kitchen waste. This in turn can increase students' knowledge on green technology, especially MFC and promote sustainability in students' daily life (Zurainy Rahman et al., 2019).

Based on Table 5, most of the students did not know about MFC and they also cannot build up MFC set up without teacher's guidance. This can be seen from item 2 and item 3, because only 2.5 strongly agree with the statements despite most of the students know that MFC is a branch of green technology. By using MFC as a green technology teaching and learning approach, this will offer genuine, real-world contexts for topics relating to sustainability and alternative energy (Tan & Lee, 2022). Thus, more teaching and learning approaches using various materials should be implemented in the school, for example practical activities or experiment related to MFC to educate and enhance students' understanding about environmental education as well as increase their manipulative skills. Through practical work, students will gain the ability to assess phenomena and information critically through engaging, interactive and active learning procedures. This is supported by Norhafizah Karim et al. (2022), where teaching and learning activities related to climate change in science education should be focused on laboratories and group work, so that students will be engaged in learning processes.

The Needs for Integration of Microbial Fuel Cell (MFC) into Biology Curriculum

All recorded audio and video of the interview sessions were analysed thematically according to 6-step guide (Braun & Clerk, 2006) to gain in-depth information on the needs to integrate Microbial Fuel Cell (MFC) into Biology curriculum (Diagram 4). Analysis was done manually to maintain a significant data interpretation (Norhafizah Karim et al., 2022). Researcher's findings were focused on content of environmental education and green technology in Biology curriculum, teachers' level of knowledge on green technology, followed by their level of pedagogical knowledge on pedagogical methods. All themes were inductively formed (Braun & Clerk, 2006; Patton, 1990) through in vivo coding, where the codes developed from respondents' words (Bingham et al., 2022). Table 6 shows the background of respondents and list of codes in the researcher's study.

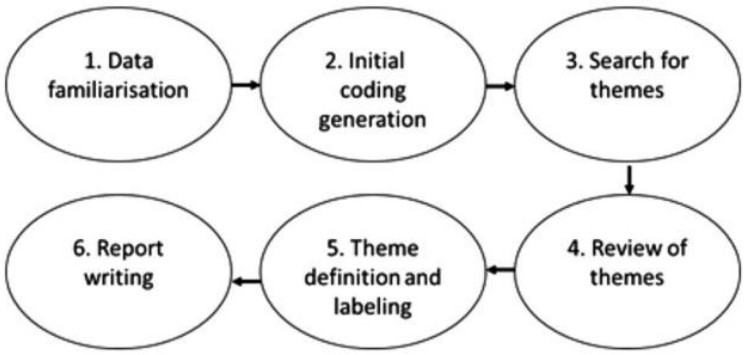

Diagram 4: Braun and Clarke's model of thematic analysis (2006)
Source: Morsink et al. (2017)

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Table 6: Background of Respondents

No	Position	Institution	Expertise	Codes
1	Lecturer	USM	Microbiology/MFC	R1
2	Lecturer	USM	MFC	R2
3	Lecturer	Taylor's University	Green technology	R3
4	Biology expert teacher	Secondary school	Biology	R4
5	Biology expert teacher	Secondary school	Biology	R5
6	Biology expert teacher	Secondary school	Biology	R6

First, the researcher identify and transcribe all informal comments based on semi-structured interview conducted. Next, the researcher manually generated initial codes. After that, the codes were compared to one another based on frequency, proximity, and conceptual links to develop sub-themes and themes. Table 7 presents a summary of the themes, sub-themes and codes that were used in the thematic analysis. For example, the initial codes included 'new approach', 'not enough' regarding green technology in current Biology curriculum. 'be creative' and 'create animation' in teaching environmental education including green technology. All themes were then reviewed before final themes were defined from the codes. Major themes included Inadequate Content Related to Environmental Education and Green Technology in Biology Curriculum, The Level of Teachers' Knowledge of Green Technology in Biology Subject Need to Be Improved, and The Level of Teachers' Knowledge On Pedagogical Methods Need to Be Improved**.** The theme were organised according to respondents' answers based on semi-structured interview protocol.

Table 7: Summary of themes, sub-themes, and codes

Themes	Subtheme	Codes
Inadequate Content Related to Environmental Education and Green Technology in Biology Curriculum	Not enough content	Only one activity in textbook New approach in green technology More modules
The Level of Teachers' Knowledge of Green Technology in Biology Subject Need to Be Improved	Lack of knowledge	I need to google Not enough knowledge Green technology is developing KeyNote application
The Level of Teachers' Knowledge On Pedagogical Methods Need to Be Improved.	Lack of pedagogical method	Create animation Be creative Integrate innovation competition

Theme 1: Inadequate Content Related to Environmental Education and Green Technology in Biology Curriculum

Experts from USM and Taylor's University suggested that activities related to environmental education need to be improved because most of the content in the Biology curriculum only focused on theory, not practical. Students should be given hands-on exposure so that they are actively involved in teaching and learning activities. Examples of responses given;

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……. for me, the activities regarding environmental education and green technology in the textbook is not enough…more activities should be added…….. (R1)

……..…..in terms of general, the content is not enough….maybe a few activities regarding current green technology should be added...we need to follow the flow of technology... because the current curriculum still lacking in terms current technology that suits the current situation.....previous activities regarding green technology is more to making compost…but actually the compost can be used to generate electricity…….. (R2)

…….there are several activities regarding green technology in previous green technology module developed by CETREE, for example wastewater management….more modules should be developed …… (R3)

All three Biology expert teachers interviewed had been involved in green technology activities using green technology module published by CETREE, USM. Nevertheless, all three experts suggest that green technology activities in the Biology curriculum need to be improved because the existing activities were too simple. Practical activities involve green technology and existing environmental education in Form Four and Form Five Biology curriculum also few compared to other science subjects.

…….…..… there's no high level questions regarding green technology … we can see in the textbook, it's just enough, the level application is not enough..... (R4)

…….it's good to integrate something new regarding green technology…… (R5)

.....only one activity regarding green technology in the textbook….compared to green technology used before….. (R6)

Theme 2: The Level of Teachers' Knowledge of Green Technology in Biology Subject Need to Be Improved

Three expert teachers gave positive feedback regarding their knowledge on green technology. Although various training and activities they have attended, teachers should be trained with activities regarding green technology with more branches and activities because the training and activities are not enough. Biology teachers should explore more knowledge related to environmental education and green technology so that they can practice and apply the activities with students. Examples of responses given;

……my level of knowledge on green technology is still not enough……..sometimes I get information from the students… (R4)

……when we talk about green technology, it is always developing….so the main challenge, the teachers should learn and improve their knowledge…we have to google there and there….. (R5)

…….I don't have problem regarding green technology, because always involved with green technology activities… (R6)

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Theme 3: The Level of Teachers' Knowledge On Pedagogical Methods Need to Be Improved

According to the expert teachers, pedagogical approaches related to green technology need to be improved, not only through classroom activities, but also outdoor activities, including during co-curricular activities. They admit that various pedagogical methods need to be learned in order to increase their professionalism in teaching environmental education and green technology. This is very important to attract students' interest in learning biology, especially green technology activities. In line with that, practical works cannot be separated from theory, and modules related to environmental education can be joined together with other subjects. But time constraints always become a big problem to implement various activities. Examples of responses given;

……for me…actually there are so many things I want to do.. for example KeyNote application…we can create animation…but it takes time..If we have a good teamwork…especially for green technology, we can create animation regarding trees…not only involved in photosynthesis…. (R4)
……..we cannot focus only on specific pedagogical methods…we need to be creative..we can join together the approach to teach students by combining the environmental education with other subject….for example..Geography, Chemistry and Computer Science.. (R5)

We have to emphasize on green technology innovation competition to educate students……there is no problem for me..but the problem is time..so I integrate green technology activities with co-curricular activities. Back then…I just focused on science stream students and STEM club members…for next activity..we can collaborate with all students from all clubs….. (R6)

Most of experts suggests that various approaches of teaching and learning activities on environmental education are the key to increase students' understanding and knowledge on green technology. Nevertheless, the content of environmental education and green technology in current Biology curriculum is not enough to increase students' understanding and their knowledge towards them. Furthermore, we also noted that experts' comments about more modules should be developed to educate students about current approach of green technology, as well as how to manage waste properly so that the students are able to practice in their daily lives. This in line with study conducted by Arasinah Kamis et al. (2019), where the implementation of module related to green technology encourage positive practices among students, which in turn help to preserve the environment for next generations.

Expert teachers in Biology also discussed that their level of knowledge on green technology need to be improved, as well as their knowledge on pedagogical methods. Environmental education is a multidisciplinary strategy for studying environmental concems that improves knowledge, fosters critical thinking, and aids students in making wise decisions. Teaching green technology is one way to educate secondary students with environmental education, so Biology teachers should participate in various activities and programmes related to green technology in order to deliver the concept of green technology in proper manner. This is supported by research done by Talirkodi Vinathan & Arumugam Raman (2021), where teachers must meet all the green practices' understanding, so that knowledge of green technology can be delivered to the students in correct ways.

Transformation of curriculum also require teachers to be more knowledgeable in pedagogical methods. According to Shulman (1987), teachers have to know seven bases to conduct effective teaching and learning processes. The knowledge bases consist of content knowledge, general pedagogical knowledge, curriculum knowledge, pedagogical content knowledge, knowledge of learners and their characteristics, knowledge of educational contest

and knowledge of educational ends, purposes, and values, and their philosophical and historical grounds. As in interview sessions, all Biology expert teachers agreed that various pedagogical methods should be applied during teaching and learning processes regarding green technology. Traditional ways of teaching is no more relevant in teaching science education, especially environmental education. Previous study done by Mageswary Karpudewan et al. (2013) showed that teachers lacking in skills and training regarding green technology will contribute to failure in achieving their goals during teaching and learning activities in the classroom. Hence, teachers' skills on pedagogical methods should be improved through training and frequent practices of 21-st century approaches in classroom, especially through green technology which is MFC.

CONCLUSION

This needs analysis study is very important to collect data and information related to the research's current situation, especially from students, teachers, and green technology experts. In addition, information obtained from this study enable researcher to develop a suitable teaching and learning material to increase the students' knowledge on green technology, especially MFC and improve their manipulative skills. The findings of this study suggest that, the integration of new branch of green technology which is MFC into Biology curriculum is relevant to educate and increase secondary school students' understanding on environmental education. The findings from this study also revealed that knowledge regarding green technology among secondary school students is at moderate level. This study also showed that teaching and learning materials consisting hands-on activities such as practical work should be developed to help teachers improve their knowledge and pedagogical approaches in teaching and learning process regarding green technology. The positive results of this study also provide opportunities for secondary schools, to focus on the new approach of green technology, which is MFC that serve to preserve and conserve the environment for the next generations. The findings of this needs analysis also will be used in the next phase of the module development process.

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