EXPLORING THE CONCEPT OF SUSTAINABLE ENERGY THROUGH CHEMISTRY CURRICULUMTEACHING SUPPORTED BY BLENDED LEARNING PLATFORM

Tan Phei Ling
Methodist Girls' School, Penang, Malaysia
< tanpheiling@gmail.com>

LohPoh Ai
Methodist Girls' School, Penang, Malaysia
<lohpohai@yahoo.com>

Abstract

The Grade 10 Chemistry Integrated Curriculum for Secondary Schools requires students to learn the topic of Electrochemistry. One of the learning outcomes states that students are able to justify the fact that electrochemical industries improve the quality of life. In order for students to learn that green chemistry has been taking its role in the industries for sustainable energy development, sample in this study were assigned to explore into how has the technology in electrochemical industries evolved towards greener environment with lesser pollution. With emphasis on the 21st century learning, this paper aims to explore the concepts of sustainable energy through chemistry curriculum teaching supported by blended learning platform. There were a total of nine groups with five students in each group. Students went through six phases in completing the task using the Edmodo platform under sub-theme Sustainable Energy for All (SE4ALL). The findings revealed that students gained more knowledge and exposure in terms of learning sustainable energy. They also gained knowledge about greener electrochemical industry. Through their guided-narrated reflection, students shared that they enjoyed learning using online platform which enabled them to exchange their opinion with wider group of people internationally. They had fun using the online learning platform. Hence, this study implies that 21st century learning integrating blended-mode activities and online learning platform provides plenty of opportunities for students to interact with others worldwide and also expose them to borderless learning not only in sustainable energy but other areas as well. It is thus suggested that future exploration could be carried out to other topics using the blended learning platforms.

Keywords: Blended learning platforms; Electrochemical industries; Sustainable energy; 21st century learning; Green chemistry

Introduction

Green chemistry refers to efficientutilization of principles that reduces or eliminates waste or generation of hazardous substances in the design, manufacturing and application of chemical products (Sheldon, Arends, & Hanefeld, 2007). Green chemistry addressed many major areas and energy sustainability is one of them. Sustainable development is definedas "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987, pg. 37). Similarly, sustainable energy also means

"a dynamic harmony between the equitable availability of energy-intensive goods and services to all people and the preservation of the earth for future generations" (Tester, Drake, Driscoll, Golay, & Peters, 2005, p. 10).

Incorporating the concept of sustainable energy into chemistry curriculum teaching is an approach used to educate students about their responsibilities towards the environment while teaching chemistry. This approach is parallel with the 10th and 11th objectives outlined in the Malaysian *Integrated Curriculum for Secondary Schools: Curriculum Specification Chemistry Form 4* which enable students to"(10) Realise that scientific discoveries are the result of human endeavour to the best of his or her intellectual and mental capabilities to understand natural phenomena for the betterment of mankind; and (11) Create awareness on the need to love and care for the environment as well as play an active role in its preservation and conservation"(Ministry of Education Malaysia [MOE], 2005, p.2).The concept of sustainable energy can be integrated into various topic in chemistry and carried out with the support of blended learning platform, e.g. Edmodo, Moodle, Wordpressand etc.

Blended learning combines traditional face-to-face teaching methods with online components that extend learning beyond the classroom (LaBanca, Worwood, Schauss, LaSala, & Donn, 2013). This teaching method is proven to be able to help schools to cope with the expectation towards the 21st century learners (Rodgers, Runyon, Starrett, & Holzen, 2006; Shinde & Deshmukh, 2012; Yuen, 2011). As suggested by LaBanca et al. (2013), 21stcentury learnersare able todemonstratesix critical skills that form the foundation for 21st century success: (1) Information Literacy; (2) Creativity and Innovation; (3) Collaboration; (4) Problem Solving; (5) Communication; and (6) Responsible Citizenship through various assignments and activities under blended learning.

This study explores integration of sustainable energy in Electrochemistry industries with the support of blended learning platform.The topic of electrochemistry in Grade 10 chemistry has been chosen to be incorporated with the concept of sustainable energy as this topic is relevant to the idea of preserving energy for the usage of present and future generation. The learning objective chosen was: "(6.7) Develop awareness and responsible practices when handling chemicals used in electrochemical industries" (MOE, 2005, p. 42). To be specific, students are required to explore in-depth into how have electrochemical industries evolved towards greener, more sustainable environment with lesser pollution. This activity is expected to achieve the learning outcome in which students are able to justify the fact that electrochemical industries can improve the quality of life.

Therefore, the main aim of this paper is to investigate the impact of the integrationof online blended learning platform on students' learningexperienceduring and after their participation for the project of 'electrochemical industries improving the quality of life'.

Methodology

This study employed case study approach involving data collection from observation, and self-narrated reflective feedback from students. Firstly, the students have been taught about the concept or topic of electrochemistry which include properties of electrolytes and non-electrolytes, electrolysis of molten and aqueous compounds,electrolysis and voltaic cell as well as all the industrial applications and lastly synthesising electrochemical series as stated in the learning objectives (i.e. 6.1 to 6.6) in Curriculum Specification of Form 4 Chemistry (MOE, 2005).

Sampling and Implementation

A total of 45 students from a secondary school in Penang Island, Malaysia participated in this study from April to end of July 2017. They were divided into nine groups There were five members in each group. Among the nine teams, five teams were from the better performing class and four teams were from other classes. This group of students has been enrolled in the science stream since January 2017 in which studying the three pure science subjects, i.e. Physics, Chemistry and Biology is compulsory.

The teaching was done using in-class instruction and experiments, then studentswent through six phases throughout the implementation of the study. The six phases included were: (1) Preparing and raising questions about the topic to decide on title; (2) Confirming title and guiding discussion on content; (3) Compiling and organizing information in Microsoft PowerPoint; (4) Submitting completed assignment to an online blended learning platform; (5) Initiating communication with people worldwide to gain and exchange opinions as well as comments on completed task and; (6) Submitting reflective feedback through guided questions to the online blended learning platform.

The online blended learningplatform used in this study was known as SEAMEO LeSMaT (Borderless) in Edmodo.com. This platform was initiated under the project of SEAMEO Student Networking for 'Learning Science and Mathematics Together' (LeSMaT) in a Borderless World [also abbreviated as SEAMEO LeSMaT (Borderless)]. The integration lasted for two weeks but students' interaction with people worldwide are still on-going. Students' responses during and after the integration were recorded and supported by their individual guided-narrated reflective feedback.

Research Instruments

The following are the research instruments used in this study:

1. Student's Learning Observation Record: The observation record includes in-class observation and learning platform observation;

2. Online Learning Platform: This platform contains course information, discussion forum, message board, files to bedownloaded, small group discussion posted and so on. Figure 1 shows the entry page of the SEAMEO LeSMaT (Borderless)] in Edmodo.

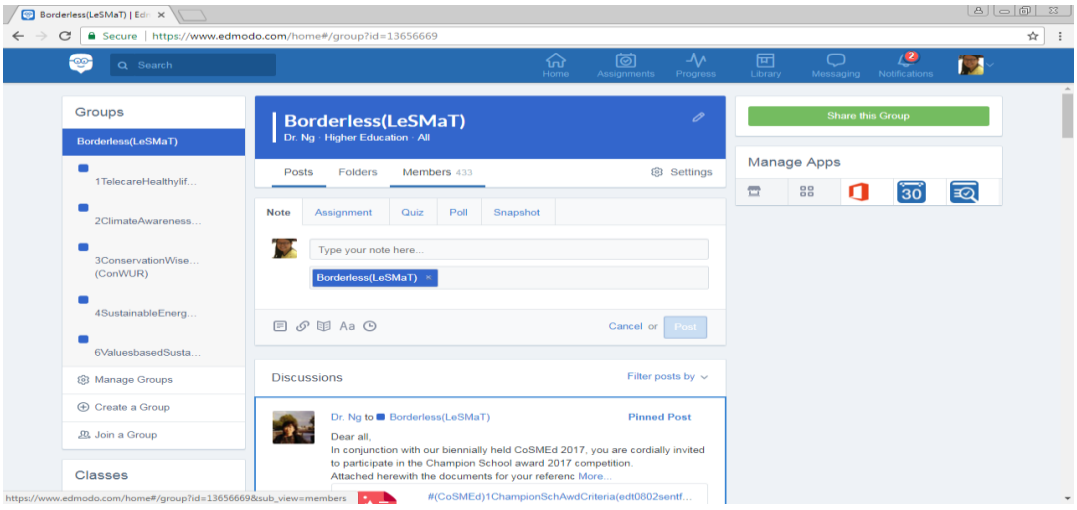

Figure 1. The entry page of the SEAMEO LeSMaT (Borderless)] in Edmodo.

3. Guided reflective feedback: It contains six questions which facilitate students to do anarrative reflective feedback based on the questions. The questions include: (i) What is the title of your project? (ii)What has your group done in your project? (iii) How did you feel and what did you learn after completing your project? (iv) How did you feel and what did you learn throughout the process of using Edmodo (https://www.edmodo.com/) for your project discussion?

The data collected included: (1) Students' work submitted to the SEAMEO LeSMaT (Borderless) platform [Figure A(i) in Appendix A] and (2) Students' individual reflective feedback which was uploaded to the same platform. The data collected were analysed by adopting thematic coding using Nvivo (http://www.qsrinternational.com/) to construct categories from students' reflective feedback. Nvivo enables researchers to work through and analyse the data efficiently. Attempts were made to understand the students' experience in using blended learning for their task and the impact that this experience has given them.

Findings and Significance

There were a total of nine groups that submitted their Power Point presentation to the SEAMEO LeSMaT (Borderless) platform under the sub-theme of the module: 'Sustainable Energy for All' (SE4ALL) in Edmodo.com.

Table 1 shows the summary of the students' work which included group number, title of presentation[in response to question (i)] and description of work[in response to question (ii)].Further illustration with screenshot of each presentation is available in Appendix B.

Table 1
The Description of the Students' Work

Group number	Title of Presentation	Description
1	E-Diesel: Sustainable Energy	AUDI's new E-Diesel, which is thefuel created by the reaction between water and air. We also studied its manufacturing process, its benefits, and its application.
2	Microbial Fuel Cell	Definition of Microbial Fuel Cell, how it works and the advantages towards sustainable energy, application of the microbial fuel cell in different field.
3	Electrolysis of molten salt	Discussions focus on industrial-based electrochemical refining of Silicon and Aluminium, including definition of molten salts and silicon history
4	High temperature photovoltaic and electrochemical cell combine to advance solar power.	Descriptions about thephoto-chemical cell to make energy more efficient and how to conserve the energy by using solar power.
5	Advanced Electroplating	The use of 'Dry' processes involving non-metal substrates and nanotechnology for greener and sustainable electroplating process.
6	Daniell Cell	Discussions focus on how Daniell cell function as a sustainable form of energy including the description of different types of Daniell cell.
7	Electroplating of metals using electrolysis	Discussions focus on the definition, process, aims, benefits and some examples of electroplating, including changes in electrolysis of Nickel.
8	Purification of metals	Discussions focus on purification of metals, specifically purification of copper and the uses of copper.
9	Extractionof Sodium metal	Discussions focus on extraction of Sodium metal, explanation of Castner Process, properties of sodium metal and uses of sodium metal.

The original Power Point presentation could also be viewed through this link: https://drive.google.com/drive/folders/1qoa-4l1Iyc1g_l88MWfKZiy5zOi6bi0q?usp=sharing

Due to time constraint, the Power Point presentations by Group 3 and Group 6 to Group 9 focused only on making justifications on how electrochemical industries can improve the quality of life and a lesser focus on sustainable energy. These groups have tried to improve on their work and they welcomed opinions for further improvements from other members in the Edmodo learning platform. Even though their work were not focusing on sustainable energy, credits were given for their first-time participation in this project and hence, their work were also included in this paper.

Apart from that, the analysis made on students' reflective feedback using Nvivoin response to the guiding question "(iii) How did you feel and what did you learn after completing your project?" revealed that overallthe students felt positive about the project. Table 2 shows the percentage of response in each category identified from students' narration in response to question (iii).

Table 2
The Percentage of Response in Each Category Identified from Students' Narration in Response to Question (iii)

Aspect	Expand knowledge about electroche-mistry	Expand knowledge about sustainable energy	Interesting	Sense of achievement	Team-work	Time manage-ment
Percentage (%)	91.3	87	60.9	34.8	8.7	8.7

The highest percentage (91.3%) of students expressed that they had expanded their knowledge about electrochemistry, particularly about sustainable energy in electrochemical industries, whereas second highest percentage of pupil (87%) expressed that they gained more knowledge after completing the task. This is supported by the reflective statement made by student T:

"*...after completing the task,I've understood more about electrochemistry. I have learnt that electrochemical is very useful to us and make things easier*."

(Reflective feedback written by student T, September 8, 2017)

Subsequently, 60.9% of students felt that learning about sustainable energy and researching into the topic of sustainable energy in electrochemistry was interesting, 34.8% of students expressed that they had asense of achievement after they had completed the assignment, quoting student X who mentioned:

"*I felt a sense of accomplishment and also a sense of relief that we were able to accomplish the assignment".*

(Reflective feedback written by student X, September 10, 2017)

The same percentage (8.7%) of students expressed that they had learnt about teamwork and time management while completing the assignment. They enjoyed and appreciated the cooperation given by their team members as student E mentioned:

"*I have also learnt teamwork and time management with my other group members."*

(Reflective feedback written by student E, September 8, 2017)

A point to note is that the total percentage in Table 2 and Table 3 did not equal to 100 because one individual student might have mentioned several aspects in the narrative reflection. The total percentage was calculated based on the total aspects mentioned by the 45 total students' narrative reflection.

In addition, from th ereflective narration of students referring to guiding question (iv) How did you feel and what did you learn throughout the process of using Edmodo for your project discussion? More than half of the students expressed that they felt positive in several aspects and only 8.7% of students expressed that they were confused when they were using Edmodo at the beginning stage. Table 3 shows the percentage of each category identified from students' narration in reply to question (iv).

Table 3
The Percentage of Responses in Categories Identified from Students' Narration in Reply to Question (iv)

Aspect	Communicate or interact and exchange opinion among students and teachers	Fun and exci-ted	Sharing of knowledge	Good platform to use	Easy to use Edmodo, less stressful	Improve IT skills	Con-fusing
Percen-tage(%)	65.2	56.5	43.5	17.4	13	8.7	8.7

As shown in Table 3, 65.2% of the students expressed that they learnt to communicate or interact and exchange opinion among students and teachers from all over the world and 56.5% expressed that they had fun and were excited as using Edmodo was a new experience for them. This is supported by the reflective statement made by student N:

"…*Feeling something new experience*."

(Reflective feedback written by student N, September 7, 2017)

In addition, Table 3 shows that students felt that using online blended learning(i.e.Edmodo) enabled them to share their knowledge with peers and also gained knowledge from people around the world (43.5%), claimed that Edmodo is a good platform to be used for learning (17.4%), claimed that Edmodo is easy to use and they felt less stressful doing their assignment using the blended learning platform (13%). Some of them also claimed that they had improved their IT skills after going through blended learning (8.7%) as mentioned by student S and J respectively as extracted in the following excerpts:

"…*I feel less stressful with the use of Edmodo in my project discussion as I can carry out this project just by sitting comfortably in front of computer".*

(Reflective feedback written by student S, September 8, 2017)

"*I also get to improve my IT skills through the Edmodo".*

(Reflective feedback written by student J, September 8, 2017)

The findings of the study showed that the students are positive towards this new learning approach for integrating the concept of sustainable energy through chemistry curriculum teaching supported by blended learning platform. The students not only can access and obtain various information as well as knowledge through in-class instruction but

also from online learning platform. In addition, group work provides students with the opportunity to stimulate them to brainstorm on the information obtained from the latest evolution in electrochemical industries as well as to organize and relate the data obtained. These findings were good motivation for the researcher and haveencouraged more such online blended learning to be carried out in the lesson.

Through students' participation in the blended learning activities, they were able to demonstrate the followingsix critical skills: (1) Information Literacy; (2) Creativity and Innovation; (3) Collaboration; (4) Problem Solving; (5) Communication; and (6) Responsible Citizenship that formed the foundation for 21st century success as described byLaBanca et al. (2013).

Conclusion

Online learning platform provides an interactive environment for communication among students and enables teachers to engage students in collaborative ways as well asthrough cooperative activities even beyond classrooms.

The findings of this study provideempirical evidence that blended learning integrating the element of collaboration among students leads to better student involvement, better performance, and higher productivity (Nunamaker, Briggs, Mittleman, Vogel &Balthazard, 1996), where students perceive greater opportunities for communication than those in a traditional classroom (McCloskey, Antonucci, &Schug, 1998).

Through the online learning platform, the studentshavegained more confidence and have become more independent. On top of that, the students were observed to be more motivated in learning through blended-mode activities as the students have more fun interacting with people across the border and to get comments from them. Moreover, the learning outcome: "Students are able to justify the fact that electrochemical industries can improve the quality of life" has been achieved.

Hence, this study implies that 21st century learning integrating blended-mode platforms provides more opportunities for students to interact with people all around the world [Figure A(ii) in Appendix A] through borderless learning not only about sustainable energy. It is thus suggested that future exploration can also be carried out for other topics using the blended learning platform to enrich the teaching content and enhance the students' learning experience.

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Appendix

Part A: Screenshots of Blended-learning Activities

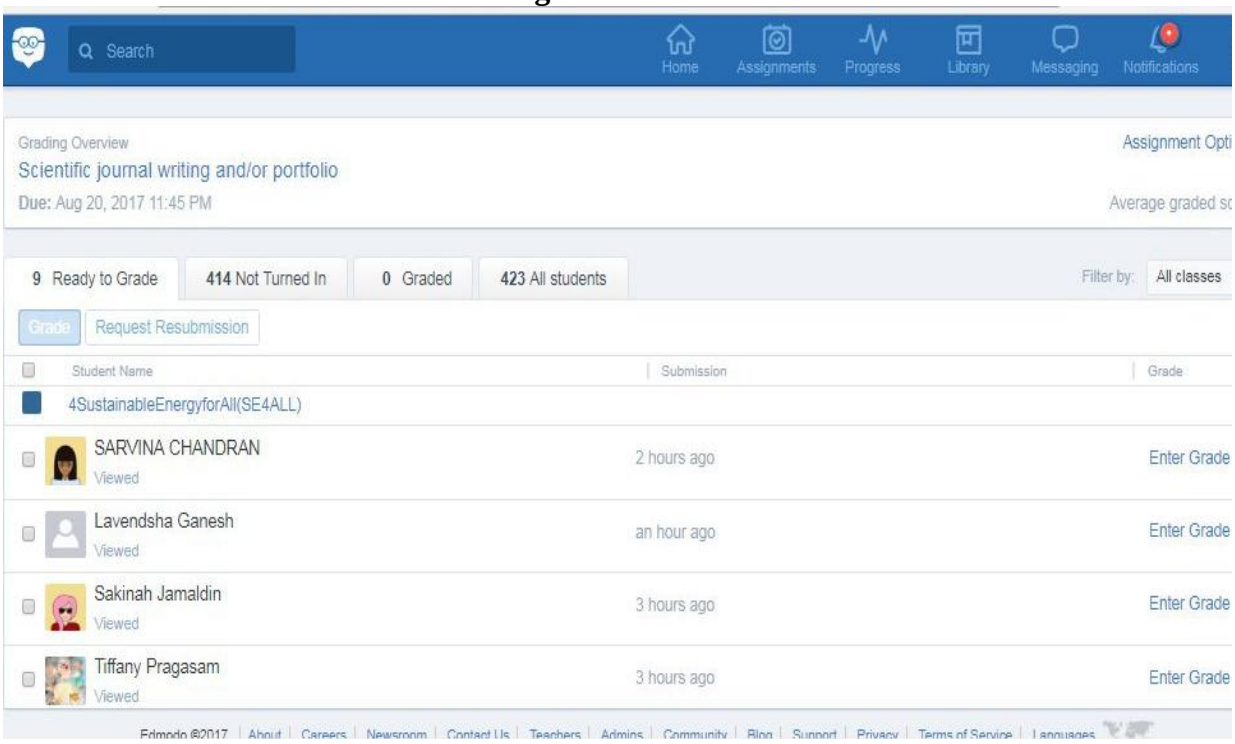


*Figure A(i).*Printscreen showing proof of submission of students' assignment into the Sustainable Energy for All (SE4ALL) in Edmodo.com.

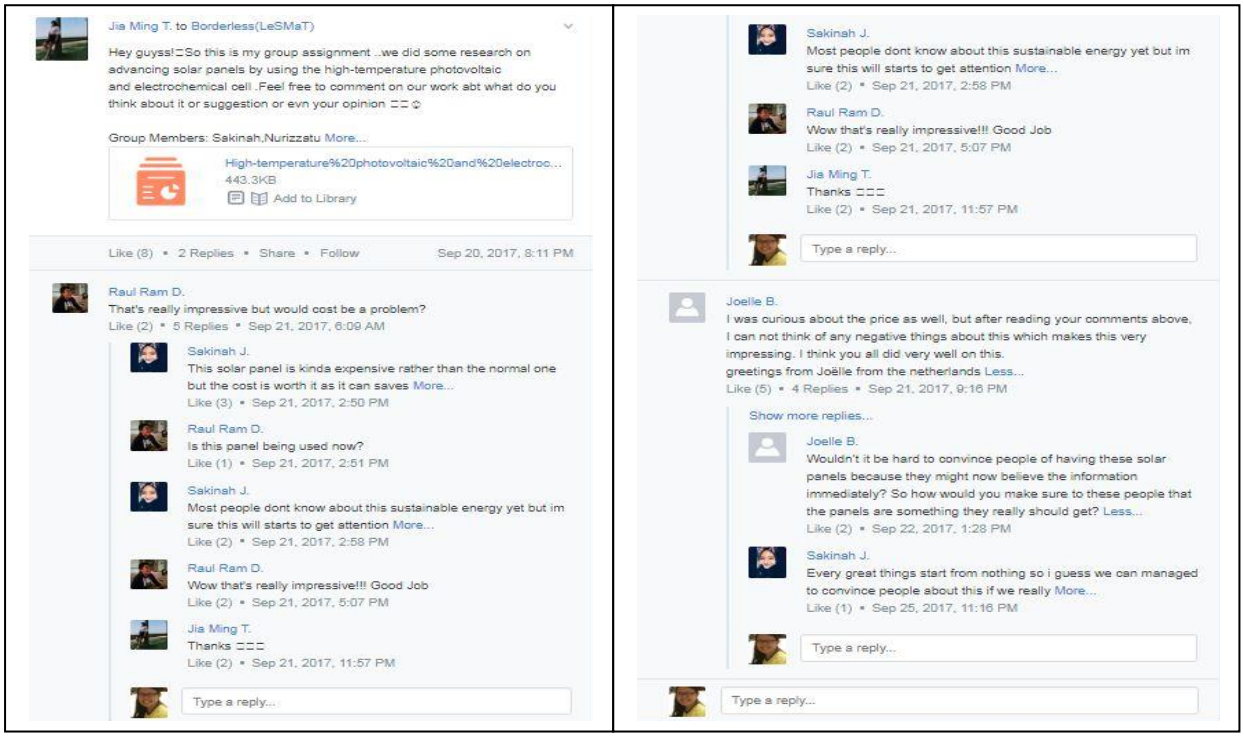
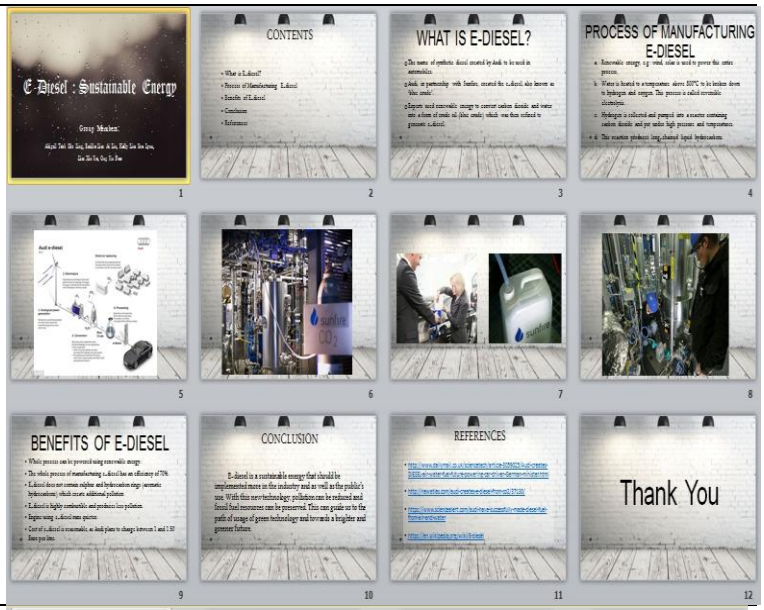
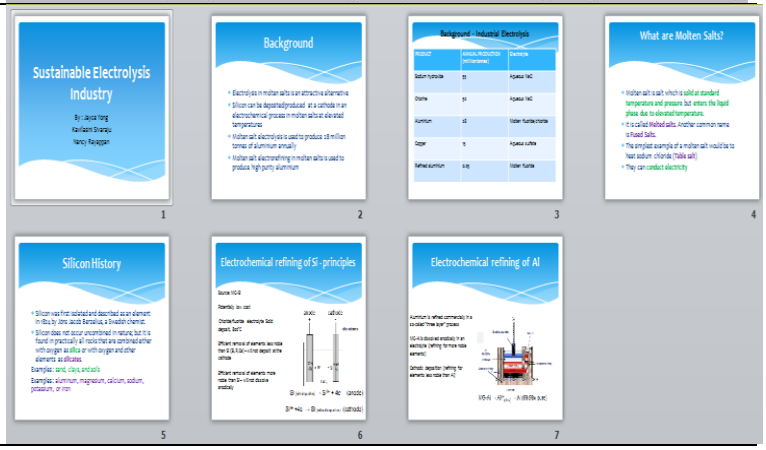
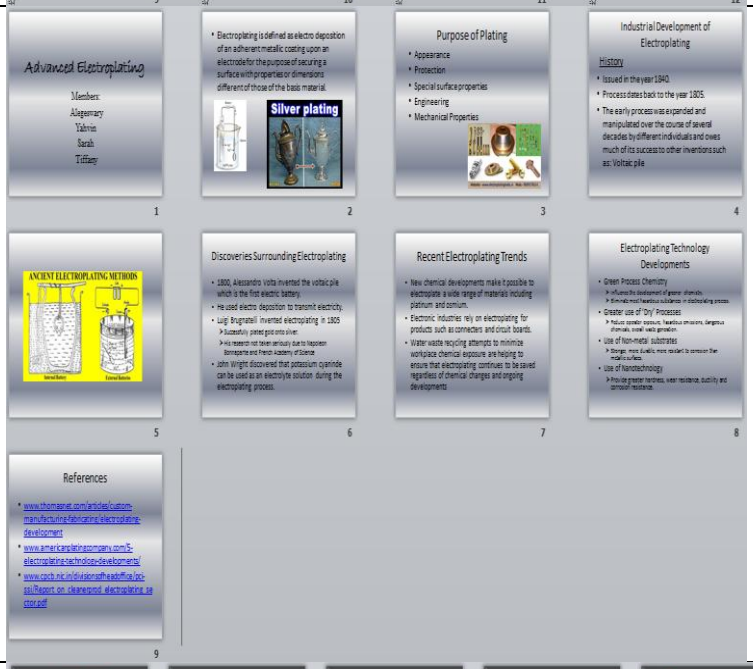
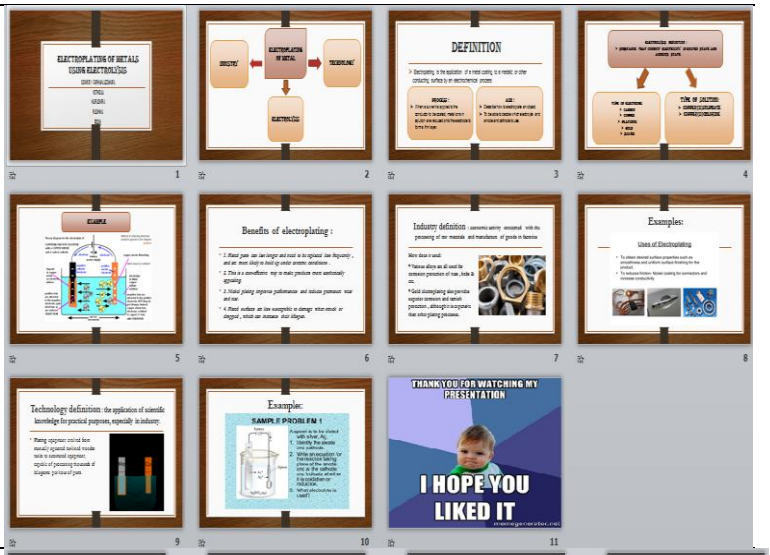
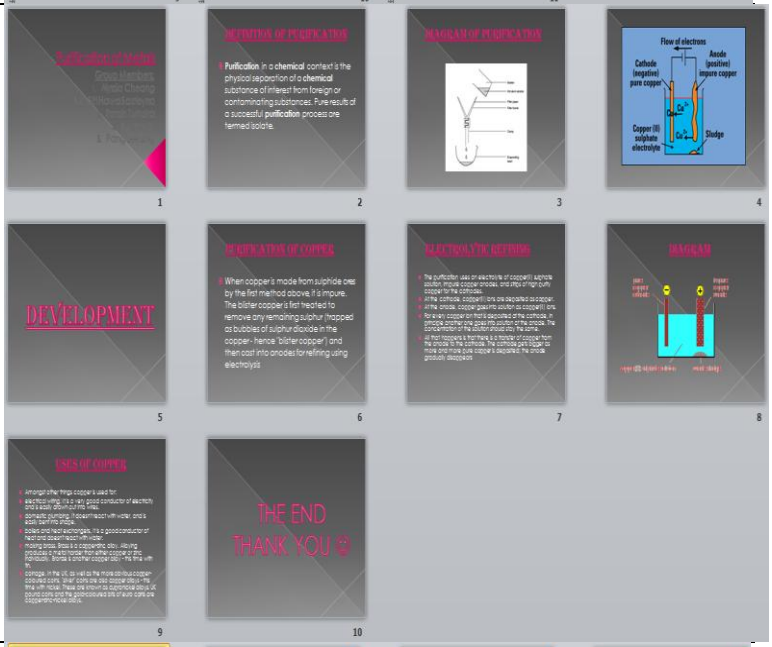


*Figure A(ii).*Printscreen showing other blended-mode networking with international students.

Part B: Further elaboration of Table 1 on The Description of the Students' Work

Group num-ber	Title of Presen-tation	Description	Screenshot
1	E-Diesel: Sustain-able Energy	AUDI's new E-Diesel, which is the fuel created by the reaction between water and air. We also studied its manufacturing process, its benefits, and its application.	
2	Microbial Fuel Cell	Definition of Microbial Fuel Cell, how it works and the advantages towards sustainable energy, application of the microbial fuel cell in different field.	
3	Electro-lysis of molten salt	Discussions focus on industrial-based electrochemical refining of Silicon and Aluminium, including definition of molten salts and silicon history	

4	High-temperature photo-voltaic and electro-chemical cell combine to advance solar power.	Descriptions about the photo-chemical cell to make energy more efficient and how to conserve the energy by using solar power.	
5	Advanced Electropla-ting	The use of 'Dry' processes involving non-metal substrates and nanotechnology for greener and sustainable electroplating process.	
6	Daniell Cell	Discussions focus on how Daniell cell function as a sustainable form of energy including the description of different types of Daniell cell.	

7	Electro-plating of metals using electro-lysis	Discussions focus on the definition, process, aims, benefits and some examples of electroplating, including changes in electrolysis of Nickel.	
8	Purifica-tion of metals	Discussions focus on purification of metals, specifically purification of copper and the uses of copper.	
9	Extraction of Sodium metal	Discussions focus on extraction of Sodium metal, explanation of Castner Process, properties of sodium metal and uses of sodium metal.