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Perceptions and Achievement in Electrochemistry Using Flipped Classroom Model

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ABSTRACT

The potential of flipped classroom instruction was undertaken to enhance the performance of students in learning electrochemistry. This study was to investigate the effects of the Flipped Classroom Model (FCM) on students' performance in electrochemistry as well as their general perceptions. The study used a quasi-experimental method that utilized pre-test-post-test nonequivalent groups design. Students' perception of FCM was based on a questionnaire. Results of the independent *t*-test noted that there was a significant difference between the two groups (*t (26) =-2.281, p-value=0.031*). The results suggested that the Flipped Classroom Group and Conventional Classroom Group are incomparable in terms of performance in electrochemistry after the intervention. The experimental group has a medium gain while control group has a low gain as reflected by the normalized gain (Hake factor) values of *0.45 (SD = 8.32) and 0.22 (SD = 6.48*), respectively. This only means that flipped classroom instruction has a generally positive effect on the achievement of students in learning electrochemistry. The students' perceptions were positive. Students perceived that FCM helped them understand the concepts in electrochemistry easily. They also

suggested that FCM was enjoyable, timely and engaging. Lastly, the majority of the students agreed about the use of Flipped classroom instruction as an effective way to learn electrochemistry.

Keywords — Electrochemistry, Flipped Classroom Model, Quasi-experimental design, Quantitative and Qualitative Research, Perception, Achievement, Philippines

INTRODUCTION

Electrochemistry is one of the most important topics in chemistry. Electrochemistry involves a large variety of problems such as balancing redox reactions; electrochemical cells; standard electrode potentials (E^0); *Nernst* equation; electrolysis; and corrosion. Additionally, strong mathematical operations are necessary to solve electrochemistry problems in which students prove hard to do (Tsaparlis, 2014). Indeed, electrochemistry topped as one of the most difficult topics for high school students and even in University level (Treagust, 2002, Lin, Yang, Chiu, & Chou, 2002, Finley, Stewart & Yarroch, 1982; Johnstone & Mahmoud, 1980) since an understanding of all these topics is needed to adequately understand electrochemical phenomena (Corriveau, 2011). The voltaic and electrolytic cells are difficult to understand because these topics are abstract and the process itself is invisible to the eye, while only the effect is observable (Corriveau, 2011). In the investigation of pre-service chemistry teachers conducted by Ekiz, Kutucu, Akkus, and Boz (2011) it was revealed that teachers could not even distinguish electrolytic cells from galvanic cells. Pre-service teachers could not even have distinguished the electrodes as anode and cathode in electrolytic cells, so they could not predict the product of the electrolysis correctly. The same result was also observed to university students (Ekiz, Kutucu, Akkus, & Boz, 2011).

From this difficulty, teachers should find ways to improve the conceptual knowledge and algorithmic ability of the students. One possibility is the use of varied teaching strategies such as the integration of technology. In addition, the use of varied activities such as visualizing and multimedia tools; small- group discussions; and concept mapping have a vital positive outcome in improving their achievement (Necor, 2018). Several researchers reported success with dispelling student misconceptions by utilizing computer animations showing particle movement in voltaic and electrolytic cells (Acar & Tarhana, 2007;

Sanger & Greenbowe, 1997b) will ease the difficulty of the students. Likewise, Sanger and Greenbowe (2000) believed that novice learners should be prompted to watch relevant details to maximize their learning experience while using computer animation. Teachers must take on the challenge of utilizing technology to commit to a paradigm shift, from a teacher-centered to a student-centered learning style, focusing not on how to teach, but how to facilitate learning. Students must be taught how to learn, so that they can continually learn on their own, even outside the classroom setting and throughout their lives (Perso, 2007 & Allan, 2007). Ergo, the flipped classroom model may help establish in improving both conceptual understanding and problem-solving skills of the students.

Flipped classroom model is a pedagogical model in which the typical lecture and homework elements of a course are reversed. Short video lectures were viewed by students at home or outside classes before the class discussion at their pacing, while the in-class time it is devoted to exercises, assessments, or discussions. Gayate and Caballes (2017) proposed that a successful flipped classroom involves detailed planning. Teachers are instructed to start small and it is unnecessary to flip the whole course. Choosing a unit that the students find challenging is usually best-suited for flipping (Wolf & Chan; 2016). They further suggested that flipped classroom instruction facilitates the transformation of the pre-existing incorrect knowledge to a scientific one. From this aspect, the flipped classroom can be viewed as conceptual change and constructivist teaching approach that effectively provides a learning environment in which students use their knowledge actively, construct their views about science, and develop critical thinking (Gayate & Caballes, 2017). Flipped classroom also creates a learning environment that provides students opportunities to change their incorrect conceptions to scientific conceptions (Bunce, 2015). In Asia, the potential of Flipped classroom is not only fueled the necessity for more resources to be channeled. It can also be of special value to schools with a strong international culture worldwide (Joanne & Lateef, 2014). Joanne and Lateef (2014) further cited to encourage schools of all levels and disciplines in Asia to take the plunge and test out flipped classroom instruction. In the study conducted by Ruddick (2012) in college chemistry, preparatory course revealed that students under flipped classroom have higher grades compared to conventional lecture sections. The students outperformed the standard lecture-based students, with higher final exam scores and overall success in class. She also added that flipped classroom is more interesting and feel less humiliated in chemistry class, and online videos and PowerPoint materials are useful (Herreid and Schiller, 2013). Teaching flipped classroom supports chemistry laboratory experiments conducted by Teo et al., (2014) provided teachers with great flexibility over the classroom time as students have time to engage lesson content at a deeper level. The widespread use of "flipped (or inverted) classroom model" in science education is fairly a new pedagogical teaching strategies to address students' difficulty in electrochemistry.

The demand to establish a higher quality of student learning in the tertiary sector is synonymous with the acquisition of a deep level approach to an understanding amongst our students. However, recent research concluded that traditional teacher-centered learning models are more likely to result in surface-level learning. Additionally, research indicates that higher quality learning is more likely to come from a more student-centered approach to study (Entwistle, 1998).

Electrochemistry exhibited as the most difficult topic in chemistry along with several algorithmic problems and misconceptions. Thus, the potential of flipped classroom instruction steer problem-solving skills prompted the researcher to undertake this study. This study was conducted to respond to the challenge of a continuous search for a more meaningful and relevant science learning strategies, which is beneficial to students and teachers.

FRAMEWORK

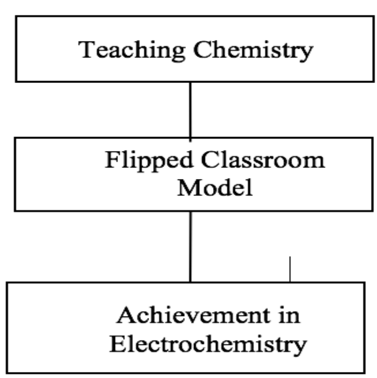

Figure 1. The conceptual framework of the study

Chemistry involves both algorithmic (and problem-solving) and conceptual understanding skills which are important ability in the quantitative problems, particularly in electrochemistry. Electrochemistry ranked as one of the most difficult topics in chemistry for both high school and college-level students. This is also apparent to some chemistry teachers. In studying electrochemistry, students need to understand both microscopically and macroscopically. These were both abstract to students, which latter affects their conceptual understanding and problem-solving performance.

Bergman and Sams (2002) suggested that the flipped classroom model is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space. The resulting group learning space is transformed into a dynamic, interactive learning environment in which the typical lecture and homework elements of a course are reversed. Currently, flipping the classroom has become an increasingly popular approach for college students. The role of a teacher changes from a lecturer and a deliverer to learning content coach, guiding students through a series of engaging and experiential learning activities. Bergman and Sams (2002), authors of flipped classroom suggested that this is beneficial to students and professionals' development setting particularly those who are busy, as videos can be viewed at a convenient time whether at home, workplace, or mobile device while traveling. The Flipped classroom has gained high reputation in recent years and has been used in teaching chemistry classes to enhance conceptual understanding and algorithmic skills. The students under flipped classroom performed better in all tests and quizzes; outperformed the standard lecture-based students; more interested and feel less intimated; supports chemistry laboratory experiments with great flexibility; and a significant increase between in the sequential exams.

OBJECTIVES OF THE STUDY

This study aimed to evaluate the effectiveness of the flipped classroom model in students' achievement in electrochemistry among freshmen Civil Engineering students and to determine the general perceptions of the students on the use of flipped classroom model.

METHODOLOGY

Research Design

This research used a quasi-experimental design, utilizing quantitative and qualitative methods of research. The instruments were administered directly to two intact classes, which were Flipped Classroom (Experimental Group) and Conventional Classroom (Control Group). Data were gathered through the use of different instruments such as results of the achievement tests, and students' perceptions in the flipped classroom model. The study was carried out in two-intact classes. All respondents were freshmen of Civil Engineering students. Matching the respondents was determined using Lawson's Classroom Test of Scientific Reasoning (LCTSR, 2000) to determine the student's cognitive level. There were 14 respondents in both groups who matched, each of them represented in the Transitional reasoning. It was pointed out that not all students in the same class were part of the analysis. However, all the instruments were administered to all students in the two classes and they were not aware who is included or not included in the study. Additionally, a readiness test about prerequisite topics in electrochemistry was administered to examine the prior knowledge of the students. This result obtained will disclose if a review of the prerequisite concepts was necessary prior to the discussion of electrochemistry. The classes were handled by the researcher in the entire semester.

Instrumentation

***a) Electrochemistry Achievement Tests* (EAT) (Post-test)**

This test serves as a basis of student's achievement in learning electrochemistry after the intervention was administered to both the experimental and control group. The test was prepared by the researcher and was adapted from existing item banks and instruments. The test is a multiple-choice with four options. The topics included are balancing Redox reaction (acidic and basic solution); Galvanic cell; standard reduction potential ($E°$); battery; corrosion and electrolysis. This test was content-validated by a panel of chemistry teachers who validated the readiness test. Reliability test was tested using the test-retest method.

b) Survey Questionnaire on Students' Perceptions on Flipped Classroom Instruction

This survey questionnaire was used to assess students' perception of the effect of flipped classroom instruction in learning electrochemistry using a Likert-Scale. The survey questions were adapted from Gayeta (2017) with slight modification was administered at the end of the course.

Data Gathering

The study started with the selection of freshmen Civil Engineering classes taught by the same teacher. One of the two classes was randomly assigned as the experimental group, and the other as the control group through coin tossing. The Lawson's Classroom Test of Scientific Reasoning (LCTSR) 2000 was administered for matching and classified as concrete (empirical-inductive) reasoning (*EI*); transitional reasoning (*TR*); or as formal operational (hypothetical-deductive) (*HD*) reasoning depending on their results. It was pointed out that not all students in the same class were part of the analysis. However, all the instruments were administered to all students in the two classes and they were unaware who was included/not included in the study. A readiness test was administered in both groups to determine whether a review of these prerequisite concepts was needed to teach before teaching the core topics in electrochemistry.

The intervention ran for only 16 hours of the first semester. After which, both groups took the post-test. The researcher used a pre-test and post-test scores of students of both groups to assess the effectiveness of the flipped classroom model.

Flipped Classroom Instruction Model (FCM)

A flipped classroom instruction (FCM) was an intervention instruction used in the study. In the flipped classroom model, students did not experience "live" lectures but they are required to watch videos, recordings, and presentation prior to class discussion and activities outside the class. The students can browse, watch or listen to the videos several times. Students are expected to do assignments and encouraged to review course materials, including online screencasts, prior to coming to the class. The topics were mirrored to those of the lectures that were delivered in the conventional class.

The video lecture content was on various topics in electrochemistry. A total of 25 video lectures were posted over the course and overall lecture time was reduced compared to the conventional classroom setting. All the videos were downloaded from YouTube by the researcher. Varied videos were used based on the researcher's time limits and/or preferences for a specific lesson.

In the experimental group, each student is required to register in the Google classroom prepared by the researcher. A Google classroom was created wherein the students can browse, watch or listen to the recordings and videos for several times. The students came to class with notes they had taken while watching the pre-recorded lectures and videos. Some students may bring questions or clarifications by writing on Flipped Classroom Student Checklist to class and these were addressed immediately during discussions.

To help track students' attendance, an assignment was given to each of several videos. The questions in the assignments were anchored on the video/s. The primary purposes of this are to motivate students to watch the video before coming to class. Note: for those students who do not have online access, a flash drive was used per lesson as suggested by Bergman and Sams (2002). By the end of the experiment, the sum of all the quizzes, worksheets, and assignments accounted for 25%, 15%, and 10% of their total grade, respectively.

During the Class

The implementation of a flipped classroom instruction during the class session was adapted from Ferri (2014). At the beginning of the class, the instructor leads the class discussion, beginning with soliciting questions held by the students or by checking the Flipped Classroom Checklist. The instructor was careful not to review the material in the video lesson again simply. The purpose of the discussion is to get feedback on what was not understood or to give deeper explanations. After which, students were given a formative assessment such as a mixture of recitation, active learning, problem-solving, and activities. During the class, the students are not allowed to browse their laptops or smart mobile phones during formative assessments. Students were encouraged to work by a partner, or by group depending on the tasks and activities. Across the sections, tests were completed on the same day and at the same time. Students' formative assessments; activities; and homework were checked and recorded properly.

Data Analyses

The effectiveness of FCM in learning electrochemistry was determined by gain scores from pre-test to post-test (EAT). An independent two-sample ***t***-test at 5% level of significance was used. Analysis of covariance (ANCOVA) was also used to determine if a significant difference existed between the post-test scores of students in both groups. Pre-test scores of both groups served as the covariate to eliminate the effects of the prior knowledge before the treatment. Thus, the improvement in the post-test scores of the experimental group could be solely attributed to the use of Flipped classroom instruction.

Additionally, results of pre-test and post-test were subsequently analyzed using the Hake factor test (normalized gain). It was used to measure the effectiveness of flipped classroom instruction in the students' performance in electrochemistry. Descriptive equivalents and verbal description for Hake Factor Test results were presented in Table 1.

Table 1. Descriptive Equivalents for the Hake Factor Test Results

Formula	Scale Range	Verbal Description
	0.71-1.00	High Gain
$h = \frac{\text{post} - \text{test} - \text{pre} - \text{test}}{1 - \text{pre} - \text{test}}$	0.31-0.70	Medium Gain
	0.10-0.30	Low Gain

Lastly, students' perceptions of the effect of flipped classroom instruction were determined. Composite mean scores were used to interpret as strongly agree; agree; neither agree nor disagree; disagree; or strongly disagree. Statements were then ranked, from highest to lowest based on weighted mean scores. Students' answers will be transcribed, analyzed, and evaluated using mean scores as shown in Table 2. Interview prompt was also conducted to clarify further students' view on a flipped classroom environment strategy using semi-structured questions. In the study, five students were selected to be interviewed. Their consent was asked before the conduct of the interview.

Table 2. Rubric in Converting Mean Score to Students' Perception under the Flipped Classroom Model

Mean Score	Verbal Interpretation
4.50 - 5.00	Strongly Agree
3.50 – 4.49	Agree
2.50 – 3.49	Neither Agree or Disagree
1.50 – 2.49	Disagree
0.00 – 1.49	Strongly Disagree

The Statistical Packages for Social Sciences, SPSS Version 25.0 software was used in analyzing the data.

Semi-Structured Interview

After the treatment was completed, the researcher prepared questions from the existing researches about the students' perceptions in the used of flipped classroom model instruction. A total of five students participated in the face-to-face interview using a semi-structured interview consisting of 3 males and 2 females. The interviews were audio-recorded, and the duration of these interviews ranged from 10 to 13 minutes. To reveal the opinions of the participants about the FCM, the following questions were asked during the interview.

- How much study time (how many hours) per week did you allocate for your out-of-class lessons?
- What are the ways did you do to learn the topics outside the classroom?
- What are the positive aspects of the Flipped Classroom for you?
- What are the topics in electrochemistry that is difficult or confusing?
- Does Flipped Classroom help you understand this topic easily?
- What are the problems you have encountered in Flipped Classroom Model?
- What solutions can you suggest to address these problems?

RESULTS AND DISCUSSION

Effects of Flipped Classroom on Student Achievement

The results of the post-test are shown in Table 3. It revealed that the experimental group (*mean=19.21, SD=3.21*) is statistically higher than the control group (*mean=16.36, SD=3.41*). This denotes that there was a significant difference between the two groups (*t (26) =-2.281, p-value=0.031*). The results suggested that the Flipped Classroom Group and Conventional Classroom Group are incomparable in terms of performance in electrochemistry after the intervention.

Table 3. Descriptive Statistics of Post-test Score on Electrochemistry Achievement Test

Group	N	Mean Pre-test	SD	t	df	Sig (2-tailed)
Conventional Classroom	14	16.36	3.41	-2.281	26	.031
Flipped Classroom	14	19.21	3.21			

To further analysis the pre-test/post-test scores statistically from different groups, an ANCOVA was done where the pre-test as a covariate. This test was used to find out if the experimental group achieved better than the control group. Table 4 shows the descriptive statistics comparing the post-test mean scores of the two groups.

Table 4. Descriptive Analysis of the Post-test Scores of the Two Groups

Group	Mean	Std. Deviation	N
Control	16.36	3.41	14
Experimental	19.21	3.21	14
Total	17.79	3.56	28

Table 4 revealed that the mean score of the experimental group is higher at *19.21* (*SD=3.21*) than that of the control group at *16.36* (*SD=3.41*) with a total mean score of *17.79*. To compare further, ANCOVA on both post-test scores of two groups with the pre-test scores as a covariate as shown in Table 5. It revealed that the pre-test scores were equal across two groups to their performance in the post-test of F (*1, 26*) =*.104* and *p<.750*. This denotes that the data of this study fulfill the ANCOVA assumptions that the pre-test scores must be proportionately related to the dependent variable (post-test scores).

Table 5. Analysis of Covariance (ANCOVA) Results of the Post-test Performance of Students with their Pre-test Scores as Covariate

Source	Type III Sum of Squares	Df	Mean square	F	Sig (p-value)
Pre-test	13.722	1	13.722	1.262	.272
Group	70.14	1	70.14	6.451	.018 S
Error	271.85	25	10.87		

R^2 = .207 (Adjusted R^2 = .143); p<.05

Moreover, Table 5 revealed that both groups had a significant effect on their performance in the post-test with F (*1, 25*) = *6.451* and *p = .018*. This disclosed that there is a significant difference between the adjusted post-test mean scores of the experimental and control groups after controlling for the influence that their pre-test scores may have on their post-test scores. Based on the mean scores, flipped classroom performed better than those in conventional classroom instruction in learning electrochemistry.

Table 6. Comparison of Students' Achievement Exposed to Flipped Classroom Instruction and Conventional Instruction (Hake Factor)

Group	Pre-test	Post-test	g	SD	Interpretation
Flipped	0.12	0.69	0.45	8.32	Medium Gain
Conventional	0.17	0.56	0.22	6.48	Low Gain

To further assess the effectiveness of the instructional treatment for each of the group, average normalized gains were calculated for each group. It revealed that the experimental group has a medium gain while control group has a low gain as reflected by the normalized gain (Hake factor) values of *0.45* (*SD = 8.32*) and *0.22* (*SD = 6.48*), respectively. This only means that flipped classroom instruction is effective in achievement in learning electrochemistry.

Ruddick (2012) used a flipped classroom for college chemistry preparatory course. He found out that students under a flipped classroom have higher grades compared to regular lecture sections. Additionally, a flipped classroom model in teaching cardiovascular, respiratory, and renal physiology in graduate students conducted by Tune, Sturek, and Basile (2013) showed scored significantly higher than in a traditional classroom. Their findings supported that a flipped classroom model is highly effective instruction in disseminating key physiological concepts to graduate students. Flipping the classroom in introductory Biology lecture course was also conducted by Marcey and Brint (2012). It exhibited that flipped-class students performed better in all tests and quizzes. There was also a significant increase between the sequential exams compared to the students in the traditional lecture section (Love, Hodge, Grandgenett, & Swift 2014). In the study conducted by Yestrebsky (2015) it showed that the percentage of high final grades increased in the test group compared to the control group. Fautch (2015) also found out that students showed increased comprehension of the material and appeared to improve their performance on summative assessments or exams in organic chemistry. The students became more noticeably passionate about the subject. Fautch (2015) also added that flipping the organic chemistry classroom may help students take more ownership of their learning. Bergman & Sams (2002) considered that flipped classroom is a pedagogical approach that moves course content from the classroom to homework, and uses class time for engaging activities and instructor-guided problem-solving. Finally, it revealed that in a flipped class, students' misconceptions were addressed, the concepts from the video lectures were applied to problems, and students were challenged to think beyond given examples (Fautch, 2015). A flipped classroom can be viewed as conceptual change and constructivist teaching approach that effectively provides a learning environment in which students use their knowledge actively, construct their views about science, and develop critical thinking (Gayate & Caballes, 2017).

Students' Perception of the Used of Flipped Classroom Model in Learning Electrochemistry

The students' perceptions in a flipped classroom instruction were obtained and analyzed. This provides meaningful feedbacks regarding flipped classroom instruction, which are of vital importance in decision making for future use. Table 7 presents students' description of their perceptions in learning electrochemistry in a flipped classroom environment.

Table 7. Students' Perception of the Use of the Flipped Classroom Model in Learning Electrochemistry

Description	Mean	Verbal Interpretation	Rank
The Flipped Classroom…			
1. Was enjoyable and interesting method of teaching.	4.25	Agree	3.5
2. Helped me understand concepts in electrochemistry easily.	4.32	Agree	1
3. Increased my appreciation in learning electrochemistry.	4.18	Agree	6
4. Helped me gain a clearer understanding of the lesson.	4.11	Agree	9
5. Encouraged me to study independently.	4.14	Agree	7.5
6. Made me more mentally active in the learning process.	4.00	Agree	13.5
7. Was an appropriate strategy in learning chemistry effectively.	4.00	Agree	13.5
8. Made me use my study time more essentially.	4.14	Agree	7.5
9. Helped me develop a positive attitude towards chemistry.	4.25	Agree	3.5
10. Helped me develop my study habits at home.	4.29	Agree	2
11. Gives me greater opportunities to communicate with other students.	4.07	Agree	10.5
12. Is more engaging than traditional classroom instruction.	4.21	Agree	5
13. Should be used by other teachers to teach other topics in the future.	4.07	Agree	10.5

14. Was able to choose how much I want to learn in a given period.	4.04	Agree	12
15. Was able to decide when I want to learn.	3.93	Agree	15
Composite Mean	4.14	Agree	

As disclosed in Table 7.0, the fifteen statements describing the flipped classroom instruction have a composite mean value of 4.14, which means that the respondents agreed to most of the statements. Students found flipped classroom helped them understand the concepts in electrochemistry easily as shown in Figure 2.

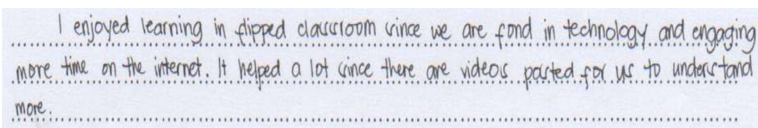
I enjoyed learning in flipped classroom since we are fond in technology and engaging more time on the internet. It helped a lot since there are videos posted for us to understand more.

Figure 2. Student E#8. Sample comments in flipped classroom instruction.

They also perceived that flipped classroom improves their critical thinking and they learned independently as shown in Figure 3.

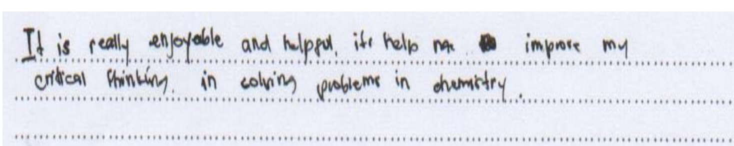
It is really enjoyable and helpful, it's help me improve my critical thinking in solving problems in chemistry.

Figure 3. Student E#5. Student comments in a Flipped classroom instruction

Additionally, they also recommend flipped classroom instruction to another subject as shown in Figure 4.

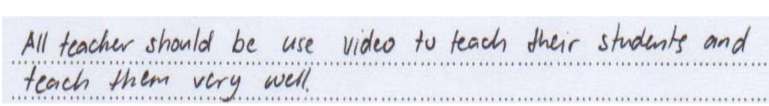
All teacher should be use video to teach their students and teach them very well.

Figure 4. Student E#28. Sample comments in a flipped classroom.

Murray, Kozniec, and McGill (2015) found out that the general perception of the students was a positive approach, particularly the convenience and flexibility of the flipped videos. They also added that the students felt they had interacted more with their instructor's face.

Certainly, the flipped classroom model has positive statements based on the composite mean scores. These findings are similar to the study of Weaver and Sturtevant's (2015) who used flipped classroom instruction at Purde University over three years. Likewise, Swinburne *et al.*, (2014) also found out that students preferred the flipped approach over traditional face-to-face delivery and reported increased engagement, satisfaction, and learning outcomes. Moore and Chung (2015) also used flipped classroom model in mathematics class. They found out that flipped classroom could be a motivating factor in learning mathematics. Moore and Chung (2015) further revealed that the perceptions and attitudes of the students were generally positive in the flipped classroom environment. The students were motivated to use the web-based instructional videos to prepare for their expected learning outcomes. This is also likewise affirmed by Lo and Hew (2017) that most of the students were able to handle advanced learning problems collaboratively. Indeed, their test results confirmed an improvement in their learning. Furthermore, from the student interviews, most of the students reported that Flipped Classroom model facilitated their learning. The students could pause the video clip so that they would have enough time to think about the material or take notes. Some students may feel embarrassed to interrupt their teacher during the lecture even though they cannot follow the lecture. But in Flipped Classroom, watching the instructional videos makes it possible for every student to learn at their own pace (Hamdam *et al.*, 2013). However, some students commented that "We cannot ask a question immediately while watching a video." Similar comments were also reported in Wanner and Palmer's Flipped Classroom. They recommended that a discussion forum should be provided for students and teacher to communicate with each other. Teachers may also arrange virtual office hours to hold live online chats with students who seek help.

From online surveys, focus groups, and informal discussion from students conducted by Hunley (2016) discovered that majority of students do prefer an FCM to a traditional classroom lecture as an additional tool or resource to access material for school. Students mentioned that classmates who have access to videos but opt not viewing the videos outside of class are frustration.

Semi-Structured Interview

Albeit not part of the original research questions, the students' perceptions of the flipped classroom are an invaluable resource to teachers envisioning a shift to a flipped classroom instruction. A face-to-face interview was conducted to five selected students in Experimental Group (E#30, E#21, E#28, E#13, and E#27) using a semi-structured question. This provides in-depth reasoning and perception of the students about learning electrochemistry using flipped classroom model. The following questions were asked and answered by the selected students. The selected students were aware and voluntarily submitted themselves for a face-to-face interview.

In the semi-structured interview which immediately followed by the informal interview, these were the findings:

a) The respondents were asked about allotted time to study in chemistry. Majority of the respondents spent at least 3-4 hours per week to study chemistry lessons before coming to class. They also added that they studied a day before the class particularly if a quiz will be given.
b) The respondents were also asked the ways on how to study chemistry. Majority of them used jotting notes, reviewing the lessons after classes or they studied by peers.
c) The respondents were also asked about the advantages of FCM. Student E#30 suggested that FCM gave him a lot of time to learn certain topics and made her easier to understand the lessons. E#21 also commented that this could be another source to understand the topics aside from the discussion of the teacher and the classes is enough because he already has prior knowledge before coming to class. So, in class, it's a matter of checking and reviewing the concepts that he doesn't understand while watching the videos at home. E#28 also added that it provides more collaboration and engagement. Additionally, E#13 through watching the videos it provides thorough discussion that a teacher might forget during lecture and in the videos, it provides more and varied example problems while in lecture, the examples are only limited. Lastly, E#27 said that using FCM it enables the student to study independently at his/her pacing. It could provide an avenue to re-watch the videos at any time. Overall, the respondents strongly agreed that FCM was very helpful to understand the topics easily.
d) The selected students also believed in some drawbacks of FCM. The respondents agreed that the most common problem of FCM is the lack of or limited online access. So, all of them recommended that the school must provide a strong internet connection. Another problem that raised in FCM is that some videos are not well organized in presenting to the

solutions of the sample problem and also the accent of the presenter. Consequently, they recommended that a teacher should make his/her videos or a subtitle can suffice this problem.

As proposed by the students, they considered that flipped classroom could be a platform for effective learning, particularly in electrochemistry. They have ample time and ready when inside the class because of the prior knowledge acquired outside the class. Furthermore, they also suggested that this strategy should be used by other subjects.

Flipping the classroom will not likely change how students learn or change the student's attitudes towards education. However, if used properly and in conjunction with a variety of other instructional methods, it can be an invaluable resource for many students who struggle with traditional education (Bell, 2015).

One aspect of the flipped classroom that is challenging is access to online to provide ample material for students. Thus, students recommended that the school must provide a strong internet connection. Another difficult aspect of the flipped classroom is ensuring a high quality of instruction in each video particularly on the use of accent. Some students have difficulty to figure out the videos because of the accent. They recommended that the teacher should make his/her videos or a subtitle might suffice this problem.

CONCLUSIONS

Results showed that Flipped Classroom Model performed better compared to the Conventional Classroom in terms of the mean score after the intervention. Statistical data shows that the Flipped Classroom Model group is significantly higher than the conventional group. It is therefore concluded that Flipped Classroom Model is effective in increasing the achievement in learning electrochemistry of the students. Majority of the students agreed about the use of Flipped classroom instruction as an effective way to learn electrochemistry.

This study affirmed the students appreciate a diverse approach to teaching, learning, and showing what they know. With the advances of new educational technologies and social media, the options to provide a rich learning experience for today's students may be limitless. The flipped classroom model is one-method teachers should consider as a vehicle to expose students to relevant technological learning resources.

TRANSLATIONAL RESEARCH

The findings of this study could be used by the teachers to reflect on their teaching experiences and encourage them to take a more active role in their professional development. Nowadays, the growth and adaption of the integration of technology into teaching are exponentially rising which, paved away the conventional way the students were taught. Hence, this study could provide insights on different ways of integrating new pedagogy and content-based to encourage students to use critical thinking skills to solve curricular-based differentiated level problems.

The use of flipped classroom model provides a platform from which students can take charge of their learning and gives both students and teachers the ability to develop higher-level critical thinking skills in a problem-posing student-centered learning environment. This will also a potential to be an effective and beneficial method of science education particularly in STEM courses and in University level which manifested benefits in teaching-learning in science and math courses. Consequently, the flipped classroom will help curriculum developers and course program writers in planning electrochemistry under STEM or at University level perspective.

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