LESSONS IN GRADE 10 MATHEMATICS FOR USE IN A FLIPPED CLASSROOM

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Abstract

Low-performance, insufficient instruction time and difficulty in providing instructional needs for diverse learners are some of the prevalent problems in mathematics education. Flipped Classroom is a rising pedagogical model that exhibits promising features in battling these dilemmas. This study aimed to develop lessons that integrates flipped classroom, uses student collaboration and incorporates contexts from students' culture and experiences. Mainly, this study provided ways on how teachers from rural areas with less technological accessibility, can implement this instructional model through the use of materials and platforms available in their community. The mixed method of research was used. Qualitative approach was utilized in the analysis of students' responses in their interviews and journals and the quantitative approach was done through pre-experimental design. Interviews to teachers and analysis of available data in the chosen school were done to know which topics are to be included in the study. The identified topics were examined to develop lessons that are best suited for the use of the model to Grade 10 Geometry. Ten lessons were made and implemented to a Grade 10 class to determine its effect on their task performance, conceptual understanding and problem-solving skills.

Effects on study habits and interest were determined using interviews, journals and inventory. Results show that there is a significant difference on the performance of the students, within the considered constructs, before and after being exposed to flipped classroom. Moreover, positive change on responding to tasks, greater initiative to take part and higher interest levels were also revealed. The implementation of flipped classroom has deepen their understanding, positively affected the way they perceive and react to tasks, boost their interest and taught learners the accountability of their own learning. Additionally, availability of learning resources at home and support from knowledgeable others are important factors that help improve students' performance.

Keywords

Flipped Classroom, Contextualized, Conceptual Understanding, Problem Solving Skills

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1. Introduction

Knowledge of Mathematics is a valuable tool for social development and global competitiveness. As we develop the mathematical proficiency and literacy of individual students, they, in turn, contribute to the skills, values and collective intellectual resources of the country, increasing our nation's funds of knowledge (SEI-DOST & MATHTED , 2011).

On that cause, the Philippine Educational System constantly strives to provide and promote high quality Mathematics education in the country. Certain indicators however, tell us that those efforts are not enough and the goals mentioned are still far from reach.

1.1 Indicators of Low Performance in Mathematics

As revealed in the 2003 TIMSS (Trends in International Mathematics and Science Study), out of 38 participating countries, the Philippines ranked 34th in mathematics. It also got the 10th and lowest rank in the 2008 TIMSS-Advance Mathematics Category even with only the country's science high schools participating. The Global Competitiveness Report of the World Economic Forum also revealed similar results. From 2015 to 2018, the Philippines nearly reaches halfway through the rankings in terms of quality of Math and Science education. (The Global Competitiveness Report, 2018).

Another indicator of students' academic performance in the country is the National Achievement Test (NAT) conducted annually. From 2005-2013, the Mean Percentage Scores (MPS) garnered in the NAT for High School only ranges from 46.97- 51.41. Although there has been an increase across the years, it's still far from the national target MPS of 75. Moreover,

Mathematics is always one of the subjects garnering the lowest MPS along with Science and critical thinking, (Philippine Education for All 2015 Review Report, 2015). These international and local data pushes educators to search far and wide to find the best instructional approaches and strategies that will help fight the persistence of low performance in the country.

1.3 Proposed Solution

The major consensus has suggested that student collaboration, infusion of technology, and teacher facilitation all promote academic achievement in the secondary Mathematics classroom (Kulkarni, 2012). These facets are the key features of a modern approach in teaching known today as the flipped classroom.

Flipped Classroom means that:

- Students gain first exposure to new subject matter outside of class, usually via reading or lecture videos, and then use class time to do the harder work of assimilating that knowledge, with the help of their peers and with the guidance of the teacher (Brame, 2013).

- In terms of Bloom's revised taxonomy, students are doing the lower levels of cognitive work outside of class, and focusing on the higher forms of cognitive work in class.

- The role of the teacher changes from a fountain of knowledge into a facilitator.

- Offloading direct instruction to videos allows teachers to reconsider how to maximize individual face-to-face time with students. Time becomes available for students to engage more deeply with content, and receive immediate feedback from their instructor (Hamden et al., 2013).

- It also allows learners to collaborate and incorporate contexts from their own culture and experiences.

It has been reported that it results to greater student motivation and interest, as well as increased interaction with peers and teachers (Bergman & Sams 2012). It also provides a medium that allows differentiated instruction for a range of students' abilities (Herreid and Schiller 2013). In this setting, students can study according to their preferred environment, time and pace so they would study complex topics according to their learning style outside class. It also allows review of ideas and concepts. Likewise, students have the option to pause or rewind the pre-recorded video; thus, gaining control over instruction time. There is also greater transparency in relation to learning intent, and greater opportunity for teachers to be aware of students' progress (Bergman & Sams, 2012).

This study aimed to provide ways on how teachers from less technologically advanced country, like the Philippines, can implement this approach to help improve students' performance through the use of materials and platforms available in their community. One of the constantly included topics in the least mastered competencies were topics in Grade 10 Geometry. The data is alarming that it needs urgent action. These were the reasons why this study developed lessons integrating flipped classroom to enhance Grade 10 Mathematics students' learning competencies in Geometry. It also investigated its effect on the students' performance tasks, conceptual understanding, problem-solving skills, study habits and interest.

2. Methodology

2.1 Research Design

The mixed method of research was used. Qualitative approach was utilized in the analysis of students' responses in their interviews and journals and the quantitative approach was done through pre-experimental design, specifically, the one group pre-test post-test design. The pre-test determined the baseline status of the students' competencies in Grade 10 Geometry. The developed lessons were employed as teaching tools referred to as treatment. Posttest was administered to the students after the treatment to gauge the effect of the use of the Lessons in their learning competencies.

2.2 Respondents

The respondents consist of a class of Grade 10 students of a Philippine National High School for the school year 2018-2019. The school was purposively chosen because it is a good representation of the diversity of Filipino secondary schools. Classes are heterogeneously grouped so there is no issue as to the students' academic performance. The class was chosen using random selection. After the selection, the flipped classroom model was implemented and afterwards, data gathered from the class were analyzed and interpreted.

2.3 Research Instrument

The main instrument used to determine the effect of the developed lessons on students' conceptual understanding and problem-solving skills was a researcher-made pre-test –post-test. The test was composed of 40 multiple choice items where 20 items is for conceptual understanding and the other 20 is for problem solving skills. The test was evaluated by seven validators to ensure validity, objectivity, practicability and utility. Its computed reliability (KR20) is approximately 0.80. Furthermore, focus group discussion guides, interest inventory

and journals were also made to gauge the effects of the lessons on the qualitative constructs of the study.

2.4 Procedures

Prior to the conduct of the study, the researcher crafted a test covering all of the required competencies on Grade 10 Geometry. The test was evaluated by seven experts to ensure content validity. After the test items evaluation, the 60-item test was pilot tested to a Grade 11 class. Difficulty and discrimination indices were also computed and revisions were made to come up to the final form.

The developed lessons and videos used in the study were also critically scrutinized by experts and refinements were made through their comments and suggestions. The key features of the lesson were checked and the multimedia materials were assured to be appropriate, learner-friendly and easy to understand. Permission to implement the study were sought, then pre-test followed. After that, the students were exposed to the validated lessons for flipped classroom. Post-test was given and focus group discussions were held. The resulting data were analyzed and interpreted to come up with necessary recommendations.

2.5 Data Analysis

The data were examined by descriptive statistics, mean gains and paired t-tests. The results of the pre-test and post-test, formative quizzes and other activities were classified according to the mastery level set by the Department of Education (DepEd) presented in Table 1. These were used to establish the effect of the lessons on the considered constructs of the study.

Table 1: *DepEd Mastery Level Classification*

Proficiency Level	Mastery Level
92 and above	Full Mastery
83-91	Near Full Mastery
75-82	Mastery
51-74	Near Mastery
25-50	Low Mastery

3. Results and Discussion

3.1 Developed Lessons in Grade 10 Mathematics for Use in a Flipped Classroom

There were ten (10) developed lessons in Grade 10 Mathematics for use in a Flipped Classroom. These lessons covered the topics and competencies about circles and coordinate geometry in Grade 10 Geometry. All of the topics were in accordance with the Curriculum Guide

of the Department of Education. The lesson plans have three parts: learning objectives, learning tasks and instructional procedure. The instructional procedures followed the flipped classroom model which includes out-of-class and in-class learning activities. The out-of-class student learning activities is where instruction is being transferred to through the use of instructional videos, note-taking templates and practice sets which students' work on at home. On the other hand, the in-class learning activities include: motivation, activity proper, exercises and evaluation where assimilation of knowledge and honing of higher-order thinking skills take place. All of the developed lessons integrated the three key features which are: contextualized, use of multimedia and use of peer instruction. These were validated by experts using criteria employing a five-point Likert Scale. All the lessons for flipped classroom were rated excellent which affirmed its appropriateness for use in learning the competencies in Grade 10 Geometry.

3.2 Performance of the Students in the Various Tasks In and Out of the Classroom

The performance of the students in the out-of-class activities garnered a Mean Percentage Score (MPS) of 84.0 and an MPS of 87.1 in the in-class tasks. These are both found to be in the near full mastery level. The performance of the students' in-class gained better results and this is probably because in-class time promotes activities that enables learners to assimilate newly-learned concepts and apply them in real-life situations. Peer and teacher support is also present so students can ask for help and clarification in case of misconceptions. Moreover, both the teachers and the students pointed out positive change on how students deal with and respond to the tasks given. Collaboration and initiative to take part were also evident. Additionally, the availability of learning resources at home and support from more knowledgeable others were discovered to be essential factors which can help improve student's performance in the out-of-class tasks.

3.3 Effects of the Lessons in Grade 10 Mathematics Using Flipped Classroom

3.3.1   Conceptual Understanding

Table 2 shows the effect of the developed lessons in Grade 10 Mathematics using Flipped Classroom on the students' conceptual understanding. The researcher used mean and percentage to identify the students' proficiency level as well as its corresponding interpretation and a paired t-test to know if the changes in the results are significant.

Table 2: *Effect of the Developed Lessons in Grade 10 Mathematics using Flipped Classroom on Students' Conceptual Understanding*

Competencies	No. of items	Mean		Mean Gain	Proficiency Level				Gain (%)
		PRE	POST		PRE		POST		
					%	D	%	D	
(1)deriving relations among chords, arcs, central angles and inscribed angles	3	1.03	1.54	0.51	34	LM	51	NM	17
(2)illustrating secants, tangents, segments and sectors of a circle	5	1.71	2.28	0.58	34	LM	46	LM	12
(3)solving problems on circles	4	0.71	2.13	1.42	18	LM	53	NM	36
(4)solving problems involving distance formula	2	0.88	1.46	0.58	44	LM	73	NM	29
(5)illustrating the center-radius form of the equation of a circle and (6)determining the center and radius of a circle given its equation and vice versa	3	0.76	1.97	1.21	25	LM	66	NM	40
(7) solving problems involving geometric figures on the coordinate plane	3	0.85	2.05	1.20	28	LM	68	NM	40
TOTAL	**20**	**5.94**	**11.44**	**5.49**	**30**	**LM**	**57**	**NM**	**27**
p-value	**0.00**								
significance	**Highly Significant**								

Legend: **FM**-Full Mastery, NFM-Near Full Mastery, M-Mastery, **NM**- Near Mastery, **LM**-Low Mastery

As reflected in Table 2, the performance of Grade 10 students in the pre-test and post-test increased in the mean gain as well as in the proficiency level of all the competencies for geometry. From the pre-test mean of 5.94 and performance level of 30%, it increased into a mean of 11.44 which is equivalent to 57%. The difference in the test results were analyzed and the resulting p-value is about 0.00. This value clearly tells us that there has been a highly significant change in the students' conceptual understanding. This result is the same as the result in the study of Kong (2014). In his study he found out that students taught in this way significantly increased their domain of knowledge.

3.3.2 Problem-Solving Skills

Table 3 shows the effect of the developed lessons in Grade 10 Mathematics using Flipped Classroom on the students' problem-solving skills. The researcher used mean and percentage to identify the students' proficiency level as well as its corresponding interpretation and a paired t-test to know if the changes in the results are significant.

Table 3: *Effect of the Developed Lessons in Grade 10 Mathematics using Flipped Classroom on Students' Problem Solving Skills*

Competencies	No. of items	Mean PRE	Mean POST	Mean Gain	Proficiency Level PRE %	PRE D	POST %	POST D	Gain (%)
(1)deriving relations among chords, arcs, central angles and inscribed angles	4	1.47	3.21	1.73	37	LM	80	M	43
(2)illustrating secants, tangents, segments and sectors of a circle	4	1.03	1.69	0.66	26	LM	42	LM	17
(3)solving problems on circles	3	1.26	1.95	0.68	42	LM	65	NM	23
(4)solving problems involving distance formula	2	0.50	1.26	0.76	25	LM	63	NM	38
(5)illustrating the center-radius form of the equation of a circle and (6)determining the center and radius of a circle given its equation and vice versa	4	1.15	2.36	1.21	29	LM	59	NM	30
(7) solving problems involving geometric figures on the coordinate plane	3	0.56	1.08	0.52	19	LM	36	LM	17
TOTAL	20	5.97	11.54	5.57	30	LM	58	NM	28
p-value	0.00								
significance	Highly Significant								

Legend: **FM**-Full Mastery, NFM-Near Full Mastery, M-Mastery, NM- Near Mastery, **LM**-Low Mastery

The results in the pre-test show that students have low mastery when it comes to problem solving in the indicated competencies. The researcher inferred that this happened because the topics as well as the problems are not familiar to them. However, the performance of Grade 10 students post-test increased in the mean gain as well as in the proficiency level of all the competencies for geometry. From the pre-test mean of 5.97 and performance level of 30%, it increased into a mean of 11.54 which is equivalent to 58%. The difference in the test results were analyzed and the resulting p-value is about 0.00 which clearly tells that there has been a highly significant change in the students' conceptual understanding.

This result is substantiated by the responses of the students in the focus group discussion when asked about the changes on how they were able to handle problem solving activities. A student said that she can already solving activities and this is due to the learnings she gained through watching the instructional videos. She also added that she goes to school equipped with what she needs to answer problems because of the new learning approach used. It can be implied that advance exposure to the topic and advance preparation helped a lot in uplifting the students' confidence in facing problem solving activities.

3.3.3 Study Habits

Through the use of the students' journal entries and responses on the focus group discussion, it was found out that there are changes in how students study. They confessed saying that they learned to really prepare their assignments beforehand because it is a must in the next day's discussion. They also said that they learned to use their spare time in doing homework rather than doing unnecessary things. They said that the lessons also enabled them to study not only during or after classes rather, they learned to study before class, during and even after class time. In terms of the study environment, it was revealed that most students are more comfortable in learning and doing certain tasks in their own homes for they are in control of their own time and they can do verification of their answers. The presence of more knowledgeable others while doing homework is also a reason why students feel more comfortable doing certain tasks at home. Furthermore, students said that they find traditional teaching style as boring and less interesting. Giving them materials that they are familiar with and they can relate to, such as videos which they can watch and play on devices they have, boosts the way they see learning towards the subject. Confidence in their answers and works is also evident. According to a student's response, she is no longer unsure or hesitant about the correctness of her answer because there is already a guide which can help her verify her answer. These shows that there is a positive effect as to how the learning materials help students in studying.

3.3.4 Interest Towards Mathematics

The next table shows the overall effect of the use of the developed lessons in the students' interest towards mathematics. The researcher used mean, percentage to identify the students' proficiency level as well as its corresponding interpretation and p-value to identify the level of significance.

It can be gleaned from the table that individually, there has been an increase in the five aspects of interest. In summary, the overall mean in the results of the students' interest inventory rose from the pre-test mean of 3.30 to 3.78 in the post-test. From somehow interested, the interpretation of the result in the post-test became interested. To know the significance of the change in the values, paired t-test was done and the resulting p-value is 0.00. The difference in the values was found to be highly significant. From something they view before as a not so enjoyable class, it is now evident that the students see that they can also be happy in learning math. This is probably because of the activities they do and the interactions they have in the class. They are given time to play as a team as well as collaborate with their peers in concept

building and in answering their exercises. The kind of materials given also affect how students are motivated in learning and engaging in mathematics. Moreover, higher regard to the importance of math and realization of its worth is also a good point to note.

Table 4: *Interest Inventory Results Summary Statistics*

Area of Interest	PRE-TEST		POST-TEST		Mean Gain
	Mean	Level of Interest	Mean	Level of Interest	
1) Enjoyment in Math	3.24	SI	3.77	I	0.52
2) Motivation in Math	3.35	SI	3.81	I	0.49
3) Appreciation of the Importance of Math	3.53	I	4.05	I	0.54
4) Positive Feelings Towards Math	3.08	SI	3.48	SI	0.40
5) Appeal of Math Activities	3.30	SI	3.71	I	0.41
Overall	3.30	SI	3.78	I	0.48
p-value	0.00				
Significance	Highly Significant				

Legend: **VI**-Very Interested,   **SI**-Somehow Interested   **NI**-Not Interested
　　　　I-Interested,   **SLI**- Slightly Interested

4. Conclusion and Recommendation

Based from the results and discussion of the study, it can be inferred that the developed lessons for use in a flipped classroom, are valid and effective learning source. Furthermore, the lessons have positive effect in enhancing Grade 10 Mathematics students' conceptual understanding, problem-solving skills and performance on different tasks. Its implementation also resulted to a positive change on students' study habits and an increase to the students' level of interest towards Mathematics. This study offers results that support previously conducted studies by other researchers (Ramakrishnan, 2016; Kong, 2014; Day et al., 2006; Pierce et al., 2012; Chen et al., 2017; Lemueco, 2017).

To further enhance students' learning performance in Mathematics, curriculum planners and administrators must promote the creation and use of lessons for flipped classrooms. Seminars, workshops, and trainings on the use of flipped classroom should also be conducted to enhance the knowledge of the teachers in terms of the procedures in integrating the approach as well as to hone their technical knowledge on the use of the devices and instructional videos.

4.1 Research Limitations

The main concern of this study is to determine the effect of the developed lessons in Grade 10 Mathematics students. This study limits itself to the use of flipped classroom model

using downloaded pre-recorded videos. It is also limited to a certain locality. It further excludes other topics than those least mastered Geometry topics purposively selected.

4.2 Scope of Future Research

Further studies may be conducted integrating flipped classroom in teaching other subjects, disciples and levels using other research designs and methods such as quasi-experimental design and others. Longer period of exposure to the teaching approach is also encouraged to effectively observe its effects on the mathematical understanding and skills of the students.

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