Inquiry-Based Lessons in Pre-Calculus for Senior High School Students

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Abstract – *This study investigated the effect of the developed inquiry-based lessons in enhancing the learners' mastery of learning competencies in Pre-Calculus, attitudes towards Mathematics and higher order thinking skills. Employing pre-experimental research design, it made use of quantitative research method in answering the problems in the study. Nine lessons were taught to forty-seven Grade 11 Science, Technology, Engineering and Mathematics (STEM). The learners' mastery of learning competencies and HOTS were assessed through parallel-form 30-item and 10-item pretest and posttest, respectively while the learners' attitude towards Mathematics was assessed using the attitudes towards mathematics inventory. Quantitative data were treated using mean, mastery level, t-test, and Cohen's index (d). T-test revealed significant differences on the learners' mastery of learning competencies in Pre-Calculus, attitudes towards Mathematics and HOTS before and after the intervention. Consequently, through inquiry-based lessons with the use of the instructional materials develops learners' mastery of learning competencies in Pre-Calculus, attitude towards Mathematics and HOTS. Hence, there is a need for teachers to design classroom tasks geared towards the development of these skills. Further validation of the said instructional materials packaged out of the lessons as a result of the study is hereby recommended.*

Keywords – *inquiry-based lessons, learning competencies, attitudes towards mathematics, higher-order thinking skills, instructional materials*

INTRODUCTION

Mathematics is valued across civilizations for its power to model and solve complicated problems and for its own simple beauty. In human societies, mathematics plays a critical and unique role and represents a strategic key to the progress of all humanity [1]. In looking at mathematics education, Mathematics is known as one of the major learning challenges to learners [2]. The common belief among learners is that learning mathematics is difficult [3]. This difficulty can be observed in the results of international, national and division Mathematics tests.

In the 2018 Programme for International Student Assessment (PISA), a student assessment of 15-year old learners across 79 countries done by the Organization for Economic Co-operation and Development (OECD), the Philippines ranked in the low 70s with 353 points against a 489 OECD average for Mathematics category [4]. In the 2008 Trends in International Mathematics and Science Study (TIMSS), even with only the science high schools participated in the advanced Mathematics category, the Philippines ranked lowest [5]. Further, according to the 2017 World Economic Forum Executive Opinion Survey, the Philippines ranked 76th out of 137 participating countries in the quality of math and science education [6].

In the Bicol Region, the low performance in Mathematics of students was shown on the 2017 National Achievement Test (NAT) results wherein the Mean Percentage Score (MPS) obtained in Mathematics is 35.52. In one of the divisions in the Bicol region, the NAT MPS in Mathematics for school year 2016 – 2017 was 34.74%, very far from 75% performance level. In one of the national high schools for instance, the NAT MPS in Mathematics for the same school year is 34.04% which is 40.96% away from the mastery level of 75%.

The problems on students' poor performance and skills deficiency in Mathematics have arisen due to some hindrances that affect their ability to progress in the subject. Students might be unable to recall basic facts, rules and formulas in Mathematics and they are not fully aware of some of the different mathematical terms and concepts. Aside from these, difficulty in memorizing formulas, analyzing and solving mathematical equations and problems, and knowing the application and real-life connection of the learned

concepts in their lives were also listed as obstacles in learning the subject [2].

The phenomenon that often happens during the mathematics teaching-learning process is that most students are more passive, reluctant, and afraid or shy to express their opinion; this situation will certainly disrupt the smooth learning and creativity of students in learning activities. Additionally, the teaching-learning process is still centered on the teacher, the teacher tends to communicate in one direction with many providing material and slightly provide opportunities for learners to interact through performance or verbal communication [7]. If this teaching-learning process will still be considered, more students will experience learning difficulties. As such, the expected students' learning outcome may not happen.

Teaching approach is one of the factors affecting students' learning outcomes. Under the teaching approach is the teaching method which helps to determine the success or failure of student learning and teaching activity [8]. The more precise method that is used by teachers in teaching is expected to be more effective in the students' achievement of learning goal [9]. Students' learning achievement is influenced by the two main aspects: the student and the aspects that come from outside the student or environmental aspects, of which 70% are influenced by the ability of the students themselves, and 30% are affected by environment [7]. For this reason, a student-centered teaching approach is needed.

Inquiry-based learning is one of the teaching approaches which is student-centered. The use of inquiry-based approach is anchored on section 5 of RA 10533 which focuses on curriculum development and stresses that "the curriculum shall use pedagogical approaches that are constructivist, inquiry-based, reflective, collaborative, and integrative" [10]. It is an approach in which the classroom environment is characterized by the student being the active participant while the teacher role is decentralized [11]. It is also defined in mathematics as a form of active learning in which learners are given a carefully scaffolded sequence of mathematical tasks and are asked to solve and make sense of them, working individually or in groups [12]. It is often used as an approach to restructure aspects of teacher education and maximize the potential of learners [13].

In an inquiry-based classroom, teachers ought to provide certain kinds of teaching-learning experiences in which students are able to work as young mathematicians or researchers. In short, students should develop their mathematical knowledge, skills and attitude through inquiry-based teaching. The inquiry teaching methodology is built on the Principles and Standards for School Mathematics [14] and the report of Project 2061's benchmarks for science literacy (American Association for the Advancement of Science [15]. They both claim that inquiry is a high-quality teaching to involve students in mathematics learning and development processes and also say that students have enough opportunities to use the inquiry cycle while learning mathematics to perform their own mathematical research. [16]. While inquiry learning is a valued educational reform strategy, in today's classrooms, it is not being successfully implemented [17] – [19].

According to Sanjaya [20], inquiry learning is a set of learning exercises that objectively and analytically emphasize the process of reasoning in order to discover and find their own solution to the problem in question. It is founded on the premise that there is an inherent desire for people to discover their own expertise. The primary aim of research learning is to help students improve academic discipline and thinking skills by offering curiosity-based questions and answers [20].

With the inquiry learning method, it will train students to dare to express views and discover their own knowledge that is useful for problem solving [7]. The efficient and successful use of inquiry learning methods would minimize the monopoly of teachers in mastering the direction of the learning process, and reduce the students' boredom in a class [21].

Based on the phenomenon mentioned that often occurs during the teaching-learning process, improving student learning outcomes and experiences are utmost concern. Thus, a study on improving student learning outcomes through inquiry-based learning is necessary considering the persistent low achievement of students in Mathematics as revealed by the cited measures such as PISA, TIMSS and National Achievement Test, students' less engagement in the subject based on the mentioned literatures and previous researches, the researcher conceptualized this study to determine the effect of the developed inquiry-based lessons in enhancing the learners' mastery of learning competencies in Pre-Calculus, attitude towards Mathematics and higher order thinking skills while they are subjected to the inquiry-based approach and to develop an instructional materials that can be packaged out of the lessons as a result of the study. Hence, it is hoped that this study would improve students'

performance in Mathematics through the developed instructional materials using inquiry-based lessons.

OBJECTIVES OF THE STUDY

This study generally aimed to develop inquiry-based lessons in Pre-Calculus for Senior High School. Specifically, it examined the effect of the developed inquiry-based lessons in enhancing the learners' mastery of learning competencies in Pre-Calculus, attitudes towards Mathematics and higher order thinking skills. Further, it tried to develop instructional materials packaged out of the lessons as a result of the study.

MATERIALS AND METHODS

Research Design

Quantitative research method employing descriptive and pre-experimental research design were used to answer the research problems. The type of pre-experimental research design used in this study is the one group pre-test/post-test. The design was utilized in the analysis of the learners' mastery of learning competencies, attitude towards mathematics, and higher order thinking skills test in Pre-Calculus using Teacher-Made Test (TMT), Attitudes toward Mathematics Inventory (ATMI), and Teacher-Made HOTS Test (TMHOTST), respectively.

Respondents

The respondents of the study were the Grade 11 learners of one of the national high schools in the Philippines during the 1st semester of school year 2019 – 2020 selected using the purposive sampling technique as the sampling design. The class was composed of 47 learners, 22 male and 25 female, enrolled in Science, Technology, Engineering and Mathematics (STEM) strand under the Academic Track. The respondents were chosen because they already have sufficient knowledge and strategies in learning mathematics.

Research Instruments

The lessons developed from the implementation using inquiry-based approach were constructed based on the curriculum guide given by the Department of Education. The inquiry-based lessons include problem-based, project-based and design-based activities and integration of philosophical views as the key features. The lessons utilized guided and structured inquiry using 5 E's (Engage, Explore, Explain, Elaborate and Evaluate) instructional model.

The developed nine inquiry-based lessons were subjected to critiquing by six experts in the field: two Master Teachers in Mathematics, two Philippine Science High School Mathematics Teachers, a Mathematics Professor in State Universities and Colleges (SUC's) and a Curriculum Expert and at the same time Director for Senior High School. They were asked to give their comments, suggestions, and recommendations on each part of the lesson for the improvement of the lesson plans. The lessons were finalized based on the corrections and suggestions given by the panel of experts.

Learners' attitudes toward mathematics were determined through the standardized Attitude Towards Mathematics Inventory (ATMI) by Tapia and Marsh [2]. The ATMI is a 40-item Likert scale inventory composed of statements on attitudes toward mathematics. The 40-item inventory represents four dimensions: value of mathematics (10 items), motivation to learn mathematics (5 items), enjoyment of mathematics (10 items), and self-confidence (15 items) as reflected in the item specifications of the instrument. The overall validity of ATMI was confirmed for 0.615, and the reliability or Cronbach α is 0.932 [23].

Learners' mastery of learning competencies and higher order thinking skills in Pre-Calculus were assessed through a teacher-made 30-item multiple choice and 10-item problem solving and mathematical reasoning pre-tests and post-tests, respectively. After identifying the learning competencies included in the lessons, the researcher prepared two sets of 30-item and 10-item parallel tests considering the learning competencies in the lessons making sure that the test items were representatives of those which were included in the lessons. The tests were constructed following the table of specifications. The pre-test and post-test contained the same types of questions, multiple choice, problem solving and reasoning. Only few items in multiple choice test and problem solving and mathematical reasoning were included since some questions required students' solutions to the problems and the test was only allotted for one hour and 45 minutes. The tests were evaluated and critiqued by the mathematics educators consisting of two Master Teachers, two Philippine Science High School Teachers, a Professor in SUC's, and a Curriculum Expert and at the same time Director in one of the private universities.

The mathematics pre-test and post-test were revised before the conduct of pilot testing to one of the nearby

schools offering STEM strand. Item analyses and reliability testing were made to determine the difficulty and discrimination indices and reliability of each item which helped the researcher decide on the final draft of the tests. After the item analysis and reliability testing, the final drafts of the mathematics pre-test and post tests were composed of 30-item multiple choice (MC) and 10 – item higher order thinking skills (HOTS) tests. The rubric adapted from Northwest Regional Educational Laboratory [24] was used for HOTS test scoring.

Data Gathering Procedure

A letter requesting to conduct the study was prepared and given to the Schools Division Superintendent of the Department of Education and to the School Head of the setting of the study on July 15, 2019 for approval. Upon approval on the same date, the researcher prepared the lessons and pre-test-post-tests using the Curriculum Guide for Pre-Calculus and submitted to experts for validation and critiquing. The lessons, pre-test and post-test were validated and critiqued on the 22nd – 26th day of July 2019. After which, revisions were done based on the suggestions of the panel of experts. The pre-test and post-test were pilot tested to the Grade 11 STEM students in one of the nearby schools of the locale of this study on 5th day of August 2019 for item analysis and reliability test purposes. After item analysis and reliability testing, the final drafts of the pre-test and post-test were done.

On the second week of August 2019, the Attitude Towards Mathematics Inventory (ATMI) and Mathematics Pre-Tests were administered to the respondents on two consecutive days. The ATMI was lasted for 15-20 minutes while the mathematics pre-test was lasted for 45 minutes to one-hour of completion. The learners were not asked to check the test for the validity of scoring.

A week before the intervention, the learners were grouped into 8 for the entire IBL sessions wherein the 7 groups consisted of 6 members and 1 group consisted of 5 members. Groupings were based on the learners' academic standing (rank) using their first quarter grade in the subject as basis. Each learner is assigned with a number from 1-47 corresponding to their respective rank. The first 8 in the rank is assigned as leader or in-charge of the group. Learners with corresponding ranks from 1-8, 9-16, 24-17, 25-32, 33-40 and 41-47 occupied the first, second, third, fourth fifth and sixth row, respectively. Numbering for rows 1, 3, and 5 started form left to right while numbering for rows 2, 4, and 6 started from right to left. The numbers from each column correspond to the groupings wherein the first, second, third, fourth, fifth, sixth, seventh and eight columns are groups 1, 2, 3, 4, 5, 6, 7, and 8 respectively.

After the administration of the inventory and tests, the intervention was started on 27th day of August 2019 and ended on the 11th day of October 2019. On the 14th day of the same month, the mathematics post-test was administered to the respondents and the ATMI was also administered on the following day. After completing the inquiry-based learning episodes, post-tests and ATMI were conducted on the 16th to 17th of October, 2019 during the availability of the learners.

Data Analysis

Cohen's index (d) was employed to measure the effect size (r) of the inquiry-based learning on learners' performance, attitudes toward mathematics, and higher order thinking skills in terms of ATMI inventory before and after the intervention and mathematics pre and post-tests, respectively. The effect size was interpreted based on Cohen's standard. A d-value higher than 0.8 indicates large effect, between 0.2 and 0.8 indicates medium effect, and a d-value between 0 and 0.2 indicates small effect.

The t-test (test of difference) was employed to measure whether the observed differences in the pre-tests and post-tests mean scores in the ATMI and mathematics tests (learning competencies and HOTS) will be significant. In testing the significant differences between means, both the t-value together with its corresponding p-value was used: p-values less than 0.05 were significant while those greater than 0.05 was interpreted as Not Significant (NS). Effect sizes were computed and reported in the results. In computing for the t-value with its corresponding p-value, Minitab 17 software was utilized.

Ethical Considerations

Respondents were informed that they were selected purposively as participants and informed consent from their parents through letter was secured by the researcher. The confidentiality of respondents' test scores, and outputs was assured.

RESULTS AND DISCUSSION

Lessons Developed in Pre-Calculus using Inquiry-Based Approach

The emphasis of the lessons developed is on teaching using inquiry-based approach that is anchored

on section 5 of RA 10533. The approach was considered since it focuses on curriculum development and it is based on one of the underlying learning principles and theories of the K to 12 mathematics curriculum framework intended to develop the mathematics knowledge, skills and attitude among K to 12 learners.

The lessons which were developed consisted of topics in Trigonometry focusing on circular functions. Weber [25] stated that Trigonometry is an important course in the high school curriculum. Understanding trigonometric functions is a pre-requisite for understanding topics in Newtonian physics, architecture, surveying, and many branches of engineering. Further, trigonometry is one of the earliest mathematics topics that links algebraic, geometric, and graphical reasoning, it can serve as an important precursor towards understanding Pre-calculus and Calculus.

Circular functions as one of the topics in Trigonometry is very important since it has many applications in various fields such as architectures, surveyors, astronauts, physicists, engineers and even crime scene investigators. It is indeed necessary that the learners will be able to learn circular functions, see its importance or applications and its large part in their daily lives. Thus, this study focused on the topics in Trigonometry which are deemed necessary in learning mathematics subject in the higher levels of education.

The lessons utilized 5 E's instructional model, a teaching-learning approach that is founded on the belief that learners learn by building new ideas on top of old ones. Using this model, learners can understand and learn concepts and skills over a series of five steps or phases of learning. This learning model is beneficial in classrooms as it can motivate learners, engage learners in an active teaching-learning process, facilitate collaboration and teamwork and help learners form conclusions through questioning, investigating, observing, analyzing, reasoning and problem-solving.

Based on the learning competencies of the Curriculum Guide for Grade 11 STEM subject, there were nine (9) lesson plans that were developed by the researcher for the content circular functions. Lessons 1-3 deal with the angles in a unit circle that include angle measure, angles in standard position and coterminal angles, and arc length and area of a sector. Lessons 4-5 focus on basic concepts of circular functions that include circular functions on real numbers and reference angle. Lessons 6-8 deal with the graphs of sine, cosine, cosecant, secant, tangent and cotangent functions. Lesson 9 deals with situational problems on circular functions.

The inquiry-based lesson has five (5) parts namely, the objectives, content, learning resources, procedures and assignment. In the objective part, the content standard, performance standard and the learning competencies are included. The content part includes the lesson and specific topics. In the learning resources, the references used that includes the teacher's guide, learner's material and textbooks are included. Geogebra Learning Materials (Applet) was used as other learning resources. The procedures contain the most important part of the inquiry-based lessons wherein the significant key features of the developed lesson can be found. In the procedures, the use of problem-based, project-based and design-based activities and integration of philosophical views as the key features were highlighted. The 5 E's instructional model was used to carry out the procedures particularly the inquiry-based lesson. This model focuses on the five (5) main events in the teaching-learning process. These are engage, explore, explain, elaborate and evaluate. The 5E teaching model [26] can be used to develop a science lesson and is based on the cognitive psychology, principle of constructivist learning, and science teaching best practices. Bybee [26] declares that "using this approach, the students redefine, reorganize, elaborate, and change their initial concepts through self-reflection and interaction with their peers and their environment".

Effectiveness of the Developed Inquiry-Based Lessons

The mastery of learning competencies, attitudes towards Mathematics and higher order-thinking skills in inquiry-based lessons included were measured by 30-item validated teacher-made parallel pre-test and post-test, attitudes towards math inventory (ATMI) by Tapia and Marsh [22] and 10-item teacher-made parallel HOTS pre-test and post-test, respectively.

Mastery of Learning Competencies in Pre-Calculus

The mastery of learning competencies of the learners in the inquiry-based lessons included was measured by a 30-item multiple choice teacher-made parallel pre-test and post-test. Table 1 shows the results of the pre-test and post-test given to the learners categorized according to the lessons and the mastery level attained reported in percentage.

Table 1. *Pre-Calculus Pre-Test & Post-Test, Mean Scores, Performance Level, t-Test and Cohen's Index*

Learning Competencies	No. of Items	Pre-Test		Post-Test		t-value	p-value	Interpre-Tation	Cohen's Index (d)	Effect Size (r)
		Mean (ML)	Interpre-tation	Mean (ML)	Interpre-tation					
1. Illustrate the unit circle and the relation-ship between the linear and angular measures of arcs in a unit circle	4	2.32 (58%)	Low Mastery	3.21 (80%)	Average Mastery	-4.19	0.000	Significant Effect	0.86	0.40 (medium)
2. Convert degree measure to radian measure, & vice versa	2	0.74 (37%)	Low Mastery	1.77 88%)	Moving Towards Mastery	-.8.27	0.000	Significant Effect	1.66	0.64 (large)
3. Illustrate angles in standard position and coterminal angles	2	0.98 (49%)	Low Mastery	1.98 (99%)	Mastered	-10.40	0.000	Significant Effect	2.03	0.71 (large)
4. Illustrate the different circular functions	4	1.74 (44%)	Low Mastery	3.17 (79%)	Average Mastery	-7.21	0.000	Significant Effect	1.30	0.54 (large)
5. Use reference angles to find exact values of circular functions	3	0.87 (29%)	Very Low Mastery	3.28 (82%)	Average Mastery	-11.92	0.000	Significant Effect	1.96	0.70 (large)
6.Determine the domain and range of the different circular functions	2	0.60 (30%)	Very Low Mastery	1.60 (80%)	Average Mastery	-6.71	0.000	Significant Effect	1.43	0.58 (large)
7. Graph the six circular functions (a) amplitude, (b) period, and (c) phase shift	10	3.40 (34%)	Very Low Mastery	8.06 (81%)	Average Mastery	-17.32	0.000	Significant Effect	2.70	0.80 (large)
8. Solve situational problems involving circular functions	3	0.66 (22%)	Very Low Mastery	2.06 (69%)	Average Mastery	-9.70	0.000	Significant Effect	1.88	0.68 (large)
Total	**30**	**11.32 (38%)**	**Low Mastery**	**24.21 (81%)**	**Average Mastery**	**-22.49**	**0.000**	**Significant Effect**	**3.09**	**0.84 (large)**

Note: At 5% or 0.05 level of significance

Data in Table 1 shows that the mean scores of the learners on the lessons during the pre-test were interpreted as low mastery for learning competencies 1-4 while learning competencies 5-8 were interpreted as very low mastery.

Looking at the data as shown in Table 1, the highest mastery level during the pre-test was on the learning competency "illustrate the unit circle and the relationship between the linear and angular measures of arcs in a unit circle" (58%) while the lowest performance level was on the learning competency "solve situational problems involving circular functions" (22%). During the post-test, the learners obtained the highest mastery level on the learning competency "illustrate angles in standard position and coterminal angles" (99%) while the lowest performance level was on the learning competency "solve situational problems involving circular functions" (69%

Data also revealed that learners mastered the learning competency "illustrate angles in standard position and coterminal angles", moving towards mastery on the learning competency "convert degree measure to radian measure", & vice versa while average mastery for the learning competencies "illustrate the unit circle and the relationship between the linear and angular measures of arcs in a unit circle", "illustrate the different circular functions", "use reference angles to find exact values of circular functions", "determine the domain and range of the different circular functions",

"graph the six circular functions (a) amplitude, (b) period, and (c) phase shift", and, "solve situational problems involving circular functions." Overall, the total mean score of the pre-test which was 11.32 and post-test of 24.21 classified as low mastery and average mastery, respectively showed a marked difference between the mastery of learning competencies of the learners from pre-test to post-test.

Based on the table, the differences noted on the mean scores during the pre-test and post-test on eight (8) learning competencies were all significant including the learning competency "solve situational problems involving circular function" which displayed very low mastery level as shown by the t-values and p-values. Moreover, the effect sizes for all learning competencies were all large based on the Cohen's index (d) and coefficient of effect size (r) except for the learning competency 1 with medium as the effect size. Of the eight learning competencies included in the study, the highest effect size was found on learning competency 7, "graph the six circular functions (a) amplitude, (b) period, and (c) phase shift" (0.80) followed by the learning competency 3 "illustrate angles in standard position and coterminal angles" (0.71) while the least on learning competency 1 "illustrate the unit circle and the relationship between the linear and angular measures of arcs in a unit circle" with only 0.40.

Overall, the results of the pre-test and post-test was significant with t = -22.49 and p = 0.000 tested at 95% confidence level. To determine the overall effect size, cohen's index (d) was used resulting to d = 3.09 and r = 0.84 interpreted as large effect. With mean scores of 11.32 and 24.21 for pre-test and post-test respectively, showing an increase of 12.89, it can be deduced that the implementation of inquiry-based lessons produced positive impact on the learners' mastery of learning competencies in terms of the lessons included in the study. Hence, the developed inquiry-based lessons are effective in enhancing the learners' mastery of learning competencies in Pre-Calculus. This is similar to the finding of Bernido & Boyon [27] that the use of inquiry based learning is effective in understanding lessons in Pre-calculus. The result of this study is also similar to the result of Kuklok [28] that after the learners learned and implemented inquiry-based practices, their self-advocacy and academic achievement increased showing that these practices affected learners in a positive manner.

Attitudes towards Mathematics

The attitudes of the learners towards Mathematics along value, motivation to learn, enjoyment, and self-confidence were determined using the weighted mean score. Table 2 illustrates the pre-test and post-test mean scores of the learners on statements along the four dimensions.

Table 2. Pre-test and Post-test Mean Scores of the Learners on Statements along Value, Motivation to Learn, Enjoyment and Self-Confidence in Mathematics

Statements	Pre-Test	Post-Test
Value of Mathematics		
Mathematics is a very worthwhile and necessary subject.	4.64	4.55
I want to develop my mathematical skills.	4.77	4.74
Mathematics helps develop the mind and teaches a person to think.	4.45	4.68
Mathematics is important in everyday life.	4.49	4.60
Mathematics is one of the most important subjects for people to study.	4.34	4.55
High school math courses would be very helpful no matter what I decide to study.	4.04	4.02
I can think of many ways that I use math outside of school.	3.70	3.64
I think studying advanced mathematics is useful.	4.32	4.47
I believe studying math helps me with problem solving in other areas.	4.13	4.13
A strong math background could help me in my professional life.	4.19	4.21
Motivation to Learn Mathematics		
I am confident that I could learn advanced mathematics.	3.57	3.62
I would like to avoid using mathematics in college.	3.19	3.26
I am willing to take more than the required amount of mathematics.	3.53	3.83
I plan to take as much mathematics as I can during my education.	3.68	3.23
The challenge of math appeals to me.	3.57	3.83

Table 2 (cont.) Pre-test and Post-test Mean Scores of the Learners on Statements along Value, Motivation to Learn, Enjoyment and Self-Confidence in Mathematics

Statements	Pre-Test	Post-Test
Enjoyment in Mathematics		
I get a great deal of satisfaction out of solving a mathematics problem.	3.81	4.23
I have usually enjoyed studying mathematics in school.	3.57	3.96
I like to solve new problems in mathematics.	3.45	3.81
I would prefer to do an assignment in math than to write an essay.	3.19	3.17
I really like mathematics.	3.34	3.81
I am happier in a math class than in any other class.	3.00	3.23
Mathematics is a very interesting subject.	3.94	4.04
I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.	3.09	3.49
I am comfortable answering questions in math class.	3.26	3.19
Self-confidence in Mathematics		
Mathematics is one of my most dreaded subjects.	3.34	3.45
My mind goes blank and I am unable to think clearly when working with mathematics.	3.45	3.53
Studying mathematics makes me feel nervous.	3.40	3.79
Mathematics makes me feel uncomfortable.	3.15	3.49
I am always under a terrible strain in a math class.	3.28	3.64
When I hear the word mathematics, I have a feeling of dislike.	2.51	3.23
It makes me nervous to even think about having to do a mathematics problem.	3.26	3.43
Mathematics does not scare me at all.	2.91	3.15
I have a lot of self-confidence when it comes to mathematics.	3.00	3.49
I am able to solve mathematics problems without too much difficulty.	2.96	3.30
I expect to do fairly well in any math class I take.	3.32	3.64
I am always confused in my mathematics class.	3.36	3.81
I feel a sense of insecurity when attempting mathematics.	3.36	3.74
I learn mathematics easily.	2.89	3.38
I believe I am good at solving math problems.	3.17	3.53

In value of mathematics dimension as shown in Table 2, the highest increase in the mean scores from pre-test to post-test was noted on the statement, "mathematics helps develop the mind and teaches a person to think" (0.23). However, declines on the mean scores of some statements were also noted, the statement, "mathematics is a very worthwhile and necessary subject" showed the highest decrease of 0.09. The overall mean score along value of mathematics was 4.31 to 4.36 (0.05) which were both interpreted as slightly positive. This implies that learners fairly valued Mathematics as a subject considering their attitudes towards math scores along the statements included in the dimension.

In motivation to learn mathematics dimension, the highest increase in the mean scores from pre-test to post-test was noted on the statement, "I am willing to take more than the required amount of mathematics" (0.30). However, declines on the mean scores of some statements were also noted, the statement, "I plan to take as much mathematics as I can during my education" showed the highest decrease of 0.45. The overall mean score along motivation to learn mathematics was 3.51 to 3.55 (0.04) which were both interpreted as slightly positive. This implies that learners' motivation to learn Mathematics denote a slight change based on the revealed mean scores on attitude towards learning the subject.

In enjoyment of mathematics dimensions, the highest increase in the mean scores from pre-test to post-test was noted on the statement, "I really like mathematics" (0.47). However, declines on the mean scores of some statements were also noted, the statement, "I am comfortable answering questions in math class" showed the highest decrease of 0.07. The overall mean score along enjoyment of mathematics was 3.29 to 3.52 (0.23) which were interpreted as neutral and slightly positive, respectively. This implies

that learners' manifested higher increase on enjoyment of Mathematics as revealed by the mean scores on attitude towards learning the subject.

Lastly, in the self-confidence in Mathematics dimension, the highest increase in the mean scores from pre-test to post-test was noted on the statement, "When I hear the word mathematics, I have a feeling of dislike" (0.72). However, declines on the mean scores of some statements were also noted, the statement, "My mind goes blank and I am unable to think clearly when working with mathematics" showed the highest decrease of 0.08. The overall mean score along enjoyment of mathematics was 3.16 to 3.51 (0.35) which were interpreted as neutral and slightly positive, respectively. The result implies that learners exhibited higher increase on self-confidence in Mathematics as revealed by the mean scores on attitude towards learning the subject.

To determine how effective are the developed inquiry-based lessons on the learners' attitude towards mathematics from pre-test to post-test, the mean scores for each dimension were subjected to t-test and Cohen's index shown in Table 3.

The data in Table 3 show that the mean scores of the pre-test and post-test along value of mathematics and motivation to learn mathematics were not significant while enjoyment and self-confidence in mathematics were significant. This implies that in terms of value of mathematics and motivation to learn mathematics dimensions, no significant impact was noted. The absence of significant impact of the inquiry-based lessons in terms of the value of mathematics is possibly due to the learners' fair level of viewpoint and appreciation of the usefulness, relevance and worth of the subject now and in the future. In terms of motivation to learn mathematics, the absence of significant impact is possibly due to learners' average level of understanding and skills acquired in the inquiry-based lessons. Further, learners' beliefs at an average level on the interest in mathematics and the desire to pursue studies plausibly contributed to the absence of significant impact of the lessons.

Analysis of the effect size using Cohen's index shows small effect on value of mathematics, motivation to learn mathematics and enjoyment of mathematics with a d-value of 0.15, 0.16, and 0.44, respectively. On the other hand, large effect was noted on self-confidence in mathematics with d-value of 1.51. The overall mean score of the learners' attitude towards mathematics from pre-test to post-test were 3.52 to 3.74, respectively and were both classified as slightly positive. The mean score had a difference of 0.22, while the t-value of t= -5.96 and p-value of 0.000 were significant at 95% confidence level. Hence, it could be concluded that the implementation of inquiry-based lessons has significant influence on the learners' attitude towards mathematics in terms of the lessons included in the study. This substantiates the result of the study conducted by McGregor [29] that inquiry-based learning has positively influencing and reshaping learners' beliefs and attitudes towards Mathematics.

Table 3. Pre-Test and Post-Test Mean Scores, t-Test, and Cohen's Index on Attitude towards Mathematics

Scales	Pre-Test		Post-Test		t-value	p-value	Interpretation	Cohen's Index (d)	Effect Size (r)
	Mean	Interpre-tation	Mean	Interpre-tation					
Value of Mathematics	4.31	Slightly Positive	4.36	Slightly Positive	-1.47	0.176	Not Significant	0.15	0.07 (Small)
Motivation to Learn Mathematics	3.51	Slightly Positive	3.55	Slightly Positive	-0.32	0.764	Not Significant	0.16	0.08 (Small)
Enjoyment of Mathematics	3.29	Neutral	3.52	Slightly Positive	-3.60	0.006	Significant	0.44	0.21 (Small)
Self-Confidence	3.16	Neutral	3.51	Slightly Positive	-8.35	0.000	Significant	1.51	0.60 (Large)
Overall	**3.52**	**Slightly Positive**	**3.74**	**Slightly Positive**	**-5.96**	**0.000**	Significant	**0.39**	**0.19 (Small)**

Note: At 5% or 0.05 level of significance

Table 4. Pre-Test and Post-Test Mean Scores, t-Test, and Cohen's Index on Higher Order Thinking Skills in IBL in Pre-Calculus

Component	Pre-Test		Post-Test		t-value	p-value	Interpre-tation	Cohen's Index (d)	Effect Size (r)
	Mean	Interpre-tation	Mean	Interpre-tation					
Conceptual Understanding	1.13	Emerging	2.54	Proficient	-23.63	0.000	Significant	4.16	0.90 (Large)
Strategies & Reasoning	1.11	Emerging	2.53	Proficient	-23.62	0.000	Significant	4.32	0.91 (Large)
Computation & Execution	1.12	Emerging	2.51	Proficient	-21.82	0.000	Significant	4.00	0.89 (Large)
Communication	1.13	Emerging	2.48	Developing	-23.61	0.000	Significant	4.30	0.91 (Large)
Insights	1.12	Emerging	2.47	Developing	-23.55	0.000	Significant	4.40	0.91 (Large)
Overall	**1.12**	Emerging	**2.51**	Proficient	**-24.58**	**0.000**	Significant	**4.57**	**0.92 (Large)**

Note: At 5% or 0.05 level of significance

Learners' higher order thinking skills in inquiry-based lessons were measured by a validated 10-item Problem Solving and Mathematical Reasoning teacher-made parallel pre-test and post-test. The problem-solving and mathematical reasoning type of test focused on the lesson about circular functions and situational problems involving circular functions. The test requires learners to use their higher order thinking skills along analyzing, evaluating and creating level which are the last three aspects of the Bloom's taxonomy [30]. Hence, HOTS is the highest part of Bloom's taxonomy of cognitive process dimension.

Table 4 shows the results of the pre-test and post-test given to the learners categorized according to the HOTS components and mean.

The higher order thinking skills component included in this study were based on the rubric adapted from Northwest Regional Educational Laboratory. This includes conceptual understanding, strategies and reasoning, computation and execution, communication and insights [24]. Conceptual understanding deals with learners' interpretation of the problem using mathematical representations and procedures that accurately reflects the importance of mathematics in the problem. Strategies and reasoning consider evidence that the learners proceeded from a plan, applied appropriate strategies, and followed a logical and verifiable process toward a solution. Computation and execution focus on the solution performed in an accurate and complete manner given the approach taken by the learners. Communication is considered if the learner was able to easily understand his/her thinking or if the learner is tasked to make inferences and guesses about what they were trying to do. While insights deals with the learners' ability to better grasp the deeper structure of the problem and see how the process used in solving the problem connects it to other problems or real-world" applications.

The scales used in the adapted rubric are emerging, developing, proficient and exemplary with 1, 2, 3 and 4 rating scale, respectively. The rating details or descriptions per component and scale were presented in the adapted rubrics itself.

Data in Table 4 shows that the mean scores of the learners on the higher order thinking skills in all components during the pre-test were interpreted as emerging. Looking at the data, the highest mean score of 1.13 during the pre-test was noted on conceptual understanding and communication components while the lowest mean score of 1.11 was on strategies and reasoning. During the post-test, learners' mean scores in the conceptual understanding, strategies and reasoning, and computation and execution components were interpreted as proficient while in the communication and insights components were both interpreted as developing. Furthermore, the learners obtained the highest mean score of 2.54 on conceptual understanding while the lowest mean score of 2.47 was noted on insights component.

To determine how effective are the developed inquiry-based lessons on the learners' higher order thinking skills from pre-test to post-test, the mean scores for each component were subjected to t-test and Cohen's index shown in Table 4. The data shows that the mean scores of the pre-test and post-test in all higher order thinking skills components were significant. Analysis of the effect size using Cohen's index shows large effect on conceptual understanding,

strategies and reasoning, computation and execution, communication, and insights with a d-value of 4.16, 4.32, 4.00, 4.30, and 4.40, respectively.

Overall, the results of the pre-test and post-test was significant with t = -24.58 and p = 0.000 tested at 95% confidence level. To determine the overall effect size, Cohen's index (d) was used resulting to d = 4.57 and r = 0.92 interpreted as large effect. With the overall mean scores of 1.12 and 2.51 for pre-test and post-test interpreted as emerging and proficient, respectively and showing an increase of 1.39, it can be deduced that the implementation of inquiry-based lessons produced significant and affirmative effect on the learners' higher order thinking skills in terms of the lessons included in the study. The result is consistent with the study conducted by Mensah-Wonkyi & Adu [31] that students who underwent inquiry-based instruction approach of teaching performed better in post-test in terms of their conceptual understanding as one of the HOTS components included in this study. Similarly, the result is also consistent with another study conducted by Zulfiani, et. al. [32] that a significant increase of higher order thinking skills towards student ability categories is manifested from both guided inquiry and free inquiry learning model.

Instructional Materials Packaged out of the Lessons as a Result of the Study

The instructional materials packaged out of the lessons as a result of the study include lessons, learning activities and assessment tools saved in the Compact Disc (CD) and uploaded to www.slideshare.net website for Pre-Calculus teachers' consumption. The instructional materials as the output of this study may serve as one of the supplementary teaching-learning resources by the Pre-Calculus teachers in the Senior High School level. These resources maybe utilized by them in teaching Trigonometry content dealing with circular functions. The slide presentations, learning guide cards and geogebra learning applets which are included under the lessons maybe used by the teachers to facilitate the teaching-learning process while the learning activities (problem-based, project-based and design-based) and assessment tool (evaluation worksheet) maybe used to facilitate the teaching-learning activities of the inquiry-based lessons. These activities may contribute in enhancing their learners' learning competencies, creativity, problem solving and higher order thinking skills in the subject.

In terms of the usefulness or relevance of this output to the new normal in education, the instructional materials may be used by the Pre-Calculus teachers as one of the additional or supplementary teaching-learning resources in their online teaching. Using the www.slideshare.net website, teachers may search and download the said resources that may aid them in preparing their respective online teaching materials for their learners. These resources may also be included in the preparation of self-directed modules as part of the Learning Continuity Plan (LCP) of the Department of Education in the new normal by considering the content and/or found in the said resources such as the learning activities and assessment tools.

CONCLUSION AND RECOMMENDATION

The developed inquiry-based lessons in Grade 11 Pre-Calculus utilizing inquiry-based approach included topics in Trigonometry which consisted of angle measure, angles in standard position and coterminal angles, arc length and area of a sector, circular functions on real numbers, reference angle, graphs of sine and cosine functions, graphs of cosecant and secant functions, graphs of tangent and cotangent functions and situational problems involving graphs of circular functions with problem-based, project-based, design-based activities and integration of philosophical views as key features. The said lessons are effective in enhancing the learners' mastery of learning competencies in Pre-Calculus, attitudes towards Mathematics and higher order thinking skills. Lastly, the instructional materials packaged out of the lessons as a result of the study include lessons which consist of slide presentations, learning guide cards and Geogebra learning applets; learning activities which consist of the problem-based, project-based and design-based activities; and assessment tool that include the evaluation worksheets.

As inquiry-based lessons effected positively, teachers need to carefully design inquiry-based lessons suited to the teaching-learning approach in teaching Mathematics considering the use of problem-based, project-based & design-based activities and integration of philosophical views as key features of the developed lessons. They also need to consider the learners' knowledge & skills in preparing learning activities focusing on project-based and design-based activities. Further, they need to embrace the said approach & other teaching-learning approaches geared towards the enhancement of the basic knowledge & skills but more so on problem-solving & higher order thinking skills.

Considering the developed lessons in teaching Pre-Calculus using inquiry-based approach had significant

effect in enhancing the learners' mastery of learning competencies, attitudes towards Mathematics and higher order thinking skills, teachers should venture to use the said approach in their classroom.

Based on the results of this study, there is hope that through inquiry-based lessons with the use of the instructional materials packaged out of the lessons will develop learners' mastery of learning competencies in Pre-Calculus, attitudes towards Mathematics and higher order thinking skills. A replication of this study on inquiry-based lessons in Pre-Calculus to large sample of respondents in the local setting might further provide additional information to support the present claim.

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