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The use of mathematical practice-based activities in teaching mathematics

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Abstract

Educators today are aware about the significant difficulties being faced by the students in understanding Mathematics. The educators in the Philippines also need to do some actions to improve Filipino students' performance in Mathematics. This study developed Mathematical Practice (MP)–based activities to help students engage in learning process. The study use different activities using the 8 Standards for Mathematical Practice, namely: 1) Make sense of problems and persevere in solving them;2) Reason abstractly and quantitatively; 3) Construct viable arguments and critique the reasoning of others; 4) Model with mathematics; 5) Use appropriate tools strategically; 6) Attend to precision; 7) Look for and make use of structure; 8) Look for and express regularity in repeated reasoning. The study had collected both quantitative and qualitative data. The study determined the effect of MP–based activities in terms of students' understanding of mathematics concepts, problem-solving skills, collaborative skills, interests in learning mathematics and the insights drawn from the experiences of the students exposed to this kind of activities. The results concluded that the developed MP-based activities improved the conceptual understanding, problem solving skills, interests in Mathematics and collaborative skills of the students. The students became more interested or motivated to learn, they showed positive outlook towards learning the subject, and they now like Mathematics. The findings suggest that the teachers must incorporate instructional approach in Mathematics, like the developed MP-based activities, that will help to realize the twin goals of Mathematics education which are critical thinking and problem solving.

Keywords: mathematical practice-based activities, standards for mathematical practice, conceptual understanding, problem-solving skills, mathematics interest, collaborative skills, grade-7

The use of mathematical practice-based activities in teaching mathematics

1. Introduction

Learning is a progression. It is a gradual advancement, forward movement from one level to another, the latter being better than the former. In the learning process, various disciplines of knowledge are involved. Learners go through several subjects in their course of learning in which they get equipped with assorted knowledge and skills depending on their specialization (Magoti, 2019). The goal of education is to build and sustain schools that support every student in achieving success. Over the past two decades, countries worldwide have substantially increased investment in education, primarily channeled toward initiatives to improve access to schooling and expand associated inputs – classrooms, teachers, textbooks – to serve a growing number of students. However, learning levels remain low (Read & Atinc, 2017). Thus, it is deemed necessary that the educators must explore different pedagogy that could enhance students critical thinking, solved misconceptions and motivate the students to learn how to learn (Valdez et al., 2015).

There are many things important to the way schools are run; one of the most important is curriculum. The curriculum is the foundation on what the teachers need to follow in order to achieve the educational goal to enhance the skills and knowledge of the students that will help in choosing careers in the future. For hundreds of years schools have debated and discussed what should be taught in schools, from math, science and social studies, to music and art, reading and writing (Catalano, 2014). In Mathematics, we all know that this is a unique subject and one of the fundamental parts of school curriculum. Knowingly or unknowingly, we are using mathematics in every facet of life. But the teachers are often encounter students in every classroom who have different views and perspectives about learning this subject. It is because some of the students are achieving excellence in dealing mathematical problems and majority of them across the world dislike Mathematics (Gafoor & Kurukkan, 2015).

Some of the topics being discussed in Mathematics are the integers and rational numbers. Educators today are aware about the significant difficulties being faced by the students in understanding integers and rational numbers. In integers, the problem mostly is when the students struggle of what it means to have number less than zero. In particular, they often question why negating a negative number will result in a positive quantity (Shanty, 2016). Moreover, students mostly have difficulties in conceptualizing numbers less than zero, creating negative numbers as mathematical objects, and formalizing rules for integer arithmetic (Stephan & Akyuz, 2012). Unlike positive number, negative number has not perception referential which is clear, and therefore, students should try harder to learn about negative number (Blair et al., 2012). Understanding rational numbers is more complex and difficult than learning integers as they are represented in several ways. In the ensuing years, numerous researchers, government commissions, organizations of mathematics teachers, and textbook writers have recommended ways of improving learning of rational numbers (Siegler & Forgues, 2017). This is because fraction and decimal arithmetic pose large difficulties for many children and adults.

In United States of America, they are also struggling in terms of academic progress particularly in subjects such as Mathematics that is why they implemented the Common Core State Standards focusing on a high level of rigor with consistency across all states (Lynch, 2015). This is an initiative that will help to improve their K-12 curriculum believing that it will help the students to learn better and to improve the nation's education. From this initiative, there are specific standards for mathematical practice because in the United States they must become substantially more focused and coherent in order to improve mathematics achievement in this country. The standards for mathematical practice describe varieties of expertise that mathematics educators at all levels should seek to develop in their students. These practices rest on important "processes and proficiencies" with long standing importance in mathematics education.

In the Philippines, Republic Act No. 10533 entitled "An Act Enhancing the Philippine Basic Education System by Strengthening its Curriculum and Increasing the Number of Years for Basic Education, Appropriating Funds Therefor and for other Purposes", otherwise known as the enhanced "Basic Education Act of 2013" approved on May 15, 2013, and which became effective on June 8, 2013. The Department of Education has in the past years been working towards the implementation of the K-12 program that is designed to "provide sufficient time for mastery of concepts and skills, develop lifelong learners, and prepare graduates for tertiary education, middle-level skills development, employment, and entrepreneurship." The extension of the basic education to 12 years seeks to boost the quality of Philippine education to make it at par with that of other countries.

However, the Philippines continues to receive poor marks for education in international performance indices and the senate moved to assess the Philippine education system. On Global Competitiveness Index 2017-2018 released by the World Economic Forum, the Philippines ranked 66th out of 137 countries for quality of primary education, 74th for quality of higher education, and 76th for quality of math and science education. The Philippine education system did even worse on the 2017 Global Innovation Index, where it was ranked at dismal 113th place out of 127 countries (Romero, 2018). According to Sen. Sherwin T. Gatchalian, a comprehensive review of the performance of the Philippine education system is necessary to craft responsive legislation and policies that will put the country on the right path toward the transformation of the Philippine education system into a world-class institution. He added that the output of the Senate subcommittee would guide the legislative and executive reforms to be crafted in empowering the state to fulfill its obligation under the Constitution and international law to "provide the Filipino People with access to quality education at all levels" (Fernandez, 2018).

In 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), Philippines is the second lowest in Mathematics with an average score of 353, much lower than the global average of 489. The education department said that they recognize the urgency of addressing issues and gaps in attaining quality of basic education in the Philippines. They added that the country's participation in the 2018 PISA would help the department establish baseline in relation to global standards, and benchmark the effectiveness of their reforms moving forward (Paris, 2019). Because of the situation of the educational system in our country, it is necessary to plan another initiative or ways to make the curriculum more responsive and relevant to the needs and interests of the students specifically in learning Mathematics. From the conceptual framework of Mathematics education in the K-12 Basic education curriculum, it was stated that the twin goals of mathematics in the basic education levels, K-10, are critical thinking and problem solving. These two goals are to be achieved with an organized and rigorous curriculum content, a well-defined set of high-level skills and processes, desirable values and attitudes, and appropriate tools, taking into account the different contexts of Filipino learners (K to 12 Mathematics Curriculum Guide, 2016).

For some reasons, the educators in the Philippines also need to do some actions to improve Filipino students' performance in Mathematics. The researcher developed activities to help students engage in learning process. These developed activities were conducted in Bulan National High School where the students of this school experienced difficulties in learning integers and rational numbers as reflected in the performance level of Grade 7 students last School Year 2018-2019 in four quarters revealed 49.14% indicating "Average mastery" and in the first quarter where integers and rational numbers are being discussed showed a performance level of 44.83% also indicating "Average Mastery".

The bases of the developed activities are the eight standards for mathematical practice, which are the following:1) Make sense of problems and persevere in solving them;2) Reason abstractly and quantitatively; 3) Construct viable arguments and critique the reasoning of others; 4) Model with mathematics; 5) Use appropriate tools strategically; 6) Attend to precision; 7) Look for and make use of structure; 8) Look for and express regularity in repeated reasoning (CCSS, 2010).These standards can be applied individually or together in

mathematics lesson, in no particular order. Often two or more practice standards are present in well-designed lessons (California's Common Core State Standards for Mathematics: Organization and Structure, 2019). By the developed activities, these will also help educators in attaining the twin goals of Mathematics that could give benefits not only for the students, not only for the teachers but for the Philippine education system as a whole.

1.1 Statement of the Problem

This study aimed to develop Mathematical Practice – based activities in teaching Grade 7. Specifically, this study sought answers to the following sub-problems: (1) What Mathematical Practice (MP) -based activities may be developed in teaching Grade 7 Mathematics? (2) What is the jurors' evaluation of the developed activities? (3) What is the effect of the developed MP-based activities in terms of students': (a) conceptual understanding; (b) problem-solving skills; (c) interest in learning mathematics; (d) collaborative skills? (4) What insights may be drawn from the learning experiences of the students in MP-based activities?

2. Methodology

2.1 Research Design

The mixed method of research was used in the study wherein both quantitative and qualitative data were gathered. The developmental research method was used for the development of Mathematical Practice (MP)-based activities. The descriptive research method was used for the evaluation that were made by the jurors in the developed MP-based activities through evaluation checklists. A quasi-experimental research method had been chosen to determine the effect of MP-based activities in terms of students' conceptual understanding and problem-solving skills through the use of test questionnaires that were administered before and after the conduct of the study, and to determine the effect of MP-based activities in students' interest in learning mathematics and collaborative skills, through observation and checklists. While a document analysis research method was used to determine the insights drawn from the learning experiences of the students exposed to this kind of activities through journals.

A quasi-experimental design has many kinds and the researcher used non-equivalent group design. This is a between-subjects design in which the respondents have not been randomly assigned to conditions. Out of the Grade seven classes as the population, the researchers selected two sections, homogenous in nature, in grade seven class. This quasi-experimental design was appropriate for gathering data since the researcher compared the experimental and control groups. The experimental group was given a pretest, received a treatment, and then was given a posttest. But at the same time, the control group was also given a pretest, did not receive a treatment, and then was given a posttest.

2.2 Respondents

The researcher selected Bulan National High School as the location to implement the study where the performance level of Grade 7 students last school year 2018-2019 in four quarters in this school revealed 49.14% indicating "Average mastery" and in first quarter where integers and rational numbers are being discussed showed a performance level of 44.83% also indicating "Average Mastery". The jurors who evaluated the developed MP-based activities were the teachers assigned in the said school, in Gallanosa National High School, Irosin, Sorsogon, and in Gate National High School, Bulan, Sorsogon.

In determining the effect of MP-based activities, the researcher selected two sections in Grade 7 regular class in Bulan National High School as the respondents for the control and experimental groups. The experimental group was exposed to Mathematical Practice-based activities while the control group followed the ready-made lessons on Grade 7 mathematics learning module. This study wants to identify the significant difference in the learning performance of the students between the use of ready-made lessons in Grade 7 Module

and MP-based activities in the classroom and how the proposed MP-based activities affect students' learning.

2.3 Procedures

To address the research questions of the study, the researcher will made lesson plans regarding MP-based activities in which the learning competencies in Grade 7 K to 12 Basic Curriculum module will be used and those are all about integers and rational numbers. The researcher, himself, was the one who conducted the MP-based activities in experimental group and the lessons in Grade 7 learning module in control group. Before the start of the first lesson in both groups, the researcher gave mathematics interest inventory and collaborative checklist to each student for the pretest in interest in learning mathematics and collaborative skills.

The control group did not use Mathematics lessons which are based on standards for mathematical practice. This group used the ready-made lessons in Grade 7 mathematics learning module. This module also contains discussions, activities and exercises, and summary of the lessons. The activities included are aligned with the DepEd curriculum performance standards and learning competencies and are designed for letting students discover and understand the lesson where some of the activities are made individually or in group. The researcher also utilized group activity and discussed lesson given in the module. After discussion, there were several exercises to assess students' learning and mastery. While for the experimental groups, the researcher prepared lessons that are based on the standards for mathematical practice to ensure the effect of the treatment in students' performance. During the study, there was a test given every after discussing the lessons or applying learning competencies. And there was an observer to observe the students' participation and cooperation during lesson implementation and to determine the effect on students' collaborative skills both in experimental and control groups.

After the implementation period, the researcher administered the posttest in conceptual understanding and problem-solving skills. The checklists for interest in learning mathematics and collaborative skills was being answered again by the students and a student journal was also given to the students in experimental group. The results were tabulated, compared, analyzed, interpreted and discussed revealing the effects in students' conceptual understanding, problem-solving skills, interest in learning mathematics and collaborative skills. In addition, the researcher determined the insights drawn from the learning experiences of students in MP-based activities.

3. Results and discussion

3.1 Developed Mathematical Practice (MP) –Based Activities

The Mathematical Practice – based Activities are activities that are based on the eight (8) Standards for Mathematical Practice (SMP), namely: SMP1: Make sense of problems and persevere in solving them; SMP2: Reason abstractly and quantitatively; SMP3: Construct viable arguments and critique the reasoning of others; SMP4: Model with mathematics; SMP5: Use appropriate tools strategically; SMP6: Attend to precision; SMP7: Look for and make use of structure; SMP8: Look for and express regularity in repeated reasoning (CCSS Initiative, 2019). These standards may help to realize the twin goals of mathematics in the basic education levels, K-10, which are critical thinking and problem solving. These two goals are to be achieved with an organized and rigorous curriculum content, a well-defined set of high-level skills and processes, desirable values and attitudes, and appropriate tools, taking into account the different contexts of Filipino learners (K to 12 Mathematics Curriculum Guide, 2016).

The MP-based activities are designed for the lessons based on the learning competencies for integers and rational numbers of Grade 7 Mathematics curriculum guide in the K-12 provided by the Department of Education. These activities can be seen in ten (10) developed lesson plans. Table 1 shows the summary of the MP-based activities developed for every lesson that also contains learning competencies and objectives and the

standards for Mathematical Practice used in the developed activities.

Table 1

Developed MP-based activities in teaching grade 7 mathematics

Lessons	Learning Competencies/ Objectives	Standards for Mathematical Practice	Activities
Addition of Integers	a. State the rules in adding integers b. Perform addition of integers c. Solve word problem involving addition of integers	Make Sense of Problems & Persevere in Solving Them Reason Abstractly and Quantitatively Attend to Precision Use Appropriate Tools Strategically Model with Mathematics	*Activity 1: Between Add and Subtract* - A contextualized problem is posted in the board. Teacher will ask series of questions before answering that problem letting the students understand the problem and look for starting points. - Students will represent the given in the problem using negative and positive integers to use addition operation. - Students will recognize the use of negative and positive integers in representing the given problem and identify correct answer by comparing to others' work and by building consensus within the class. The teacher also checked their work. *Activity 2: Modelling Lines and Tiles* - Each group will be given a ruler, a marker, Manila papers, colored papers, scissors, and glue. The students will manipulate the given tools to create models. - Students will create signed tiles and number line to model addition of integers.
Subtraction of Integers	a. State the rules in subtracting integers b. Perform subtraction of integers c. Solve word problem involving subtraction of integers	Reason Abstractly and Quantitatively Construct Viable Arguments and Critique the Reasoning of Others Look for and Make use of Structure Look for and Express Regularity in Repeated Reasoning	*Activity 1: Select or Discard* - Students will represent selecting and discarding integer cards using positive and negative integers to discover solutions in subtracting integers. - Students will interpret data from a given table to answer the posted problems through small group and whole class discussion letting students consider ideas and evaluate reasoning of the others. *Activity 2: Where is My Place?* - Students will look for a pattern or structure discovering, 8 – 3 is the same as 8 + (-3) prior to identifying rules in subtracting integers. *Activity 3: Try Again!* - Teacher will give 8 – (-3) as another problem to be modelled and solved by the students and compare to previous problem for them to conclude and generalize the rules in subtracting integers.
Multiplication of Integers	a. State the rules in multiplying integers b. Perform multiplication of integers c. Solve word problem involving multiplication of integers	Make Sense of Problems & Persevere in Solving Them Reason Abstractly and Quantitatively Construct Viable Arguments and Critique the Reasoning of Others	*Activity 1: Describing n-times Integer* - Teacher will post series of problem statements or questions in the board but before doing/ answering that, students will relate lesson objectives to make sense on the posted problems and define some terms in representation of integers and mathematical symbols. - Students will answer the problem statements/ questions by referring to the recorded data in the table and represent each problem using negative and positive integers and equations. - Students will interpret data from a given table and answer problem through small group and whole class discussion letting the students listen to the arguments of the others and ask useful questions to determine if their ideas make sense.
Division of Integers	a. State the rules in dividing integers b. Perform	Look for and Make use of Structure	*Activity 1: Do the 1-Minute Challenge* - Students will solve problems in 1 minute. They will use their previous knowledge about dividing numbers

	division of integers		and the new learning that is written in the lesson summary.
	c. Solve word problem involving division of integers	Attend to Precision	- The students will check their answers by the correct answer posted in the board. The teacher will emphasize the use of negative and positive signs for the students. The teacher assessed them to make sure that their wrong response will turn into correct response.
		Look for and Express Regularity in Repeated Reasoning	- Based from the 42-item solved problems, the students will observe and compare problems to each other to discover rules in dividing integers
Properties of the Operations on Integers	a. Define the properties of operations on integers		*Activity 1: Pictionary Game: Read and Assemble*
	b. State and illustrate the properties of operations on integers	Use Appropriate Tools Strategically	- Students will be tasked to complete the incomplete illustrations by selecting appropriate materials: pictures, operation symbols, strips containing words, and glue and arrange these based on the given clues or statements.
	c. Rewrite the mathematical expressions using the properties of operations on integers	Model with Mathematics	- Students will define different properties of operations based on completed illustrations done by the students as models.
		Construct Viable Arguments and Critique the Reasoning of Others	- Some of the groups will present their work in the class. The students will find the correct illustration through whole class discussion. The other group will give comments and asks questions to the presenters.
Rational Numbers in the Number Line	a. Define rational numbers		*Activity 1: Examples and Counterexamples*
	b. Illustrate rational numbers on the number line	Make Sense of Problems & Persevere in Solving Them	- The teacher will display a question in the board for students to answer. This will be followed by a series of questions and they will be given a manila paper with illustration to help them initiate plan in answering the main problem.
	c. Arrange rational numbers on the number line	Reason Abstractly and Quantitatively	- Students will cite examples of mathematical expressions and counterexamples for the question: "Is the quotient of two integers always an integer?"
			Activity 2: Dividing the Line into Ten
		Use Appropriate Tools Strategically	- Every group will be given 2-meter string, scissors, marker, manila paper and tape to create model of rational numbers in the number line by following some instructions to be given by the teacher.
		Model with Mathematics	- The students will use the strings as representation of the real number line and how to locate the rational numbers in that number line.
Forms of Rational Numbers	a. Identify terminating and repeating and non-terminating decimals		*Activity 1: Compose and Decompose*
		Make Sense of Problems & Persevere in Solving Them	- The teacher will display the problem in the board and ask students a series of questions as guide for them to be ready and make sense in answering the problem.
	b. Express rational numbers from fraction form to decimal form and vice versa	Use Appropriate Tools Strategically	- The teacher will give the materials for the activity(ten 0.1-kilogram bags of rice, digital scale, 1-meter strip of paper, meter stick, blank meter strip of paper, ruler, markers or crayons, and manila paper) and let the students use them to do the activity without the help of the teacher but guided by instructions to be posted in the board.
	c. Solve problems using models.	Model with Mathematics	- The students will draw a tape diagram to represent the the number of bags and the total amount of rice and create a number line to locate fraction- and decimal-formed rational numbers.
Addition and Subtraction of Rational Numbers	a. Perform addition of rational numbers		*Activity 1: There is Rational in Real-life*
	b. Perform subtraction of rational numbers	Make Sense of Problems & Persevere in Solving Them	- The teacher will display word problems on the board and ask guided questions to make the students connect on those problems, understand them and to confirm their readiness in answering the problems.
		Reason Abstractly and	- Each group will create an equation representing the

	c. Solve problems involving addition and subtraction of rational numbers	Quantitatively Construct Viable Arguments and Critique the Reasoning of Others Attend to Precision	problem assigned to them. They will state what is asked in the problem, write the given and label it based on its context and create appropriate solution on it. - Through group discussion, teacher give time for the students to share arguments with their group mates on how to solve the problem. Each group will share their answer in the class and let the other group critique their work. The teacher will give direction to the class about the importance of label and units in the final answer. A concluded statement should also be stated in solving word problem.
Multiplication and Division of Rational Numbers	Perform multiplication of rational numbers Perform division of rational numbers Solve problems involving multiplication and division of rational numbers.	Reason Abstractly and Quantitatively Construct Viable Arguments and Critique the Reasoning of Others Look for and Express Regularity in Repeated Reasoning	*Activity 1: Word Problem: Create and Modify* - Each group will create a word problem involving integer multiplication to be solved by the other group. And modify the created word problem by changing integers into rational numbers and solve. - All groups will post their work on the board for presentation and checking. The other groups will be encouraged to give comments about the work of the group presenter. The teacher will let the students share arguments, give feedbacks to find the correct answer. *Activity 2: Compare and Contrast* Referring to activity 1 students will compare the multiplication and division word problems involving integers to word problems involving rational numbers to see if the rules in multiplying and dividing negative and positive numbers are the same. The teacher will display more examples of multiplying and dividing rationals to generalize rules.
Properties of Operations on Rational Numbers	a. Define the properties of operations on rational number b. State and illustrate the properties of operations on rational number c. Rewrite the mathematical expressions using the properties of operations on rational number	Reason Abstractly and Quantitatively Look for and Make use of Structure	*Activity 1: Observe, Relate, Discover* - Referring to the solved problems in Activity 1, the students will observe and describe related equations by linking to properties of operations discussed in integers. *Activity 2: Enumerate Properties of Operations* - Students will be asked to enumerate the used properties of operations in the 10 problems that they will be written in the paper. From the recalled properties of operations in integers, students will also identify what are the other properties not being used from those problems. From that, students are asked to give some problems involving operations of rational numbers that will check if the other properties can also be used.

The developed MP-based activities are intended to achieve the following learning competencies: (1) perform fundamental operations on integers, (2) illustrate the different properties of operations on the set of integers, (3) express rational numbers from fraction form to decimal form and vice versa, (4) arrange rational number on a number line, and (4) perform operations on rational numbers. The MP-based activities are student-centered which place more emphasis one what the learners is doing. The standards for mathematical practice can be considered as teaching processes to organize activities that leads to integrate several teaching approaches such as problem-based, interactive, inquiry-based and discovery learning approaches.

3.2 Jurors' evaluation of the developed MP- based activities

The jurors validated and evaluated the mathematical practice-based activities using the researcher-made rating sheet with two categories. The first category is the "Essential learning activities Features" modified from the instrument used by Alondra (2015) on his study. This criterion will help to identify if the activities presented in the lesson plans can be used in teaching lessons in Mathematics. The third category is the "MP-based Activities features" which evaluates the developed activities according to standards for mathematical Practice.

Table 2 shows the rating of the jurors about the essential learning activities features. It has nine (9) indicators to validate if these activities can be accepted to use in teaching integers and rational numbers in Grade 7 students.

Table 2

Jurors' evaluation on essential learning activities features

	Essential Learning Activities Features	Mean	Descriptive Interpretation
1.	The activities are consistent with the objectives of the lesson.	4.74	Outstanding
2.	The activities are clearly stated.	4.67	Outstanding
3.	The activities are suitable to the ability of the students.	4.64	Outstanding
4.	The activities are student-centered.	4.62	Outstanding
5.	The activities promote active participation	4.73	Outstanding
6.	The activities require the students to share their findings with the class as a form of collaboration.	4.70	Outstanding
7.	Instructions are properly constructed.	4.57	Outstanding
8.	The activities invite curiosity, inquiry, and critical thinking.	4.63	Outstanding
9.	The activities given measure the mastery of the competencies involved.	4.73	Outstanding
Average Mean Score		4.67	Outstanding

The students spend most of their daytime in the classroom, thus it is important that the classroom should be active and interesting by maintaining space for activities which engage the students and teachers resulting in effective learning. According to Knapen (2018), an engaging activity encourages the students to be active members of the class, thinking on their own, using their brains, resulting in long-term memory retention. Not only the students' knowledge will improve, but their interest, team spirit and confidence will increase as well. In table 3, the first indicator stating: "The activities are consistent with the objectives of the lesson" had the highest mean of 4.74 indicating "Outstanding" interpretation. The jurors considered that the developed activities were organized for the students to perform and attain the learning objectives. The developed MP-based activities accurately reflect the learning objectives in which during the assessment, these objectives will be achieved by the students as they practice and perform these in activities being employed in the discussion. While the seventh indicator stating: "Instructions are properly constructed" had the lowest mean of 4.57.

Overall, it shows that the developed MP-based activities were evaluated with a mean score are 4.67 indicating outstanding descriptive interpretation that made the developed activities accepted as learning activities to be used in teaching integers and rational numbers. A seminal paper by Biggs (2012) argues that good teaching focuses on what students are doing. The focus should not be on what the teacher is saying or doing, or how much they know; it should not even be on what students are hearing. Rather, the focus of good teaching must be on what students are actually doing with the knowledge, skills and competencies they are acquiring, because learning doesn't occur through just listening; action is also required. Thus, the use of MP-based activities will help the students to construct knowledge and perform skills that arise motivation and interest towards learning Mathematics.

On the other hand, table 3 shows the rating of the jurors about the MP-based activities features that can be seen in the part B of lesson plans. This is to validate if the standards for mathematical practice are evident in the developed lesson plans.

Table 3

Jurors' evaluation MP-based activities features

Mathematical Practice-based Activities Features	Mean	Descriptive Interpretation
The activities showed:		
SMP1: Make sense of problems and persevere in solving them	4.59	Outstanding
SMP2: Reason abstractly and quantitatively	4.65	Outstanding
SMP3: Construct viable arguments and critique the reasoning of others	4.60	Outstanding
SMP4: Model with Mathematics	4.67	Outstanding
SMP5: Use appropriate tools strategically	4.73	Outstanding
SMP6: Attend to precision	4.65	Outstanding

SMP7: Look for and make use of structure	4.60	Outstanding
SMP8: Look for and express regularity in repeated reasoning	4.67	Outstanding
Average Mean Score	4.65	Outstanding

The standards for mathematical practice (SMP) describe what students at any grade level are doing as they learn mathematics. These eight (8) standards provide a framework for strengthening the teaching and learning of mathematics. In table 3, the SMP5 stating: "Use appropriate tools strategically" had the highest mean of 4.73 indicating "Outstanding" interpretation. This means that the MP-based activities were accepted by the jurors as learning activities letting the students strategically choose appropriate tools and use it correctly to complete a certain task. This SMP was used as bases to create MP-based activities in learning the topics "Addition of Integers", "Properties of the Operations on Integers", "Rational Numbers in the Number Line" and "Forms of Rational Numbers. Based from the evaluation of the jurors of the MP-based activities for each of these topics, only the MP-based activity in Forms of Rational Numbers got a perfect mean of 5 in this indicator. While the MP-based activity with the lowest mean rated for this indicator is in the lesson Addition of Integers. But this do not claim that the activity since the mean is 4.64 which is also indicate outstanding descriptive interpretation.

On the other hand, the SMP1 had the lowest mean of 4.59, however, this also indicates outstanding descriptive interpretation. This SMP1 states "Make sense of problem and persevere in solving them". The MP-based activity in this standard should encouraged the students to interpret and make meaning of the problem by looking for starting points. Hence, the developed activities meet the standard as this was also accepted by the juror. The MP-based activities that showed the other standards for mathematical practice was also accepted by the jurors having an outstanding descriptive interpretation on each. Overall, it shows that the developed MP-based activities had a mean score of 4.65 which also indicates outstanding descriptive interpretation. This means that the mathematical practice-based activities have followed.

The essential learning activities features and MP-based activities features used as criteria for evaluation of the developed MP-based activities provide information to produce engaging, relevant and stimulating teaching and learning activities that excite and motivate students. The MP-based activities were evaluated by the jurors with "Outstanding" interpretation in all indicators from the two categories that means all the indicators are evident and accepted to be used in teaching Integers and Rational Numbers. Based from Raudys (2019) engaging activities can help remain focused, learn differently, and learn faster. The students who are learning actively are less likely to become bored and disinterested. When students are involved in the learning process, they are more engaged emotionally, helping them experience learning in a dynamic, new way. Learning firsthand requires deep problem-solving and critical thinking. These processes boost student engagement, accelerating learning and improving content retention.

3.3 Effects of the developed MP- based activities

In the K to 12 Mathematics Curriculum Guide (2016), critical thinking and problem solving are the two main goals for the development of mathematical skills of the students. Critical thinking, is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. On the other hand, mathematical problem solving is finding a way around a difficulty, around an obstacle, and finding a solution to a problem that is unknown. The same goal is intended for the study presented. The study sought to determine the effect of the MP-based activities in terms of students' conceptual understanding and problem-solving skills.

Furthermore, the students' collaborative skills and interest in learning Mathematics subject were also determined. Since the MP-based activities are group activities, it is therefore a need to find if these activities show significant increase in the students' collaborative skills. Collaboration within the class that involves groups of students working together to solve complete a task, solve problems specifically in learning Mathematics While the students' interest is essential in the learning process because it prepares the mindset of the learners

towards the subject. According to McCarthy (2019), a higher level of activating interest is to have students propose their own ideas for products and activities. This engages students to do more complex work and spend more time on the task than they normally would. Thus, the researcher also measured the students' interest toward Mathematics.

Conceptual understanding **-** Table 4 shows the mean scores of the students' conceptual understanding before and after the implementation of the MP-based activities and are also compared to the control groups' mean scores. This is based from 30-item multiple choice pretest and posttest. The table also includes standard deviation, p-value, significance and effect size.

Table 4

Result of students' performance in conceptual understanding

	Experimental Group		Control Group	
	Pretest	Posttest	Pretest	Posttest
Mean	8.2	21.18	8.16	18.91
Standard Deviation	2.92	3.22	2.19	3.50
P-value	0.00		0.00	
Significance	Highly Significant		Highly Significant	
Effect Size Between Pretest & Posttest	2.88		2.82	
Descriptive Interpretation	Huge Effect		Huge Effect	
Effect Size Between Groups	0.78			
Descriptive Interpretation	Large Effect			

Table 4 shows the effect of the MP-based activities in the conceptual understanding of the students which reflects a highly significant increase in the pretest and posttest scores because of the p-value of 0.00. In terms of standard deviation, the experimental group were more dispersed after using MP-based activities compared to its standard deviation before implementation. But compared to the control group, the experimental group obtained a less increase in standard deviation from 2.92 to 3.22 than the control group from 2.19 to 3.50. It means that after implementation the scores of the students in experimental group are more concentrated compared to the scores of the control group.

In terms of effect size both experimental and control groups show huge effect between pretest and posttest. This means that the students in both groups learned the concepts in integers and rational numbers. This is probably because the activities conducted in control group let the students also explore and discover concepts in an active and meaningful way as the researcher also conduct group activities letting them share ideas to each other same with experimental group, the developed activities provided students opportunities to explore and discover mathematics concepts in a meaningful way of learning. The only difference is that in the developed MP-based activities, there are specific process to be followed by the teacher such as working the activity in groups, answering series of questions, exploring and modeling mathematics concepts and presenting tasks in the class letting them construct arguments and generate conclusions. This is because there are cited standards for mathematical practice that need to be attained during learning instruction not just only the learning objectives.

While in control group, it is up to the teacher what kind of strategy he has to use to execute activities in the module, if the activity could be done individually or in groups in order to attain learning objectives. In addition, it is also shown in the table that the effect size between groups describes large effect with 0.78 Cohen's D effect size. It means that there is a significant difference between the two groups in favor of experimental group. The table also shows the mean of both groups in pretest and posttest which results to a mean gain of 12.98 for the experimental compared to a mean gain of 10.75 for the control group.

This led to the conclusion that teaching using MP-based activities offers a positive impact among the students' conceptual understanding in learning integers and rational numbers in Mathematics. One of the students said "I learned every lessons in Math. I learned how to add, subtract, multiply and divide integers". This indicate that after implementing MP-based activities, the concepts and competencies that should be demonstrated by or developed from the students were attained which is a big help for the teacher to teach the lessons in

Mathematics. Supporting the claim of the study of Partin (2017) that there is an increase in student growth after Mathematical Practices was implemented in the state of Tennessee. However, based from the study of Lynch (2015) it is found that student math achievement showed no significant difference with the initial transition to Common Core State Standards. Nevertheless, teachers are the ones who will develop and arrange their lessons and choose teaching instructions.

Problem solving **-** Table 5 shows the mean score of the students' problem solving in both the experimental group before and after the implementation of the MP-based activities and the control group using the DepEd's Grade 7 Learning Module. This is based from 20-item pretest and posttest. The table also includes standard deviation, p-value, significance and effect size.

Table 5

Results of students' performance in problem solving

	Experimental Group		Control Group	
	Pretest	Posttest	Pretest	Posttest
Mean	3.80	19.75	3.93	14.21
Standard Deviation	3.34	3.69	2.21	4.03
P-value	0.00		0.00	
Significance	Highly Significant		Highly Significant	
Effect Size Between Pretest & Posttest	3.54		2.73	
Descriptive Interpretation	Huge Effect		Huge Effect	
Effect Size Between Groups	1.82			
Descriptive Interpretation	Huge Effect			

Table 5 shows the effect of the MP-based activities in students' problem-solving skills which reflects a highly significant increase in the pretest and posttest scores because of the p-value of 0.00. In terms of standard deviation, the experimental group were more dispersed after using MP-based activities compared to its standard deviation before implementation. But compared to the control group, the experimental group obtained a less increase in standard deviation from 3.34 to 3.69 than the control group from 2.21 to 4.03. It means that after implementation the scores of the students in experimental group are more concentrated compared to the scores of the control group. However, both experimental and control groups show huge effect in the effect size between pretest and posttest. This is because both groups have no or less ideas in solving word problems involving integers and rational numbers before the implementation. Both activities and lessons in Grade 7 Module and in MP-based activities showed positive impact to the students to learn how to solve word problems in the said topics.

In control group, there are also several word problems in the module that can be used to develop students' skills in the problem. While, the MP-based activities provided word problems from the start of the lesson which the students explored answers through group discussion. Before answering the problems there were several procedures to follow and questions to answer that helped the students make sense of problems, reason quantitatively, construct, share and critique arguments, represent through mathematical models and attend to correct solution in which the standards for mathematical practice intended to achieve. Furthermore, the table also shows a huge effect of 1.82 between groups. This means that there is a difference between the performance in problem solving skills in control and experimental groups which is in favor of the experimental group as also shown in the table that the experimental group's mean score was from 3.80 to 19.75 having a mean gain of 15.95 while in the control group, the students' mean score was from 3.93 to 14.21 which results to a mean gain of 10.28. It means that the experimental group had greater improvements in problem solving skills compared to the control group.

Therefore, it can be concluded that the use of MP-based activities also improved the problem-solving skills of the students. In other words, the developed MP-based activities are indeed applicable and can be a medium in teaching students about solving problems. According to Bien (2018), teacher should include fostering flexible problem-solving strategies and encourage students put more mental effort and strategy in solving word problems.

The use of problem solving in mathematics helps the students to reason out and explain ideas on their own, represent problems using mathematics concepts and properties, and solving problems critically specifically in learning integers and rational numbers which are one of the topics that are difficult for the students to understand.

Interest in learning mathematics **-** Table 6 shows the effects of MP-based activities in the pretest and posttest scores in terms of the interest of the students in learning mathematics as compared to the control group. It includes proportion, p-value and significance, and effect size.

Table 6

Results of students' interest in learning mathematics

	Experimental Group		Control Group	
	Pretest	Posttest	Pretest	Posttest
Proportion	0.47	0.83	0.48	0.59
Significance (Difference in Proportion)	Significantly Increased		Significantly Increased	
P-value	0.00		0.00	
Significance (p-value)	Highly Significant		Highly Significant	
Effect Size Between Pretest & Posttest	1.14		0.38	
Descriptive Interpretation	Very Large Effect		Moderate Effect	
Effect Size Between Groups	11.25			
Descriptive Interpretation	Huge Effect			

Table 6 shows that in experimental group, the students' proportion in posttest is higher than the proportion in pretest having 0.83 and 0.47, respectively which also reveals that there is a significant increase of the proportion who responded "Agree" and "Strongly Agree" after implementing MP-based standards. While in control group, it also shows that proportion of the students is 0.48 in the pretest and 0.59 in the posttest that also reveals significant increase of the proportion who responded "Agree" and "Strongly Agree" after the conduct of the lesson stated in Grade 7 Module.

In addition, both groups reflect a highly significant increase in the pretest and posttest, assessing the interest of the students towards learning integers and rational numbers, because of the p-value of 0.00. It means that both groups improved their interest in learning mathematics. This is because the Grade 7 Module also contains several activities that could be implemented in the class. The activities also help students to gain interest in the subject. However, as reflected in the effect size between pretest and posttest of both groups, it reveals that there is a very large effect in experimental group with 1.14 effect size compared to moderate effect in control group with 0.38 effect size. Furthermore, there is a huge difference in effect size between groups in favor of experimental group. More students responded "Agree" and "Strongly Agree" in experimental group compared to control group.

The use of MP-based activities arouses the students' interests and desire to learn Mathematics subject. Most of them answered that the activities were very interesting and fell that the time was well spent as they performed the activity. When a topic connects to what students like to do, engagement deepens as they willingly spend time thinking and creating ideas in meaningful ways (McCarthy, 2019). The students will also gain interest if the learning activities are fun letting them enjoy and give more focus on the subject. As reflected in Plate 6, the observer' comment show that the students were really enjoying the MP-based activities as they trying to find and understand the concepts in Mathematics. Thus, the MP-based activities caught the interest of the students leading to positive result in terms of academic achievement as they enjoy, paid attention and gave focus in learning the lessons.

Collaborative skills **-** The instrument used to measure the students' cooperative skills was adopted from the study of Ocfemia (2016). The collaborative skills were rated by the students as follows: Trust-Building (TB), Leadership (L), Decision Making (DM), Communication (C), Conflict Management (CM), Self-management (SM) and Working effectively with others (W).

Table 7 shows the effects of MP-based activities in collaborative skills of the students which were compared

to the control group. It includes the mean score in each indicator, the overall mean, the descriptive interpretation of the overall mean, the p-value and the level of significance.

Table 7

Students' collaborative skills before and after implementation

Collaborative Skills		Experimental Group			Control		
		Pretest	Posttest	Significance	Pretest	Posttest	Significance
Proportion of Students (Response: A or SA)	TB	0.61	0.95	Significantly Increased	0.79	0.91	Significantly Increased
	L	0.53	0.89	Significantly Increased	0.61	0.78	Significantly Increased
	DM	0.50	0.87	Significantly Increased	0.55	0.68	Significantly Increased
	C	0.45	0.90	Significantly Increased	0.62	0.70	Not Significant
	CM	0.57	0.90	Significantly Increased	0.60	0.80	Significantly Increased
	SM	0.51	0.84	Significantly Increased	0.56	0.66	Significantly Increased
	W	0.53	0.89	Significantly Increased	0.70	0.77	Not Significant
	AP	*0.53*	*0.89*	Significantly Increased	*0.62*	*0.74*	Significantly Increased
P-value			0.00			0.00	
Significance (p-value)			Highly Significant			Highly Significant	
Effect Size Between Pret&Posttest			1.00			0.54	
Descriptive Interpretation			Very Large Effect			Large Effect	
Effect Size Between Groups				6.3			
Descriptive Interpretation				Huge Effect			

Legend: A – Agree; SA – Strongly Agree; TB – Trust-Building; L – Leadership; DM – Decision Making; C – Conflict Management SM – Self-management; W – Working effectively with others; AP – Average Proportion

Table 7 reveals that there is an increase in the proportion of the students who responded "Agree" and "Strongly Agree" in the collaborative skills in both experimental and control group which also resulted to highly significant with p-value of 0.00. In the pretest, the average proportion of the experimental group results to 0.53 which is smaller than the average proportion of the control group results to 0.62. But in posttest, the average proportion of the experimental group results to 0.89 which is larger than the average proportion of the control group results to 0.74. It means that after the implementation, the experimental group shows higher collaborative skills than the control group.

However, both experimental and control group show significant increase in the average proportion between pretest and posttest. The researcher also utilized group activities in control group based from the activities cited in Grade 7 Module to compare in experimental group because the developed MP-based activities are group activities integrating collaborative learning approach. But as reflected in the table there are skills in control group that show no significant difference between pretest and posttest, these are communication and working effectively with others. These two skills are one of the most important in collaboration because the students are sharing ideas in their groupmates developing communication skills and on how to interact effectively with others. While in experimental group, all the collaborative skills show significant difference in which after implementing MP-based activities all these skills have improved.

In comparing proportions in the posttest of the experimental group, the skill that shows highest mean is the "Trust-Building Skill". It is simply because the students were working in groups which also letting them to know each other and communicating effectively which led to create trust towards each other. The collaboration helped students respectfully understand the abilities and qualities of their group mates. While the skill that shows the lowest proportion is the "Self-Management Skill". This is because some of the students could not cope up or follow the rules and instructions easily. But because of the MP-based activities there is also an improvement

along this skill. The researcher recommended that the use of activities that are based on standards for mathematical practice can also be implemented in a long period of time.

In terms of the effect size between pretest and posttest of both groups, it reveals that there is a very large effect in experimental group with 1.00 effect size compared to large effect in control group with 0.54 effect size. And there is also a huge difference in effect size between groups in favor of experimental group. More students responded "Agree" and "Strongly Agree" in experimental group compared to control group. The use of MP-based activities developed students' collaborative skills making them participate in the lesson by sharing knowledge and ideas and construct arguments that will lead them learn the subject.

In conclusion, the MP-based activities developed students' collaborative skills since these are group activities that promotes collaboration. Based from David (2019), collaboration among students in the learning process is an effective tool in teaching. Students may learn better when they work together because they are held accountable to each other.

3.4 Insights drawn from the learning experiences of the students in MP-based activities

The use of MP-based activities in teaching Mathematics specifically in Integers and Rational Numbers presents an interesting approach to teach and learn Mathematics. It also made the students to be more interactive in the learning process. The use of MP-based activities made the students learn a lot in Mathematics and it made them easily understand the lessons. In order to determine the insights drawn from the learning experiences of the students, a journal was given to each of them comprising of questions that was being answered by the students after implementing MP-based activities. Based on the results of the study and the answers of the students in journals, several insights were drawn.

Lessons were made easy. Teachers should know that in teaching lessons the students do not feel uncomfortable in learning the subject because for them they feel that the lessons are difficult to understand which made them hate the subject and get low performance during assessment. A teaching instruction that will make the students connect their prior knowledge and help them easily understand the lesson will give a meaningful learning. It can be noted that there is positive feedback about the use of MP-based activities as reflected from the answer given by the students: "I found the activity very easy and interesting" and "It is challenging but really awesome and I can understand it easily". This indicates that the students easily understood and learned the lesson with the help of MP-based activities. Another student said that the he enjoyed the activity which made him focused on the lesson letting them solve math problems in an easy way. In addition, from the interest inventory checklist given to the students, the indicators "I find it easy to understand the topics in Math" shows an increase in weighted mean from pretest with 3.27 interpreted as moderate interest to posttest with 3.93 interpreted as high interest. This indicates that the use of MP-based activities in teaching integers and rational numbers made the students easily understand the lesson as they were interested and motivated to learn. The engaging activities create positive results in terms of difficulty in learning Mathematics.

Promotes Positive Outlook towards Mathematics. It is also important that the students show positive outlook towards learning the subject because this reflects interests and the wants to learn more and gain relevant knowledge helping them to improve performance in a certain subject. When the students were asked what they can say about MP-based activities, they have an overwhelming positive feeling towards the activities which is supported by the answer given by the students: "The activities given by the teacher makes me interested to learn mathematics because it is different from the activities that we'd done in the previous grade level. Now I'm more eager to learn mathematics. I want to learn more about the subject which makes me excited".

Learning activities help to improve students' mathematics learning by eliminating their negative beliefs and overcome fears towards the subject. The students are also encouraged to strive and persevere to continue the quest for learning. As reflected on the comment given by the observer that the students were very determined to finish the task. Their eagerness to learn the lesson was manifested from their performance in the activity. In

addition, from the interest inventory checklist given to the students, the indicators "I always look forward to activities in Math" shows an increase in weighted mean from pretest with 3.39 interpreted as moderate interest to posttest with 4.07 interpreted as high interest. This indicate that after implementing MP-based activities the students showed positive outlook towards learning Mathematics.

Improved Self-Confidence. Students' participation in the class especially presenting tasks in front of their classmates boosts self-esteem and also encourage students to have interests in the subject. It is also a practice for the students to communicate and respond easily to the listeners who can also give feedbacks or ask questions. It is also very helpful when they enter higher educational level especially in college because they were trained to feel at ease when they present in front of the others. Regarding this idea, one of the students said, "It was a great experience because whenever I present a task to my classmate, I felt calm and more confident because I know how to explain solutions to math problems". This statement reveals that the students had developed their confidence to present and explain in front of the class. Learning will be meaningful if the students show confidence to share ideas not only on their classmates but also presenting it to their teachers without hesitation. In MP-based activities, the students were required to share their ideas not only in their group mates but also in front of the class which is evident in the comment given by the observer that the students constructed knowledge through explanation of answers on the board while the others were listening and give feedbacks.

Improved Communication with Others. The students will not learn better if they will not collaborate with their classmates. Through communication, the students were helping each other by sharing ideas and thoughts which made the learning process effective. One of the students believed that it is helpful to collaborate with classmates in generalizing ideas and generating solutions prior to learning the subject. Through the use of MP-based activities the students were encouraged to work collaboratively from small group discussion to whole class. It is evident statement given by the student that they were exchanging ideas and gaining more knowledge coming from their classmates. It is also reflected from the comment of the observer that the group activities let the students collect, select and respond to the ideas or arguments of others. The students work actively through collaboration for them to solve the given problems in the activity.

Students like Mathematics. Learning also takes place if the students like the subject. If they like the subject they can give their attention and strive to accumulate information and think that understanding ideas is easy and interesting. One of the students said, "I'm very happy because I enjoyed the activities. I think I like more now mathematics than the other subjects". The MP-based activities made the students realize that learning Mathematics is interesting. It is also reflected from the results for students' mathematics interest of experimental group, the indicator: "math is the most like among my subjects" shows an increase in weighted mean from pretest with 3.11 interpreted as moderate interest to posttest with 3.75 interpreted as high interest. This means that after implementing MP-based standards, the students now like mathematics. The students tend to love Mathematics if they experience an interesting and enjoyable approach in learning the said subject. Thus, it promotes effective teaching not only developing the students' cognitive skills but also their affective skills which also important in promoting academic excellence.

In conclusion, using the MP-based activities, the students gained significant experiences and realization specifically: (a) realized that the lessons integers and rational numbers are easy to understand, (b) students showed positive outlook towards learning the subject, (c) students felt confidence to present work in front of the class, (d) students found the activities helpful in learning to communicate with others, and (e) students now like Mathematics.

4. Conclusion and Recommendations

4.1 Conclusion

Based on the findings, the following conclusions are made:

- The developed MP-based activities can be used by the teacher in teaching integers and rational numbers in Grade 7 classes as these also accepted and validated by the experts.
- The MP-based activities resulted to improve conceptual understanding, problem solving, interests in Mathematics and collaborative skills of the students
- Using the MP-based activities, the students gained significant experiences and realization specifically: (a)realized that the lessons integers and rational numbers are easy to understand, (b) students showed positive outlook towards learning the subject, (c) students found the activities helpful in learning to communicate with others, (d) students felt confidence to present work in front of the class, and (e) students now like Mathematics.

4.2 Recommendations

In accordance with the findings and conclusions drawn from the study, the following are recommended:

1. The developed lesson activities in this study can be adopted and improved by the teachers teaching Grade 7 Mathematics as these are also competency-based and there are integration of other approaches such as Problem-based learning, Inquiry-Based Approach, Discovery Learning, and/or Collaborative Learning.

2. Mathematics teachers may develop MP-based activities for other Grade level guided by the MP-based activities developed and implemented in this study.

3. Curriculum developers and administrator may consider these developed instructional activities as these may help to realize the twin goals of Mathematics in basic education which are critical thinking and problem solving.

4. For future local researches, further research on similar problems may be undertaken such as:

a. The use of MP-based activities at all levels in junior high schools, senior high school and elementary school

b. Longer period of exposure on the use of MP-based activities to effectively observe its effect on the conceptual understanding and problem solving skills of the students

c. Further study on the effectiveness of MP-based activities with some specified subjects such as diverse students, slow learners, large/small number of classes, students with dyscalculia, etc.

5. References

Alondra, G. A. (2015). *Differentiated instruction by students' learning styles: Effect on the performance in Mathematics IV*. Unpublished masteral thesis, Bicol University, Albay, Philippines.

Bien, J. (2018). *Schema-broadening instruction in grade 9 Mathematics.* Unpublished masteral thesis, Bicol University, Albay, Philippines.

Biggs, J. (2012). *Teaching and learning activities.* Retrieved from UWC.

Blair, K. P. et al. (2012). Beyond natural numbers: negative number representation in parietal cortex. *Frontiers in Human Neuroscience*. http://dx.doi.org/10.3389/fnhum.2012.0000

Catalano, H. (2014). *Teachers' perceptions of the effects of the common core standards on student academic Achievement.* Unpublished masteral thesis, State University of New York, New York, USA.

CCSSI. (2019). *About the standards.* Retrieved February 16, 2019, from http://www.corestandards.org/about-the-standards

David, J. M. (2019). *Benefits of cooperative learning.* Retrieved February 23, 2019, from https://www.pressreader.com

Fernandez, B. (2018). *Senate to review PHL's ranking in education*. Retrieved August 21, 2018, from

www.businessmirror.com.ph

Gafoor, K. A., & Kurukkan, A. (2015). *Why high school students feel mathematics difficult? An exploration of affective beliefs*. Unpublished paper, Farook Training College, Kerala, India.

K to 12 Mathematics Curriculum Guide (2016). Retrieved from http://depedbohol.org/v2/wp-content/uploads/2016/03/Math-CG_with-tagged-math-equipment.pdf

Knapen, R. (2018). *20 interactive teaching activities for in the interactive classroom.* Retrieved June 13, 2018, from https://www.bookwidgets.com/blog/2018/06/20-interactive-teaching-activities-for-in-the-interactive-classroom

Lynch, J. (2015). *The effects of implementing the common core state standards on student achievement*. Unpublished research paper, Northwest Missouri State University, Missouri, USA.

Magoti, E. (2019). *Why most students dislike mathematics subject*. Retrieved February 16, 2019, from https://www.academia.edu

McCarthy, J. (2019). *Learner interest matters: Strategies for empowering student choice.* Retrieved February 17, 2019, from www.edutopia.org/blog/differentiated-instruction-learner-interest-matters-john-mccarthy

Ocfemia, A. S. (2016). *Development and use of PowerQuest in teaching genetics*. Unpublished masteral thesis, Bicol University, Albay, Philippines.

Paris, J. (2019). *Philippine ranks among lowest in reading, math, and science in 2018 study*. Retrieved from Rappler: amp-rappler-com.cdn.ampproject.org

Partin, J. M. (2017). *Implementing mathematical practices within mathematical content*. Unpublished doctoral dissertation, Carson-Newman University, Tennessee, USA.

Raudys, J. (2019). *7 experiential learning activities to engage students.* Retrieved August 27, 2019, from www.prodigygame.come/blog

Read, L., & Atinc, T. M. (2017). Investigations into using data to improve learning: Philippines case study. *Global Economy and Development at Brookings.*

Romero, P. (2018). *Senate to review education system.* Retrieved from https://www.philstar.com

Siegler, R. S., & Forgues, H. (2017). Hard lessons: Why rational number arithmetic is so difficult for so many people. *Current Directions in Psychological Science, 26*(4), 346-351.

Stephan, M., & Akyuz, D. (2012). A proposed instructional theory for integer addition and subtraction. *National Council of Teachers of Mathematics, 43*, 428-464.

Valdez, A. V., et al. (2015). Developing critical thinking through activity-based cooperative learning approach in teaching high school chemistry. *International Journal of Science and Humanity, 2.*