The Use of Non-Math Analogies in Teaching Mathematics

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Abstract This is a quasi-experimental study on the effect of teaching with the use of non-math analogies on achievement in and attitude towards mathematics of students from two sections of a college institution in Manila as respondents. Mathematics Achievement Test (MAT) and Attitude towards Mathematics Inventory were administered as pre- and posttests, and the data collected were interpreted using t-tests. Results revealed comparability of the two groups prior to the conduct of the experiment. Further, the achievement of students taught with the use of non-math analogies improved better than those taught without non-math analogies. Likewise, the learning experience of students with non-math analogy seemed to have a positive significant effect on their attitude towards mathematics. Students find learning with non-math analogy easier, more meaningful, and more enjoyable because they could relate the abstract concepts in mathematics to what they experience in real-life. Consequently, mathematics teachers are encouraged to use non-math analogies in teaching mathematics as a strategy that could help their students appreciate and better understand the lessons.

Keywords: Lecture-discussion, non-math analogy, personal reflections

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Introduction

Learning is the primary goal of education and thereby, a major concern of educators and trainers of teachers. The most powerful evidence of learning is when students can establish the connection between what they have learned inside the classroom and what they have experienced in life. As stressed by Giardini (2016), learning with a purpose involves experiences in mathematics that are relevant, meaningful, and connected to the real world. Abstract concepts are made understandable and more significant when teachers give sufficient examples relating them to students' experiences. Moreover, students see meaning in what they learn when teachers show the connectedness of the lessons to their everyday concern.

Mathematics is one of the ideas that most teachers find difficulty in connecting the concepts they are teaching with real life situations. Similarly, as Hewson (2011) mentioned, many students find difficulty in applying the concepts that they learned in mathematics because they are unable to translate the meaning of what they learned to real-world situations. Consequently, students perceive mathematics as abstract, worthless, and dull. Unfortunately, the way students perceive mathematics greatly affects their attitude towards it and as a result, their achievement in mathematics is greatly affected.

Thus, a challenge for mathematics teachers is to make the learning of mathematics meaningful for students. In coping with this challenge, mathematics teachers should integrate in the lessons life-like situations so as to make students' learning experiences meaningful. One way to do this, as suggested by Sarina and Namukasa (2010), is to use analogies. Non-math analogy refers to a systematic correspondence (a mapping) between a better known source analog and a more novel target where the analog and the target are across domains, e.g. balancing equation is like balancing a scale (Richland, Zur, & Holyoak, 2007). In teaching using non-math analogy, concepts in mathematics are presented analogically with non-math concepts that are familiar to the students, specifically those that are related to students' real-life situations and experiences. In this technique, analogs are elicited from the students who are guided to construct the connection between the analogs and the target. Consequently, students are able to see the connections between the concepts they learned and those that they experience in real life. This redounds to better assimilation of concepts learned in mathematics (Sarina & Namukasa, 2010).

A vast amount of researches about the use of analogy as an approach to teaching (Adams & Elliot, 2013; Richland & McDonough, 2009; and Sarina & Namukasa, 2010) have been conducted to assert its effectiveness. Salandanan (2008) cited that, as utilized in instruction, a generous use of analogies works best in analyzing learning situations that call for new solutions, ideas, and ways of doing things. Further, according to Sarina and Namukasa (2010), the use of non-math analogies lowers students' level of mathematics anxiety, promotes deeper understanding of mathematics concepts that they learned, and eases their comprehension to build connections of mathematical concepts. Similarly, Adams and Elliot ("Capturing the king: using analogies to teach mathematics to adults, n.d. para. 3) noted that when analogies are used to convey mathematical concepts, students could easily relate to such concepts and subsequently, their understanding and confidence are increased.

In view of the discussions above, the researchers conducted a study on using non-math analogy in teaching mathematics. It is hoped that the use of this technique could improve students' achievement in and attitude towards mathematics.

Literature Review

On the Use of Non-Math Analogies and Constructivist Learning Environment

Adams and Elliot (2013) claimed that the use of analogies is done by connecting a concept to already known concept, idea, or situation. More specifically, in using an analogy, a familiar source/information is mapped to an unknown target or new information. This “mapping technique” supports the idea of learning in a constructivist classroom. Fortes (2016) emphasized that in a constructivist learning environment, students construct their own understanding, and the teacher guides them to connect prior knowledge or a familiar situation with new information. Moreover, researches (Adams & Elliot, 2013; Richland, Zur, & Holyoak, 2007; and Richland & McDonough, 2009) revealed that if teachers use non-math analogies, learning is facilitated because students could better assimilate mathematics content, increase ability to apply in a future context, and lessen cognitive overload.

On the Achievement in and Attitude Towards Mathematics

Achievement in mathematics is measured by the amount of mathematics content learned and skills developed in the teaching-learning process. Attitude is a tendency of a person to respond towards a certain idea or situation. According to Moenikia and Zahed-Babelan (2010), students’ attitude towards mathematics affects how well they achieve in it, how often they perform it, and how much pleasure they gain from it. Further, Farooq and Shah (2008) reiterated that achievement in mathematics, both in lower and secondary school levels, is affected by students’ attitude towards it. This was also supported by Mata, Monteiro and Peixoto (2012) who claimed that high achievement in mathematics is a function of student variables that include attitudes.

Framework of the Study

This study is anchored on the constructivist theory of learning. Stavredes (2011) emphasized that the constructivist theory is a cognitive approach in which students formulate their own understanding of concepts by linking previous knowledge, beliefs, and experiences with the new information. Such theory is used in teaching by analogies. Richland and McDonough (2009) claimed that instructional analogies provide opportunities for teachers to compare a mathematical idea to a non-math representation. This forms a backbone of thinking and learning in mathematics and subsequently, enables students to develop and comprehend new knowledge based on their prior knowledge. Furthermore, Richland, Zur, and Holyoak (2007) claimed that teaching by analogies typically involves mapping the more familiar source with an unusual target. The unusual targets are those mathematics lessons or concepts that most students find abstract while the more familiar sources may be students' actual experiences, experiences resulting from interacting with other people or other familiar events that students found important. The similarities between the familiar situations and the lesson will be used as springboard to help students give meaning to math concepts that they find intangible and not concrete.

The discussions above suggest that the gap between the new and pre-existing knowledge of students in mathematics may be bridged when teachers use analogies. It is hoped that said technique in teaching may improve students' attitude towards mathematics that may redound to better achievement in said subject.

The framework of the study is shown below.

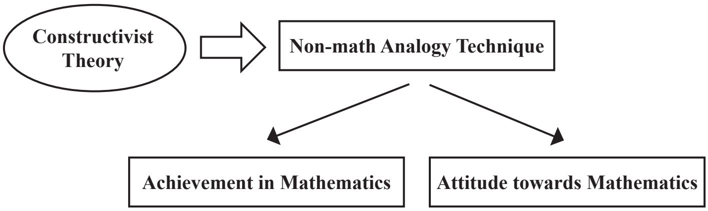

Figure 1. Framework of the study

The framework depicts that a theory on constructivism is considered in using the non-math analogy technique in teaching mathematics. This is signified by the arrow in the diagram that stemmed from constructivism to non-math analogy technique. Further, when such technique is being used, students' achievement in and attitude towards mathematics would be affected. Such effect is indicated by the two arrows in the diagram that emanate each from the non-math analogy technique to achievement in mathematics and attitude towards mathematics.

Purposes of the Research

The study aimed to find out the effects of the use of non-math analogies on the students' achievement in and attitude towards mathematics. Specifically, the study sought to:

1. Determine how the use of non-math analogies enhance the academic performance of first year college students in mathematics; and
2. Determine how exposure to non-math analogies changes the students' attitude towards mathematics.

Methodology

Research Design

This study employed a quasi-experimental design, using the nonrandomized (non-equivalent) control group design. The pre- and posttests performance of the non-math analogy and the usual discussion (without non-math analogy) groups in the achievement and attitude tests were compared.

Participants

The participants, with ages ranging from 16 to 17 years, were from two classes of first year students of a college institution in Manila who were enrolled in Enrichment Mathematics, a course on some basic concepts in arithmetic and algebra such as real numbers and fundamental operations. These two groups were identified upon the recommendation of the Admissions Office based on their mathematics scores in the admissions test. Students who got low scores in math were advised to enrol in Enrichment Mathematics. The group assignment was done through lottery. Table 1 below presents the number of participants in each group.

Table 1. Frequency distribution of participants.

Group	Frequency
Non-math analogy group	23
Usual discussion group	26
Total	49

Instruments

The instruments used in the study include the following:

Mathematics Achievement Test (Pretest and Posttest) - This is a researcher-made test which intended to determine if there was a significant difference in the mathematics achievement of the students in the usual discussion and non-math analogy groups. Prior to the conduct of the experiment, this 40-item multiple-choice test was developed and underwent the usual process of content validation by experts, item analysis with the test administered to a group of first year students who were not part of the experiment, and validity and reliability tests with each process done by having different groups of first year student-examinees who were not part of the experiment. The instrument was found to be valid and reliable with the computed validity coefficient of .72 and reliability coefficient of .84.

Attitude towards Mathematics Inventory (ATMI) – This is a 40-item test developed and validated by Tapia and Marsh (1996). The Cronbach alpha coefficient of .97, factor analysis and test-retest results showed the ATMI's good internal consistency and stability over time. Further, three experts were asked to evaluate the instrument to ensure that the test is fitted to the purpose of this research, and it was also pilot tested to thirty freshmen to check internal consistency and to localize the norm. The computed Cronbach alpha is .76 which revealed that all forty items are internally consistent.

Performance Evaluation Form (PEF) – This instrument is a 24-item questionnaire that was used by the college institution to evaluate teacher's competence in terms of mastery, method, medium (80%); classroom management (10%); and personal traits (10%). This was used to ensure that there was no significant difference between the performances of the instructor in teaching the two groups as evaluated by the mathematics area chairman.

Students Evaluation Form (SEF) – This is a survey form used by students of the college institution to evaluate their teachers' instructional skills and competencies (40%); work attitude(30%); and classroom management (30%). This was used to ensure that there was no significant difference between student satisfactions in terms of the way they were taught the topics.

Portfolios – These are compilation of students' experiences and personal reflections on learning the topics.

Lesson plans – These are instructional materials that describe the flow of classroom discussions in the two groups. Below is an excerpt of lesson plans used in each group.

Table 2. Lesson Plans

Non-Math Analogy Lesson Plan	Usual Discussion Lesson Plan
Lesson Proper: ***The Real Number System Using Hierarchy Analogy***	*Lesson Proper:* ***The Real Number System***
Let one or two students discuss in class their research about the organizational structure of the school. Ask the students to choose one office and explain its function. *Elicit an explanation from the students about the importance of the organizational structure in a company or institution.* *After discussing the special task, introduce the new lesson through the "Hierarchy Analogy." Establish the analogy between*	*Start the discussion by asking the students to give any number. As they give a number, write it on the board. Let the students give fraction, decimal, positive and negative integers, zero, and pi or any irrational number.* *Ask the students to group the numbers on the board based on their similarity. Example: 1, 5, 7, 2, -4, -9 are integers; and 2/3, 3/5 , 4/9 are fractions. Tell the students that they may use the numbers more than once to*

the organizational structure and the real number system. Discuss that offices are like sets of numbers since, as they become subordinate of a higher office, their function becomes more specific. Similarly, as a group of numbers become subordinate of a larger set of numbers, they become definite.	*establish another set of numbers. Example: 1, 5, 7 are positive integers; 2, -4, -9 are negative integers. The students may work in dyad.* *From the activity, introduce the new lesson to the students by identifying the different kinds of real numbers.*

Ten lesson plans were developed, and each plan was subjected to content and face validation by mathematics education experts. Table 3 below shows the topics in the plans and the corresponding analogy used.

Table 3. Mathematics content in the lesson plans and the corresponding analogy

Lesson Number	Topic	Analogy Used
1	Basic concepts on sets	Facebook analogy
2	Power set	Ice cream analogy and family analogy
3	Set operations and Venn diagram	Marriage analogy
4	Real number system and properties of whole numbers	Hierarchy analogy
5	Operations on signed numbers	Angels and Demons analogy
6	Divisibility	Free taste analogy
7	Prime factorization	Friendship analogy
8	Greatest comm. factor (GCF) Least common multiple (LCM)	Mutual friends analogy Circle of friends analogy
9	Fractions and simplifying fractions Adding and subtracting fractions	Character analogy Getting to know you analogy
10	Multiplying and dividing fractions	KFC analogy

Data Collection

Phase I - Pre-Experimental.

The Mathematics Achievement Test (MAT) was prepared and validated and, together with the Attitude towards Mathematics Inventory (ATMI), was administered to the two groups. The lesson plans used for both groups were crafted and revisited based on the suggestions given by other mathematics instructors. Finally, the two groups of participants were identified based on the results of the College Admissions Test.

Phase II - Experimental.

The two groups were taught the same topics by the same instructor but using different techniques for eight weeks. Lessons for the non-math analogy group were delivered using non-math analogies while no non-math analogies were used for the usual discussion group. The instructor started the discussion in each group with a sharing of students' personal reflection about the previous learning activity, followed by a short review of the previous topic.

In the non-math analogy group, the instructor introduced every new topic through the prepared analogy. The association of the new topic and the students pre-existing knowledge were clearly written in the lesson plans. On the other hand, in the other group, the instructor taught the lesson without using non-math analogies. Both groups were given pen-and-paper activities after the discussion. The teacher encouraged the students in both groups to participate in board work and oral recitation. The two groups were given the same exercises to facilitate learning. The assessment and evaluation of the two groups were also the same. Students from the two learning groups were asked to write their personal reflections after the discussion.

To ensure that the instructor would not be a threat to the validity of the results, the mathematics area chairman was requested to visit in some of the lectures in both groups. He was asked to fill out the PEF during classroom observations and in evaluating the instructor's performance and students' classroom participation. Likewise, students from both groups were also requested to evaluate the instructor's performance using the SEF.

Moreover, to address ethical issues in the conduct of the experiment, an orientation was held where the nature of the experiment was discussed with the participants, and their consent to participate was sought. Moreover, the participants were assured of their safety and protection while participating in the experiment, and protection of privacy and confidentiality of information about them were guaranteed.

Phase III - Post-Experimental.

A posttest was administered to both groups. The results of the pre and posttests were analyzed to find out the effects of the use of non-math analogy in classroom discussion. The ATMI was re-administered 15 minutes after the posttest. Finally, interviews were conducted with each group to triangulate the students' ratings that they revealed on the SEF and their perceptions on the teaching techniques used by the instructor that they wrote in the portfolios.

Data Analysis

The means of the pre- and posttests, and t-tests for independent samples were computed in order to determine if students' achievement in mathematics was enhanced and their attitudes towards mathematics changed.

Results and Discussion

On Students' Achievement

The MAT pretest mean scores of the two groups were compared to determine the comparability of the two groups in terms of their knowledge prior to the conduct of the treatment. Results are summarized in Table 4.

Table 4. Comparison of the MAT pretest mean scores of the two groups.

Groups	MAT Pretest			
	n	**Mean***	***df***	***p-value***
Non-Math Analogy	23	15.39	47	$p > .05$
Usual Discussion	26	15.00		

** Interpretation: 25-40 (Excellent), 20-24 (Very Satisfactory), 16-19 (Satisfactory), 11-15 (Unsatisfactory), 0-10 (Very Unsatisfactory)*

When the mean scores in the pretests are compared at .05 level, it was found out that there is no significant difference between the mathematics achievement of the students in the usual discussion and non-math analogy groups. This seemingly implies that the students in both groups had the same background in terms of content prior to the experiment.

Further, to determine the significant effect of the treatment, the MAT pre- and posttests mean scores of the students were compared in each group. Results are presented in Table 5.

Table 5. Comparison of the pretest and posttest mean scores in the MAT.

Groups	*n*	Pretest Mean*	Posttest Mean*	*df*	*p-value*
Non-Math Analogy	23	15.39	28.00	22	$p < .05$
Usual Discussion	26	15.00	22.54	25	$p < .05$

** Interpretation: 25-40 (Excellent), 20-24 (Very Satisfactory), 16-19 (Satisfactory), 11-15 (Unsatisfactory), 0-10 (Very Unsatisfactory)*

As Table 4 reveals, the students in the non-math analogy group performed unsatisfactorily or a little below the satisfactory level in the pretest but excellently in the posttest. Furthermore, when the t-test for dependent samples at .05 level was used to compare their mean scores, the result revealed that there is a significant difference between the pretest and posttest mean scores of the students in the math-analogy group. This significant gain in favour of the posttest mean score implies that there was a transfer of learning in the non-math analogy group.

Similarly, the students in the usual discussion group performed unsatisfactorily or 1 point below the satisfactory level in the pretest and very satisfactorily in the posttest. Moreover, a comparison of the mean scores at .05 level revealed that there is a significant difference between their pre- and posttest mean scores. Like the other groups, the difference implies that learning was also significantly achieved by the students in the usual discussion.

For further analysis, the MAT posttest mean scores of the two groups were also compared. The results are summarized in Table 6.

Table 6. Comparison of the MAT pretest and posttest mean scores of the two groups.

Groups	**MAT Posttest**		
	Mean*	***df***	***p-value***
Non-Math Analogy	28.00	47	$p < .05$
Usual Discussion	22.54		

** Interpretation: 25-40 (Excellent), 20-24 (Very Satisfactory), 16-19 (Satisfactory), 11-15 (Unsatisfactory), 0-10 (Very Unsatisfactory)*

It may be gleaned from Table 5 that a comparison of their posttest mean scores at .05 level shows that the students in the non-math analogy group achieved significantly higher than those in the usual discussion group. Thus, it can be inferred that non-math analogy can better improve students' achievement in mathematics than the usual discussion method of teaching.

It may be noted that teaching using non-math analogy begins with what a student already knows brought by their real-life experiences. This supports the idea of Richland, Zur, and Holyoak (2007) and that of Richland and McDonough (2009) that learning is facilitated when it is built on what a student already knows. It seems that a student can grasp new information quickly when teaching begins by comparing the new knowledge with information that is already known. Additionally, some used the analogy in the pen-and-paper tests to recall the lessons, which in turn helped them to remember the concept and the algorithm in solving, and consequently, enabled them to answer the questions. In fact, during the researchers' interview with the students and as what were written on their portfolio, some of them mentioned that they could easily understand the lesson by making the association between the analogy and the topic. In fact, a student claimed, *"Today, we used the Angels and Demons Analogy to understand the confusing part in Algebra. It was satisfying what I learned especially the subtraction part."* This statement suggests that the student seemed to be confused with some procedures in Algebra particularly subtraction, but such confusion was clarified with the use of the Angels and Demons Analogy. Moreover, a student said, *"By the use of Friend-Enemy Analogy used in this lesson, we learned the lesson well. Way back when I was still in high school, it was really hard for me to think if it is positive or negative. But now that our teacher used the analogy, I think fast in the -/+ sign."* These comments seem to illustrate that the concepts related to positive and negative numbers were made clearer to the student with the use of the Friend-Enemy Analogy. This is the same case when a student claimed, *"Today, we discussed about the operations on sets and the laws of sets using Marriage Analogy. The analogy made it easier to understand the topic. It's fun that I knew how to solve word problems using Venn diagram. I'm happy."* The comments are simply saying that understanding the concepts and problem solving that are related to sets seems to be made easier with the use of the Marriage Analogy.

The above quantitative and qualitative data support the researchers' inference that the use of non-math analogies made students better understood the concepts taught by the teacher even though they initially thought that these concepts were confusing and difficult to understand. Following are excerpts from students' reflections that illustrate this kind of thinking.

> "*At first, I thought this lesson is going to be hard, but our teacher explained it very well by using the ice cream analogy."*

> *"Today, we have discussed about the connection of Venn Diagram with operations on sets. At first, I thought I would not understand the lesson, but with the help of the marriage analogy, I was able to understand and answer the exercises our professor prepared. Using analogy is really helpful."*

Notably, as claimed by Sarina and Namukasa (2010), students taught with non-math analogies were observed to have a deeper understanding of concepts they learned. Thus, mathematics became a friendlier subject that they enjoyed and less detached to their own experiences in life. Going back to the results discussed earlier, the significant difference between the pretest and posttest mean scores in the MAT seems to be a manifestation that students better understood the concepts when they were taught using non-math analogies, and this resulted in higher achievement test scores. Likewise, deeper understanding of concepts seems to be one of those that students gained from being taught with non-math analogies as reflected in the excerpts of student responses written above.

On the contrary, students taught without using non-math analogy claimed entirely the opposite of what were claimed by the non-math analogy group. This could be derived from what they wrote in their portfolios. Some of these reflections are quoted below.

> Student 1: *"I understood the topic while our teacher was discussing it, but I easily forgot them when the teacher stopped the discussion."*
>
> Student 2: *"Math really gives me headache. When the teacher was discussing the lesson, I was really listening and jotting down notes. But no matter how hard I tried to recall them during exams, my mind exploded like a firework."*
>
> Student 3: *"Just like the GCF, least common multiple is one of the easiest lessons that we tackled. But again, I forgot everything about it during the exam. It's confusing."*
>
> Student 4: *"The lesson was easy and fun, but I forgot it the following day."*

Claims of Students 1, 2, 3, and 4 give the impression that they seemed to understand the lesson/topic while their teacher was still discussing it. In fact, Student 2 was listening and even writing some notes during discussions. However, when the lesson was over, these students seemingly forgot what transpired during discussions. Actually, Students 2 and 3 even said that during exams, either their minds explode or the concepts become more confusing.

These qualitative data from the usual discussion group further support the evidences that understanding the topic being discussed lasted only while the discussion was still ongoing. Unfortunately, students lost what the teacher had shared with them when the discussion was over. Consequently, it may be inferred that minimal learning occurred with the use of lecture-discussion as compared to the maximized learning that transpired with the use of non-math analogies. This supports the conclusions of Singha, Goswani and Bharali (2012) derived from their study that was related to various problems faced by students in learning mathematics. They concluded that students regard mathematics as too complex to understand and is confusing because there are lots of formulae to memorize.

On Students' Attitudes

The attitude pretest mean scores of the students were compared in each group. The results are presented in Table 7.

Table 7. Comparison of the attitude pretest mean scores of the two groups.

Groups	**Attitude Pretest**			
	n	**Mean**	***df***	***p-value***
Non-Math Analogy	23	2.94	47	$p > .05$
Usual Discussion	26	3.00		

It was found out that, at .05 level, there is no significant difference in the attitude pretest mean scores of the non-math analogy and usual discussion groups. These results seem to imply that the attitudes of the students in the two groups were comparable prior to their exposure to the teaching techniques.

Further, to determine if the treatment had a significant effect on students' attitudes, the researchers looked into the difference between the pre- and posttest mean scores in the attitude test of each group of students. The results are summarized in Table 8.

Table 8. Comparison of the pretest and posttest mean scores in the attitude test.

Groups	**n**	**Pretest Mean**	**Posttest Mean**	***df***	***p-value***
Non-Math Analogy	23	2.94	3.13	22	$p < .05$
Usual Discussion	26	3.00	3.07	25	$p > .05$

Based on Table 7, the mean scores on the attitude of the students in the usual discussion group did not significantly differ at .05 level. This seems to indicate that the usual discussion strategy, (teaching with no non-math analogy) did not influence a positive change in the students' attitude towards mathematics as evidenced by the following excerpts from some journals of the usual discussion group.

Excerpts from the usual discussion group:

"Math really gives me headache. When our teacher discusses the lesson, I really listen and jot down notes. But no matter how hard I try to understand what's happening, my mind explodes like a firework."

"Just like the GCF, least common multiple is one of the easiest lessons that we have tackled. But again, it's confusing and confusing. I really don't like Mathematics."

The quantitative and qualitative data presented above support the claim that mathematics is a difficult subject, and certain people find it less interesting (Ganal & Guiab, 2014). Unfortunately, as mentioned by Farooq and Shah (2008), attitude towards mathematics plays a critical role in learning mathematics as it affects achievement in the said subject.

This concept seems to be the underlying reason why only minimal learning occurred with the use of lecture-discussion as compared to the learning that transpired with the use of non-math analogies. Thus, it may be inferred that the negative attitude of the usual discussion group seems to affect their achievement in mathematics.

Similarly, it was found out that the attitude of students in the non-math analogy group was neutral prior to and after the treatment. However, it is worthwhile to note that the non-math analogy group got a mean score that is significantly higher (at .05 level) in the attitude pretest than in the attitude posttest. This seemingly implies that there was a positive change in the students' attitude towards mathematics when the non-math analogy was used in teaching the lessons. In fact, many students in the non-math analogy group shared to the class that they tend to make their own analogy for a particular topic. Some students even mentioned that, after various non-math analogies were incorporated by their instructor, they find it interesting to make an association between the learned topic and their ordinary life experiences. As revealed by researchers (Adams & Elliot, n.d., para. 3; Corpuz & Salandanan, 2007), analogies made it possible for students to relate to mathematical concepts, thereby reducing their fear and increasing their confidence in mathematics.

Moreover, during interviews, students even claimed that the learning experience they had in class was enjoyable, and they were excited to know a new analogy at every start of the lesson. They mentioned that learning mathematics was made easy through the non-math analogy approach. These claims were consistent with what students from the non-math analogy group wrote in their portfolios, some of which were quoted below.

Excerpts from the non-math analogy group.

"*Today, we discussed about the operations on sets and the laws of sets using the Marriage Analogy. The analogy made it easier to understand the topic. It's fun that I now know how to solve word problems using Venn diagram, unlike before – no Marriage Analogy, so I didn't like it. Now, I'm happy with the analogy.*"

"I had fun and kept on solving when our teacher used the ice cream analogy."

The foregoing suggests that students from the non-math analogy group tended to have a positive change in attitude towards mathematics. It may be because of the good learning experience that they had in class. Their positive attitude made them concentrate on the lesson while enjoying it. This result is supported by Mata, Monteiro and Peixoto (2012) who claimed that emotional disposition in relation to mathematics, as reflected by attitude, dictate one's behaviour to achieve in the subject. Accordingly, a student would probably achieve better in mathematics if he/she enjoys it, has confidence in it, or he/she finds it of value in life. This seems to support the findings mentioned above in relation to the maximized learning that occurred with the non-math analogy group. Their positive attitude towards mathematics, as influenced by the use of non-math analogies, seemed to improve their understanding of the mathematical concepts that they encountered (Adams & Elliot, n.d., para 3). Indeed, it must be wise to engage students in activities that they experience in real life since students more readily internalize and apply concepts or ideas that are relevant to their needs and problems (Corpuz & Salandanan, 2007).

Conclusion and Recommendations

The findings of the study revealed that using non-math analogy in teaching better improves students' achievement in mathematics than using the usual discussion approach. Further, students' learning experiences with non-math analogy seemed to have a positive significant effect on their attitude towards mathematics. Students find learning with non-math analogy easier, more meaningful, and more enjoyable because they could relate the abstract concepts that they discuss to what they experience in real life.

Based on the literature cited above, most students find mathematics difficult to learn, understand, and appreciate because they find the concepts they encounter in learning it are abstract. However, with the findings above, an alternative strategy in teaching mathematics may be used to address this concern. The use of non-math analogy may help students to appreciate and better understand the lessons in mathematics. This strategy could also fill the gaps between what the students need to know and what they already know.

Consequently, the National Center for Teacher Education and other teacher education institutions may expand their Bachelor in Mathematics program to include in a mathematics pedagogy course a discussion of what non-math analogies may be used and how they are used to teach math concepts. Also, the Philippine's department of education may instruct their training providers to include this strategy in training in-service mathematics teachers. As a result of appropriate training, mathematics teachers may use this strategy to improve the teaching-learning process in mathematics.

Finally, considering the benefits of better assimilating mathematics concepts and improving attitude towards mathematics that may be derived from the use of non-math analogies, future researches along this area may be conducted. More non-math analogies in teaching math concepts that students find too abstract may be thought of, and experiments on their effects on achievement in and attitude towards mathematics may be conducted. Also, inasmuch as the experiment was conducted only in eight weeks with just two sections in Enrichment Mathematics and with limited number and nature of participants (e.g., students whose ages are in the range 16 to 17 years and who got low scores in the mathematics component of the entrance exam), it is further recommended that a similar study be conducted in a longer duration and a larger group of participants with varied ability levels in mathematics.

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