Students' Level of Conceptual Understanding in Algebra Using Multi-Modal Learning Strategy

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ABSTRACT

This research was conducted to determine students' level of conceptual understanding of algebra using a multi-modal learning strategy. The researchers involved 42 Grade 7 students from Marawi City National High School in the school year 2019-2020. This study used single-group pre-test-post-test design, a type of pre-experimental research design that uses only one group as an experimental group exposed to a treatment. To gather the necessary data, the participants were given a pre-test and then exposed to a multi-modal strategy for one month. The post-test was administered after the intervention. Participants' scores were tabulated, interpreted, and analyzed using simple frequency, percentage distribution, mean, and t-tests. The results showed that there is a significant difference between the performance of the students as well as their conceptual understanding in the pre-test and post-test. Specifically, their performance improved significantly from fair to satisfactory with a margin of 12 points, and their conceptual understanding improved from low to an average level. In the interview with the participants, they revealed that MMS is an effective strategy and it helped them enhance their performance in solving word problems in Algebra. Hence, teachers are highly encouraged to use innovative strategies using the six modes of representation of the multi-modal strategy.

Keywords: **Multi-modal Strategy, Conceptual Understanding, Level of Conceptual Understanding, Algebra**

I. INTRODUCTION

Mathematics is known as a challenging subject for learners in secondary schools around the world. Students experience difficulty and lack motivation when it comes to learning the subject — thereby affecting their achievement. Learning mathematics is not about providing practice on rote skills and memorization, but is looking at students' thinking ability and abilities to apply what they comprehend to solve a problem. Algebra is a way of thinking that requires students to provide good reasoning and proof. On the other hand, teaching algebra is viewed as one of the most difficult subjects where it constantly involves learning entirely new ways of thinking. It is commonly accepted that math is difficult, obscure, and of little interest to certain people, but some students are not aware that every day of their life is a work of algebra.

One of the specific branches of Mathematics is Algebra, which uses letters and symbols to represent numbers, points, and other objects, as well as the relationships between them. It moves students beyond an emphasis on arithmetic operations to focus on the use of symbols to represent numbers and express mathematical relationships. It is often the first mathematics subject that requires extensive abstract thinking, a challenging new skill for many students.

The goal of mathematics is to provide learners with opportunities to be able to develop mathematical concepts and skills needed for living competitively in this world (Taha, 2016). If students learn how to solve math problems, their logical skills are enhanced; hence, they have a better grasp of how to solve real-life problems.

Problem-solving is an important skill needed not only in a mathematics class but in everyday living as well. Worded problems have been a major part of algebra education for they provide students with opportunities to apply mathematical tools by promoting a link between algebra and real-life context, using problem-solving heuristics, and developing new concepts and skills (Verschaffel, Greer, & Corte, 2000). Problem -solving is not an easy task. It requires effort, styles, proper teaching methods, and appropriate teaching approaches to help the students succeed in problem-solving (Soancatl et al., 2010). Hence, teaching multiple strategies is required in order to improve students' skills in solving word problems in algebra.

Multi-modal teaching is a style in which students learn the material through a number of different sensory modalities. Teachers can use any combination of learning modalities; however, in multi-modal teaching, a teacher must utilize more than one. This teaching style implements many strategies to ensure stu-

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dents understand and retain information. According to Lazear (2011), multi-modal learning means that more information may be learned in different ways. The multi-modal approach may also be integrated with educational technology.

The Multi-Modal Strategy (MMS) is an attempt to translate these modes of representation into a systematic technique for teaching algebra. It focuses on a variety of experiences to make the learning of algebra more enjoyable and challenging for the students (Yoong, 1999). Furthermore, the use of a multi-modal strategy is believed to be a potential strategy for improving the level of thinking skills and conceptual understanding of students in Algebra (Asotigue, 2009). Using different modes of representations in the MMS such as numbers, symbols, diagrams, words, stories, and realia in teaching algebra will enhance students' conceptual understanding in learning about word problems in algebra. Research has shown that learning in multiple ways reinforces knowledge comprehension underlining the need for a multi-modal strategy in the classroom (Lazear, 2008).

It is the goal of this study to help students have a better understanding, appreciate learning algebra in different ways, and eventually improve their performance. This study further aims to help teachers to be more creative in using the Multi-Modal Strategy which uses different modes of representation to cater diverse learners in the classroom.

Statement of the Problem

This study involved the use of Multi-Modal Strategy in teaching algebra among Grade 7 students of Marawi City National High School, Marawi City, Lanao del Sur.

Specifically, it sought to answer the following questions:

1. What is the participants' profile in terms of age, gender, and latest grade in algebra?
2. What is the performance of the participants on the pre-test?
3. What is the performance of the participants on the post-test?
4. What is the level of conceptual understanding of the students?
5. Is there a significant difference between the participants' pre-test and post-test scores before and after the intervention?
6. How does the multi-modal strategy approach enhance the level of conceptual understanding of the students?

II. METHODS AND MATERIALS

This study used the single group pre-test-post-test design, which is a type of pre-experimental research design that uses only one group as an experimental group exposed to a treatment. A pre-test and a post-test are conducted to determine whether there is an improvement in their performance after the application of the treatment. In this study, the multi-modal strategy was the treatment that the experimental group was exposed to.

Among the materials used in the study was a researcher-made questionnaire consisting of two parts. The first part gathered the participants' profiles in terms of age, gender, and latest grade in Algebra and the second part was a 30-item word problem-solving test on Algebraic Expressions written in English. A pilot test was conducted on a different section of Grade 7 students of MCNHS with forty-three (43) participants to measure reliability of the questionnaire. After its validity and reliability were established, it was then used as the final instrument of the study during the pre-test and the post-test.

Another material used was a set of lesson plans that covered the topic of Algebraic Expressions. The lesson plans were checked and validated by the researcher's thesis committee before they were adopted for use.

Data Gathering Procedure

The researchers first asked permission from the principal of Marawi City National High School and secured the informed consent of the Grade 7 teacher in Algebra to distribute the researcher-made questionnaires. The two-part questionnaire gathered the participants' profiles in terms of age, gender, and latest grade in Mathematics, followed by a 30-item word problem-solving test on Algebraic Expressions. Upon approval, the pretest was administered at the Marawi City National High School to determine the initial level of conceptual understanding of the students prior to the appreciation of the six modes of representation, the Multi-modal Strategy which are number, symbol, diagram, word, story, and real thing. After the pre-test, the intervention officially started.

The researchers introduced the use of a multi-modal strategy in learning algebra and the process representation in solving word problems. It lasted for eleven (11) days by 2-day interval, which is equivalent to two (2) hours and twenty-five (25) minutes per MMS session, an overall of twenty-five (25) hours of sessions. A post-test was administered after the inter-

vention. Throughout the data collection, the researchers assisted the participants in accomplishing the instruments so that they would follow the instructions.

III. RESULTS AND DISCUSSION

Participants' Profile

Table 1- Distribution of the Participants' Age

Gender	Frequency	Percent
Male	19	45.2
Female	23	54.8
Total	**42**	**100.0**

Table 1 shows the frequency distribution of the participants' ages. As seen in the table, many of the participants (16 or 38.1%) were 13 years old. The ages 10, 11, 12, and 17 years old represented the least number of respondents, while the majority included 13- to 16-year-old students.

The result implies that the average age is aligned with the age range of junior high school students starting from 12 to 15 years old (DepEd, 2012). However, there were still a few who were too young or too old for their grade level. According to Aragasi & Mangondaya (2016), as cited by Ampuan & Nahder, 2019), most students may understand the lessons better since their minds are developed in terms of maturity. If the age of the student is not appropriate for their grade level, it may have relative effects on their academic performance. According to Khun and Touron (2019), aging and cognitive skill learning are concerned with age-related changes and differences in how we gather, store, and use information and abilities. Hence, the student may be a slow learner if they enter school at a very young age and it will be hard for them to adjust to new things. The student may also be a fast or advanced learner if they are old for their grade level and can adapt to new things easily.

Table 2 - Distribution of the Participants' Gender

Age	Frequency	Percent
10 years old	1	2.4
11 years old	1	2.4
12 years old	2	4.8
13 years old	16	38.1
14 years old	6	14.3
15 years old	6	14.3
16 years old	6	14.3
17 years old	4	9.5
Total	**42**	**100.0**

As shown in Table 2 above, out of forty-two (42) participants, nineteen (19), or 45.2% were male, and twenty-three (23), or 54.8% were female. This implies the sample from Marawi City National High School was dominated by females. It was also noted that, during the class sessions, most of the female students were seated in the middle while the male was seated on both sides of the classroom. It was their sitting arrangement prepared by their teacher to maintain classroom management. According to Gonzales (1997, as cited by Hadjinor & Pangandaman, 2019), the abundance of women in the Philippines is naturally ongoing. Around 86% of the total percentage of females surveyed in both public and private schools. It showed that the female-to-male ratio in both public and private schools had a high difference.

However, it is still uncertain which gender performs better in algebra. According to Felson (1991), gender may not be a factor in algebra performance as there was no evidence of gender effects on parental encouragement in mathematics, and girls' anxiety about algebra reflects general test anxiety rather than any special fear of algebra.

Table 3 - Distribution of the Participants' Latest Grade in Mathematics

Grade	Qualitative Description	Frequency	Percent
76	Passing	9	21.4
75	Passing	1	2.4
77	Passing	2	4.8
78	Passing	7	16.7
79	Passing	5	11.9
80	Passing	6	14.3
81	Fair or Satisfactory	3	7.1
82	Fair or Satisfactory	2	4.8
83	Fair or Satisfactory	4	9.5
85	Fair or Satisfactory	1	2.4
74	Failed	2	4.8
Total		**42**	**100.0**

Scaling:

98 and above - Excellent	81 – 86 - Fair/Satisfactory
93 – 97 - Very Good	75 – 80 - Passing
87 – 92 - Good	74 and below - Failed

Table 3 shows the distribution of the participants' latest grades in Algebra. As shown in the table above, nine (9) or 21.4% of the sample got 76 mark in Algebra. This is followed by 78 with 7 or 16.7%, 80 with 6 or 14.3%; and 79 with 5 or 11.9%. Overall, 95% of the respondents passed their Algebra subject. However, majority of them only incurred a passing grade while very few reached fair or satisfactory.

Mastur and Mustapha (2010, as cited by Hadjinor & Pangandamun, 2019), noted that the poor performance of the students in Algebra can be traced back to their previous lower-level schooling due to the lack

of basic mathematical concepts and solving basic problems. Some learners' difficulties were due to teachers who did not understand the basics of planning and executing instruction.

As shown, most of the participants of MCNHS only had a passing remark in their Algebra subject. This calls for an intervention that aims to improve their performance effectively. It could be a strategy that would cater to their individual learning needs and would fill the gap created by their previous schooling.

Pre-Test Performance of the Participants

Table 4 - Distribution of Participants' Performance Profiles on the Pre-Test

Score	Transmuted Grade	*f*	%	Mean Score	Qualitative Description
4	56.67	2	4.8		
5	58.33	2	4.8		
6	60	5	11.9		
7	61.67	2	4.8		
8	63.33	6	14.3	8.9286 / 64.8805	*Failed*
9	65	7	16.7		
10	66.67	5	11.9		
11	68.33	8	19		
12	70	3	7.1		
13	71.67	1	2.4		
15	75	1	2.4		
Total		42	100		

Scaling:

98 and above - Excellent	81 – 86 - Fair/Satisfactory
93 – 97 - Very Good	75 – 80 - Passing
87 – 92 - Good	74 and below - Failed

Table 4 shows the performance of the participants in solving word problems before exposure to the use of the Multi-Modal Strategy. As presented, the overall transmuted grade of 64.8805 with a mean score of 8.9286 means that a large majority of the participants failed the pre-test. This implies that perhaps the participants were having a hard time understanding the situational meaning of the word problems and translating them into equations due to their conceptual understanding.

According to their teacher, the participants had a low performance in Algebra due to the lack of resources and strategies to enhance the learning process of the participants. The researchers found that the participants had low performances in the pre-test as attributed to their poorly or fairly satisfactory performance in their previous Algebra subject which signifies that they lacked prior knowledge and mastery of the concepts in the subject.

Post-Test Performance of the Participants

Table 5 - Distribution of Participants' Performance Profiles on the Post-Test

Score	Transmuted Grade	*f*	%	Mean Score	Qualitative Description
15	75	1	2.4		
16	76.67	2	4.8		
17	78.33	3	7.1		
18	80	5	11.9		
19	81.67	3	7.1	20.9286/ 84.8810	*Fair/ Satisfac-tory*
20	83.33	4	9.5		
21	85	5	11.9		
22	86.67	5	11.9		
23	88.33	4	9.5		
24	90	6	14.3		
25	91.67	2	4.8		
Total		42	100		

Scaling:

98 and above - Excellent	81 – 86 - Fair/Satisfactory
93 – 97 - Very Good	75 – 80 - Passing
87 – 92 - Good	74 and below - Failed

Table 5 shows the performance of the participants in solving word problems after their exposure to Multi -modal Strategy. As seen in this table, participants obtained an overall transmuted grade of 84.8810 with a mean score of 20.9286, which means that all of the participants passed the post-test. This finding implies that after using the six modalities of multi-modal strategy in learning Algebra, the participants' post-test results improved in general. Perhaps, the use of a Multi-Modal Strategy (MMS) or the six modalities (number, symbol, word, story, real thing, and diagram) in teaching algebra helped the students to improve their performance in solving word problems, since it made teaching word problems in Algebra more creative, innovative and understandable.

The gained result signifies that the strategy used was effective in improving the participants' conceptual understanding of solving word problems in Algebra. Moreover, the data revealed a great development in the students' performances after the intervention as evidenced by obtaining fairly satisfactory remarks in their post-test.

This is supported by Yoong (1999) as cited by Asotigue (2009), who claimed that the multi-modal framework creates flexible connections among the six modes of representation (number, symbol, word, story, real thing, and diagram) of the same piece of Algebra so that the students can pose and solve real and meaningful problems.

Participants' Level of Conceptual Understanding

Table 6 - Level of Conceptual Understanding of the Participant's Pre-Test and Post-Test

Level of Conceptual Understanding	Pre-Test			Post-Test		
	f	%	Mean Value	*f*	%	Mean Value
High	0	0		14	33.3	
Average	1	2.4	Low	28	66.7	Average
Low	41	97.6		0	0	

Scaling:
14-17 -High level of conceptual understanding
9-13 -Average level of conceptual understanding
0-8 -Low level of conceptual understanding

Table 6 presents the students' level of conceptual understanding of Algebra in the pre-test and post-test. The table above shows that 41 or 97.6% of the participants in the pre-test had a low level of conceptual understanding. Only one or 2.4% had an average level while none of the participants had a high level of conceptual understanding. In the post-test, none had a low level of conceptual understanding, 28 or 66.7% of the participants had an average level, and 14 or 33.3% possessed a high level of conceptual understanding of the course. In general, there is an observed improvement in the students' conceptual understanding of Algebra after their exposure to the multi-modal strategy.

Before the intervention, the student's level of conceptual understanding was low, which suggests that they had difficulties in understanding Algebra concepts as evidenced by the result of their pre-test. The participants' math teacher informed the researchers that majority of students had poor performance, especially in solving word problems in Algebra. The teacher added that the lack of resources and strategies to cater to the diversity of students had been a challenging problem.

According to Gaigher, Rogan, and Braun (2007), as cited by Asotigue (2009), success in calculating correct numerical answers do not necessarily imply that a corresponding level of conceptual understanding was revealed. Conceptual understanding is developed through a multi-modal approach that includes activities, the use of substitution and diagrams, trial and error, the notion of "reasonableness of answers", communication in various forms, discussion in cooperative settings, and use of problems that relate to contexts that are meaningful to students.

Hence, the teachers' ability and creativity help the learning and understanding on the part of the students. Problems should be presented in different forms, such as open-ended questions which can be used to promote divergent thinking.

Table 7 - Significance Difference between Participants' Pre-Test and Post-Test Scores

Group	Means Score	Qualitative Rating	*p*-value	Interpretation	Action Taken
Pre-Test	8.9286	Failed	0.000	Significant	Reject H_o
Post-Test	20.9286	Fair/ Satisfactory			

Table 7 shows the t-test analysis of the participants' pre-test and post-test scores in solving word problems. The findings showed that the p-value is less than 0.05 level of significance. Therefore, there is a significant difference between the pre-test and the post-test scores of the participants. This means that the use of Multi-modal Strategy (MMS) in teaching algebra significantly improved the performance of the participants. As shown, the pre-test showed all of the participants got failed remarks. When the participants were taught using the six (6) modalities of representation, the participants got a fair or satisfactory remark in the post-test. When composed can be seen that there is a great difference between the two scores, which is 12 points.

This finding was supported by Cagas (1998, as cited by Asotigue, 2009), that there are many proposals made by some researchers and educators for the reform of Algebra education. Its ultimate goal is to raise the achievement in Algebra with more emphasis on conceptual understanding. It shows that a Multi-modal Strategy (MMS) could be included in these reforms because it can improve the performance of the participants in terms of solving word problems.

Participants' View on the Use of Multi-Modal Strategy in Learning Algebra

Interviews with selected three (3) participants held out substantial information about the use of MMS. They played a vital role in clarifying and supporting the quantitative data gathered in the quasi-experiment.

The purpose of the interviews were to gather data that were not directly observed during the relevant data that would support the findings of the study. The researchers asked permission from the selected partic-

ipants to interview them. The face-to-face interview with the participants was recorded by taking down notes and voice recording. Additional data collection tools were used when necessary, such as a camera for taking pictures with the participants during the interview. After the interview, answers were analyzed thematically to determine and categorize the ideas of the participants.

Below are some of the responses of the participants to the questions provided when asked about how multi-modal strategy helped them in learning to solve word problems:

Participant 1: *"Ma'am actually na so multi-modal strategy mapiya, mapiyo so barambarang so dinyo dikandiscuss ko kapagsolve sa word problem, miyasowa akn so kasolve ron lagid o division sa polynomial (Ma'am, the multi-modal strategy that you used is actually very good. The different ways of teaching word problems were very understandable just like in solving division of polynomials)"*

Participant 2: *"Ma'am malbod sabotun so kapamangdaw niyo kiya clear ago dikaminiyo kasi so mga strategy (Ma'am, it was easy to understand the way you teach. It was so clear because of the different ways that you used)"*

Participant 3: *"At first hindi ako marunong mag solve ng solving word problem pero ngayon natutunan ko po kasi iba't iba ang way ng pagtuturo niyo sa amin paano simulan parang pinasimple niyo yong dating tinutoro sa amin na napakahirap yong minsan parang story telling tayo (At first, I did not know how to solve word problems. I've learned since you taught us the different ways on how to start solving it. It is as if you made it simple and felt like you were telling us stories)"*

The majority of the participants shared that they found the Multi-Modal Strategy helpful in understanding concepts in solving word problems. Below are some of the responses of the participants to the questions provided when asked about how the Multi-Modal Strategy helped them enhance their problem solving skills:

Participant 1*: "Ma'am mas nadagdagan yong kaalaman akn sa pagsosolve sa probem sa math poon sa multi-modal strategy a inosar iyo sa kiyapangdaawa niyo rkami (Ma'am, it enhanced my knowledge about solving problems in Math because of the multi-modal strategy that you used to teach us)"*

Participant 2: *"Ma'am lumawak yong kaalaman ko about sa pagsolve sa math dahil sa mga strategy nyo po, kasi ma'am, ka aaply ko mga pud a problem a ipumgay rkami e sir (Ma'am, it broadened my knowledge about solving Math [problems] because of the different strategies that you used. It will be useful for the problems that will be given by our teacher)"*

Participant 3: *"Ma'am first time ami kasi a mapamangdao rkami sa math about sa kasolve sa word problem, dati kasi ma'am nah diakn type so kasolve sa word problem ka maregen (Ma'am, this was the first time that we have a student-teacher who taught us about solving word problems. I really don't like studying Math because it is so difficult)"*

The majority of the participants shared that they found the Multi-Modal Strategy helpful in understanding concepts in solving word problems. In line with this, the researchers observed that the participants were willing to learn due to the reason that the strategy used in their learning contributes a lot to motivate the learners in solving word problems in Algebra. This proved that the six modalities of representation (number, symbol, word, diagram, story, and real thing) were effective as a strategy for the students to have an interest in Algebra.

According to Yong (1999, as cited by Asotigue, 2009), the multi-modal framework fosters flexible connections among multiple modes of representation of the same piece of mathematics so that the students can pose and solve real and meaningful problems. Thus, instruction is not limited to the predominantly symbolic mode, which is a serious obstacle to learning for many students. Hence, the use of a Multi-Modal strategy in learning algebra could increase students' interest in solving real and meaningful problems.

Almost all of the interviewees shared that the Multi-Modal Strategy enhanced their skills in solving word problems. However, the researchers observed during the conduct of the experiment that they encountered difficulties in solving word problems. The participants are unaware of some mathematical skills and techniques to be used in word problem-solving in mathematics. According to Lester (1980, as cited by Dansal & Meris, 2005), the usage of various types of problems, the definition of problem-solving in different manners, and the complexity of problem-solving procedures have confused the generalization of the research subjects. Thus, mathematical problem-solving requires knowledge of skillful definition and analysis.

Considering the views of the participants, the use of the Multi-Modal Strategy in learning Algebra was indeed helpful to the student's learning because it enhanced their skills in solving difficult word problems, particularly analyzing and interpreting definitions.

IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The study aimed to see the effectiveness of using the Multi-Modal Strategy in improving students' conceptual understanding and problem-solving performance in Algebra. Based on the results, the researchers found that solving word problems in algebra needs deep understanding to get better results. It was seen in the outcome of the pre-test that most of the participants got a failing remark because they were unable to analyze and understand the concept of solving word problems. With the findings, this study concludes that the use of the Multi-Modal Strategy has significantly improved the conceptual understanding of the participants. The result of their grades in mathematics showed that they had low performance in Algebra and that they failed the pre-test given by the researchers. However, after the intervention, the participants improved and passed the post-test with a satisfactory remark. The major difference between the pre-test and post-test is clear evidence that there is progress after the intervention and that the MMS is effective for them.

Furthermore, the interview data fortified the positive effects of the Multi-Modal Strategy as previously as revealed in the experiment. According to the interview, the participants found the MMS as an effective strategy and it helped them enhance their performance and understanding in solving word problems in Algebra.

Recommendations

In line with the findings and conclusion of this study, the researchers recommend that students should empower themselves to enhance their conceptual understanding in Algebra and enhance their performance by spending time learning in Mathematics not only at school but also at home. Teachers should not limit themselves to a single strategy, but instead, be creative in using different strategies to enhance students' interests and performances in Algebra. Parents and guardians should always motivate and support their children to improve their skills in solving word problems in Algebra. School administrators should adhere to the standards in the selection of qualified and innovative teachers. They must implement effective programs and provide more materials for the students to perform well in their academics. Curriculum developers should develop curricula and programs by incorporating activities that facilitate learning. They can consider using a multi-modal strategy as one of the ways of teaching mathematical concepts. Future researchers should conduct more studies related to students' level of conceptual understanding using the Multi-Modal Strategy in learning algebra or replicate and continue this study in a different context.

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