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Research Article

# Numeracy Assessment Tool to Learners' Conceptualization of Quadratic Equations among Grade 9 Learners

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**ABSTRACT**

Mathematics proficiency starts at conceptual understanding, wherein learners are expected to absorb the knowledge about the relationships or foundational ideas of a certain topic. However, teachers observed that learners have difficulty in this strand. With this, DepEd IV-A Mathematics Department devised a systematic examination known as Numeracy Assessment Tool. This study aimed to identify the effect of the Numeracy Assessment Tool on the learners' conceptualization of Quadratic Equations. Participants of the study were underachieving Grade 9 learners of Cuenca NHS, which were chosen through Purposive Sampling. The study employed One Group Pretest-Posttest Design. The pre-and post-test results underwent various statistical treatments such as Frequency, Mean, and T-test Method to identify the significance of the results. The group underwent eight sessions in which they were taught lessons on Mathematics. Based on the results, it was found that the use of numeracy assessment tool has a significant effect in developing the students' conceptual understanding of quadratic equations.

## INTRODUCTION

Students consider mathematics as a challenging subject. While numeracy is proven to be a necessary life skill (SEI-DOST, 2011), learners tend to look at mathematics as a horrific and strenuous subject. Most of the time, it is regarded as a death-defying subject. These negative attitudes, rather than the lack of innate talent, are at the root of the numeracy crisis, according to National Numeracy (2014).

Numeracy is defined by the National Numeracy (2014) as "the capability to use numbers and solve problems in real life." It is about having the confidence and the skill to utilize numbers and mathematical approaches in life. It is the ability to utilize the learned concepts to solve problems in a real-world scenario.

The Philippine educational system aims to mold learners who are not only numerate but also mathematically proficient. As discussed in the book "Adding It Up" by the National Research Council (2001, as cited in Garg, 2017), mathematical proficiency comprises five strands that an individual goes through. Conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition are the strands of mathematical proficiency. At the lowest level, learners are expected to absorb

the knowledge about the relationships or foundational ideas of a certain topic. This includes forming their definition of a new concept and giving examples as presented in many ways. The next level, which is the beginning of attaining proficiency in Mathematics. is applying the concept in solving word problems.

Knowing that a mathematical concept is the 'why' or 'big idea' of mathematics, a student knows the workings behind the answer. One will know the reason for getting the answer without memorizing answers or formulas to figure them out. Understanding a mathematical concept is like reaching the upper tier in mathematics, allowing one to rationalize and process abstractly ("What is a Math Concept?", 2019) . Conceptual understanding is the ability to comprehend mathematical concepts, operations, and relations. It is also an integrated and functional grasp of mathematical ideas (Smith & Freels, 2017). A person is said to have a conceptual knowledge in mathematics if he/she can represent mathematical situations in diverse ways and know how various representations can be useful for a plethora of purposes (NRC, 2001 as cited in Awofala, 2017).

Under the strand of Conceptual Understanding on mathematical proficiency, concepts must be defined by the learner. A concept is a notion or image that an individual comes up with when thinking of some groups of related thoughts or ideas. These are mental categories for facts, objects, events, people, ideas – even skills and competencies – that have a common set of features across multiple situations and contexts (Elsevier Evolve, 2019). The process of defining a concept is called conceptualization which involves writing out clear and concise definitions. Conceptualization might be simple as merely applying any random definition given to a term that involves some initial brainstorming, but it goes beyond that (Saylor Academy, n.d.). Conceptualization is a complex process that involves concept formation, conceptual thinking, and conceptual classification. Hunt (n.d.), in his article in Encyclopedia Britannica, defined and classified each process of conceptualization. First is concept formation, a process in which a person learns to categorize detailed experiences and draws out universal rules. Mindfulness of such rules/generalizations serves as a guide in new situations. The second is conceptual thinking which refers to the individual's subjective manipulation of those abstract rules. A concept is a ruling that can be used in deciding if a particular object falls under a specific class.

In some cases, scientific or mathematical concepts are difficult to understand until they have been defined using familiar terms. With that, concept formation is being built. Lastly is the conceptual classification that contrasts another type of classification behavior known as discrimination learning. Under discrimination learning, things are categorized based on the perceived properties such as size or shape. The emphasis on the concrete physical features in it contrasts with the more abstract nature of concept formation.

For a clear conceptual understanding of the lesson, there is a need to have a two-step concept learn-

ing process. First is the unearthing of which qualities are pertinent. The second is the detection of how they are related. This two-step interpretation assumes that the individual has learned the rules. Concepts do not need to be limited to simple groupings. They also can be interpreted as models or rules that reflect critical potentials for change. Concepts provide a basis in deciding if certain alterations will have substantial effects. In that case, conceptual learning becomes helpful. It is an educational method that is anchored on big-picture ideas and learning how to catalog information. It also emphasizes understanding larger principles or ideas that can later be useful to various definite examples (Elsevier Evolve, 2019).

As an entry point to grade 9, quadratic equations were the first topic of the first quarter. Learners are prompted with new concepts that pose challenges to their prior knowledge. They are tasked to recall the concepts like operations on integers, properties of equality, special products, etc. All of which are used in a single word problem. Based on observation, most learners hardly recall the previous topics. This dilemma poses a threat to attaining the required competency on a given day as the time devoted for recall or review becomes greater than the lesson proper. While most students end up identifying the concept, some still get stuck and need further guidance. These learners are referred to as 'underachieving'' in mathematics.

Underachievement describes a situation wherein one's performance is below what is expected based on ability. It can be applied at the level of an individual pupil or describe a class or school, or indeed a system. Low achievement differs from underachievement. A learner is low achieving if he/she is achieving to the full extent of her or his ability but is well below average compared to her or his peers (Department of Education, 2011 as cited by Northern Ireland Signature Project for Literacy and Numeracy, 2012). Underachieving in mathematics is inequitable to being not good at numbers or innumeracy. There are topics or lessons which are difficult to grasp, especially when the foundation is too weak or when a student falls under certain circumstances or conditions at the time of the assessment. To address this concern, this paper was conceptualized.

The Centre for Education Statistics and Evaluation Australia (2016) emphasized that for schools to ensure that all students achieve their potential in numeracy, there should be a systematic implementation of targeted teaching. Targeted teaching refers to methods used by teachers to improve the performance of students who are many years behind and to challenge students who are already well ahead of year-level expectations. In line with this, the Department of Education Region IV-A CALABARZON's Mathematics Department devised a systematic examination in Mathematics known as Numeracy Assessment Tool. It aims to elevate the numeracy level of learners while assessing their numerical ability and evaluating their understanding of the key concepts, principles, standards, and competencies in Mathematics. The test is primarily used to determine the level of numeracy of each learner (Villanueva, n.d.) and is used as a reme-

dial of an advancement activity. It also aids the teachers in making informed and appropriate decisions on the kinds of teaching materials, methods, and programs that are most suitable for the learners.

The Tool consists of three phases and is delivered differently in various media. The first phase is a written examination which is given to all students. The second phase serves as remedial for those learners who attained 79% and below is done by answering the problem or questions through an e-game. The third phase involves learners who still received 79% and below in the second phase. This phase is done through oral questioning, wherein the learner's time of response is recorded. This continues for several attempts until the learner reaches the 'Approaching Proficiency' level or a percentage of 80.

Mathematics, which is a subject offered from primary school to university level, is a challenging subject for most students, according to Shafie, Shahdanb & Liew (2010, as cited in Magayon & Tan, 2016). Moreover, most Filipinos tend to hate mathematics, and they even claim that it is not one of their favorite subjects in school, as Lim (2015) affirmed.

In his article on revolutionizing mathematics and science education, Garces (2008, as cited in Villanueva, n.d.) emphasized that Mathematics is a continuous process that builds on prerequisite skills. Learning math is sequential; hence, each lesson must be understood. If students missed a concept, then they may also miss a part of the succeeding concepts. This will only create a greater domino effect if not solved earlier. Students are encouraged to work independently to develop speed and confidence in their work. Several studies supported that a good foundation on basic mathematical concepts increases the numeracy rate of countries (Estonanto et al., 2017). In her article on math mastery, Lee-Chua (2011, as cited in Villanueva, n.d.) agreed that the characteristic of the New Mathematics was the spiral approach where the same sequence of many different topics was followed annually but with growing complexity.

According to Watson & Gable (2012), mathematics authorities emphasize attaining mathematics' conceptual understanding and procedural skills that encompass various cognitive processes. This includes constructing representations, creating arguments, reasoning about mathematical objects, explaining their thinking, and constructing proofs, among others (as cited in Magayon & Tan, 2016). However, Grigg, Kelly, Gamoran, and Borman (2013, as cited in Magayon & Tan, 2016) believed that teaching practices influence students' achievement. In the Philippines, schools normally teach mathematics through extensive drills and rote memorization methods, which are ineffective and unenjoyable for young learners (Lim, 2015).

On the Trends International Mathematics and Science Study (TIMSS), the Philippines ranked 39th among the 41 participating international countries (Mullis et al., 2007 cited in Cordova & Tan, 2018). Cordova & Tan (2018) said that this only shows that

Filipino learners could not go beyond simple recall

McNaught and Hoyne (2011, as cited in Brady, n.d.) had examined the issues associated with students in university who are lacking skills in even basic and simple mathematics. In their study, they identified the factors that have arisen in this situation. It was found that students nowadays are completing less and less rigorous mathematics courses in their senior secondary education, with many studying no mathematics at all. Moreover, it was found that the current generation of learners has become more calculator-dependent. They now lack some mental mathematical skills and the ability to reason and analyze without using technology.

With these pressing concerns on building concepts and making them relevant, Safer and Fleischman (2006, as cited in Villanueva, n.d.) said that educators need tools to help them identify students who are at risk academically. Moreover, they need instructional strategies to meet those needs better. Bottge et al. (2006) believed that for students, learning takes place when instructional methods and materials are motivating and appropriate (as cited by Villanueva, n.d.). This was proven in the study of Reis and Boeve (2009, as cited by Magayon & Tan, 2016), which found that when students are given a chance to select their content-based reading resources on their area of interest, they can read more appropriately. When teachers provide flexibility in solving practical math problems in number sense activities, they encourage students to use their critical thinking (Yang & Ru Wu, 2010 as Magayon & Tan, 2016).

It is important to note that the primary goal of mathematics education in the Philippines is to develop mathematically empowered citizens (SEI-DOST, 2011). Hence, a way to uplift the educational struggle in mathematics of learners is needed. In this case, the numeracy assessment tool is seen to be one of the activities that may be used in creating a better mathematical conceptualization of learners in Mathematics.

This study was conceptualized to address the pressing concern on the difficulty of learners on the conceptualization of quadratic equations and the availability of an emerging tool for numeracy.

The study aims to identify Numeracy Assessment Tools' significant effect on the learners' conceptualization of Quadratic Equations. Specifically, it seeks to answer the following questions:

1. What is the learner's pre-test mean score in conceptualizing quadratic equations?
2. What is the learner's mean score in conceptualizing quadratic equations based on the post-test?
3. Is there a significant difference in the learner's mean score before and after administering numeracy tools?
4. What output can be derived from the results?

## MATERIALS AND METHODS

The participants of the study were the underachieving Grade 9 learners of Cuenca National High

School in the School Year 2019-2020. They were chosen through Purposive Sampling. Fifty participants were taken based on their pre-test results. These participants scored below 30% of the total score in the conducted pre-test.

Confidentiality of the respondents and their responses was primarily considered through informing the Principal about the conduct of the study. Upon allowing, parents were informed about the study through a letter with the author's complete information and contact details with his signature as endorsed by the Principal. Attached with the letter was a permission slip that asked their permission to allow their children to partake in the study. A week was given to the parents to give their consent. After completing the permission slips, learners were allowed to stay for an hour to take the remedial class. The author considered the confidentiality of the learners by strictly following Republic Act No. 10173 also known as the Data Privacy Act of 2012, in which no names, pictures, or signatures of the participants were mentioned within the conduct and presentation of this endeavor. All data gathered underwent anonymity upon processing by utilizing codes for each learner, and all outputs were only handled and kept by the learners themselves for security.

This study employed the One-Group Pre-test-Posttest Design wherein the group of learners was given a pre-test to identify their proficiency level. The group underwent eight sessions in which they were taught the following lessons: (1) Introduction to quadraitc equations), (2) Solving quadratic equation by Extracting the Square Root, (3) Solving quadratic equation by Factoring, (4) Solving quadratic equation by Completing the Square and (5) Solving quadratic equation by Using Quadratic Formula. Each session was completed in an hour and was conducted through a face-to-face modality. At the end of each session, students were assessed through the numeracy assessment tool utilizing Phase 1 or the written format. Students who attained 79% and below underwent Phase 2 or through the e-games of the tool administration. In the 8th session, they were given a post-test. The pre- and post-test examinations included a ten-item test which was taken from the standardized summative test for grade 9 learners utilized by the school.

The pre-and post-test results underwent various statistical treatments such as Frequency, Mean, and t-test Method to identify the significance of the results. Frequency was used in presenting the numbers of learners who attained a certain score in their pre-and post-test. The mean was used in solving for the population's and the sample's average score. The T-test method was used in determining the significant difference between the pre- and post-test scores of the learners.

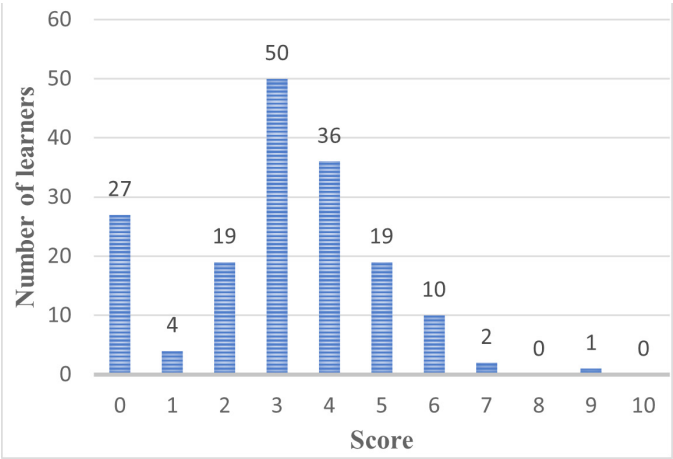
## RESULTS AND DISCUSSION

Based on the data gathered from the respondents, the following were the salient findings of the study.

Figure 1 shows the pre-test scores of the 168 learners of Grade 9 for the S.Y. 2019-2020. The population

mean score is 3.06, which means that the population scores an average of three out of 10 on the pretest.

**Figure 1. Population Pre Test Scores**



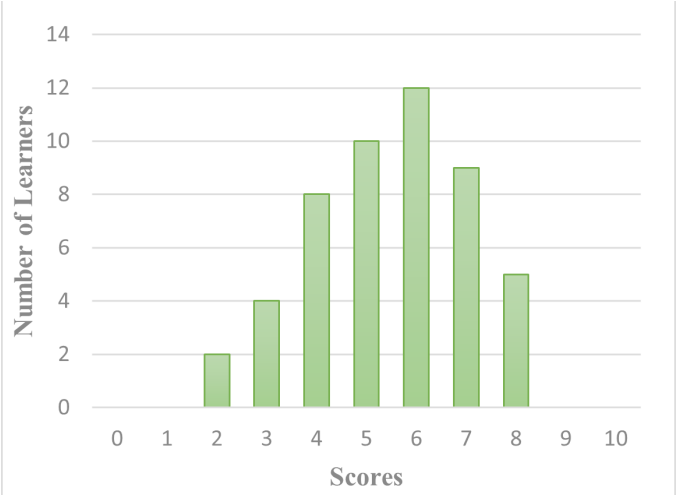

The study participants were taken from those on the lowest end of the test and who got scores of zero, one, and two with 50 learners, which are all below the population mean score. The sample mean score is 0.84, which means a score of one out of 10 was the average score of the sample. Compared to the population mean score, the sample mean score is one-fourth or 27% of the scores. This shows that the sample showed difficulty on the test or has little idea of the topic.

The result of the pretest was found similar with Cordova and Tan (2018) in their study as Grade 9 learners were categorized under the beginning level in mathematical proficiency. This implies that they can do basic arithmetic for their grade level. According to Moradi and Amiripour (2017), academic underachievement in math was due to reluctance and low interest in learning math. It is found to be due to the abstract nature of mathematics and the intangibility of its concepts. It was supported by Arcallana, Etcuban, Dinauanao and Macugay (2018) that their performance in mathematics was related to their age, previous grades in math, and attitudes towards mathematics.

However, Baring, and Alegre (2019) found that attitudes, profile, and teacher competency did not contribute to the learners' difficulty. The difficulty that the learners experienced was completely due to the topic of quadratic equations alone.

Underachievement in Mathematics was observed in the 2018 Programme for International Student Assessment (PISA) which placed the Philippines in 78th among 79 countries in Mathematics (Orbeta, Melad, & Potestad, 2020).

**Figure 2. Participants' Post Test Scores**




It can be gleaned from Figure 2 that the participants garnered a better score on the posttest, with most of them scoring a five, six, or seven. A significant increase in the mean score of the participants from 0.84 to 5.46 was also observable.

A similar result was found with Dumigsi and Cabrella's (2019) study in the use of intervention materials in which Grade 9 learners showed a satisfactory performance remediated by the strategic intervention materials. It only proves that using intervention and remediation materials like numeracy assessment tools help learners to perform better in Mathematics.

**Table 1. Comparison of Pre-test and Post-test using T-test**

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 0.84 | 5.46 |
| Variance | 0.912653061 | 2.539184 |
| Observations | 50 | 50 |
| Pooled Variance | 1.725918367 | |
| Hypothesized Mean Difference | 0 | |
| df | 98 | |
| t Stat | -17.58335946 | |
| P(T<=t) one-tail | 2.25652E-32 | |
| t Critical one-tail | 1.660551217 | |
| P(T<=t) two-tail | 4.51304E-32 | |
| t Critical two-tail | 1.984467455 | |

When the results were compared on the participant's pre- and posttest, with a p-value of 4.5×10-32 as shown in Table 1, which is less than 0.05, it was found out that there is a significant difference between the pre-and posttest scores. It implies a significant effect on numeracy assessment tools in developing the learners' conceptual understanding of quadratic equations. Baring and Alegre (2019) emphasized the need to have instructional materials like numeracy assessment tools that could enhance learners' skills regarding quadratic equations. Kabar (2018) also provided lessons that can help learners in understanding quadratic equations procedurally and conceptually.

With these results, an action plan was created. The action plan involves a standardized numeracy assessment tool to be given to underachieving learners as part of the remedial activity and its equivalent e-game.

## CONCLUSION AND RECOMMENDATIONS

Based on the pretest given to the entire population of Grade 9 for the S.Y. 2019-2020, they obtained a mean score of 3.06 which means that they scored an average of three out of 10 on the pretest. Those below the mean score became part of the sample. The sample mean score is 0.84, which means that they scored barely one out of 10. The participants of the study showed difficulty on the test or had little or no idea about of the topic.

When intervention through numeracy assessment tools and e-games were provided, the participants garnered a better score on the posttest, with most of them scoring a five, six, or seven. A significant increase in the mean score of the participants from 0.84 to 5.46 was observed.

Hence, the numeracy assessment tool was proven to effectively elevate learners' conceptualization of quadratic equations, as seen in the increase in their mean scores. The assessment tool can be used to remediate underachieving learners. Therefore, an action plan was created.

Based on the preceding results, the researcher recommends the following:

1. Create a standardized numeracy assessment tool for the grade level;
2. Provide numeracy assessment tool to all types of learners;
3. Expand the study by including the entire population and having a simple random sampling; and
4. Conduct a parallel study to another grade level or another topic of the same grade level.

All learners will be given the pretest on Mathematics 9 on the first day of class. The non-numerate and/or emergent level students in Mathematics will undergo the Numeracy Project that will be carried out during the silence period from 12:10 – 12:30. This will happen from Mondays to Fridays for the entire quarter.

**Project PLUS-Q**

*(Promoting Learners' Understanding of Simple Quadratics)*

The project aims to elevate learners' conceptualization of quadratic equations. Specifically, by the end of the quarter, the learners will be able to:

1. Illustrate quadratic equations;
2. Solve quadratic equations through various methods; and
3. Apply the concept and the skill of quadratic equations in real life situations.

| Target | Procedure | Persons Involved | Time table | Criteria for Outcome Evaluation |
|---|---|---|---|---|
| Project Orientation | Orient the persons' involved on the objectives and background of the project | School heads, faculty members, Parents, Learners | May 2020 | School Head, faculty members, parents and learners are informed about the project objectives and its repercussions, |
| Pre test | Identify struggling learners through a pre-test | Head teacher, Math Coordinator, Learners | June 2020 (first day of class) | Learners were properly identified and had undergone background check and verification. |
| Parents Involvement | Inform and include parents in the implementation of the project | Parents | June 2020 (first week of class) | Parents agreed upon undergoing their children into an additional class. |
| Project Implementation | Conduct sessions to students | Learners | June to July 2020 | Learners submitted the results of their assessment tool and continued to the next level if needed. |
| Project Evaluation | Administer the post test to the students | Learners | July 2020 | Learners took the post-test and its result and interpretation was included in the portfolio. |

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