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Understanding, Procedural Competence, and Dispostions in Mathematics of Grade Nine Students

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UNDERSTANDING, PROCEDURAL COMPETENCE, AND DISPOSITIONS IN MATHEMATICS OFGRADE NINE STUDENTS

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by
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APPROVAL SHEET

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Chapter I

THE PROBLEM AND ITS BACKGROUND

Introduction

Knowledge of mathematics is very important in life. It is practically used by all individuals in their daily activities. The skills that students learn in mathematics help them succeed in doing tasks that require problem solving, decision making, reasoning, and computing. Such pervasive influence of mathematics has rendered its prime importance in education.

Mathematics is a universal language. It consists of a large body of principles that may be of great help to the individual's physical, social, and intellectual development. Thus, it can be said that it greatly contributes to the improvement of man's quality of life.

Mathematics is important since every human being must be able to perform some basic mathematics in order to participate effectively within his or her society. Knowledge in Mathematics enhances the capabilities of the human mind, which in turn, contributes to the development of science and technology. Capacity for logical thought, explanation and justification evolves from the study of mathematics. Reasoning, critical thinking and problem solving which are essential in life, are developed through the various mathematics studies. Knowledge and skills in mathematics are important tools in society. It is used to explain the many situations in life. Many use it to be more creative and to engage in productive pursuits. In all walks of life, individuals use mathematics to resolve difficult situations, to decide on what actions to take, to prioritize, to compute numerical values, and many more. The usefulness of mathematics is universal. It is a discipline that has no limits. It is boundless. Hence, it has a niche in the curriculum. Major observations reveal that many learners still need to demonstrate deep understanding of mathematical ideas. Various sectors of society want learners to be proficient in mathematics in order to prepare them for their future roles to compete successfully in the worldwide economy and to participate fully as informed citizens. In the workplace, individuals are tasked to engage in computing, reasoning, decision making, and problem solving. These are mathematics skills that are inherent in mathematics. However, it appears that there is much to be desired when it comes to students' mathematical skills. In order to develop these skills, it is believed that mathematics teachers should ensure that students understand concepts thoroughly in order to value emerging processes, recognize and appreciate logical systems leading to procedural competence, apply learned concepts and skills in appropriate situations, and be able to explain processes, products and emerging value systems.

Mathematics is developmental and begins long before the child enters school. It evolves from some desirable habits and attitudes in life. A child's mathematical interests develop from awareness of surroundings. Daily activities reveal the importance of numbers. Some situations are better understood when their numerical attributes are described. Relations expressed numerically often lead to solutions to problems of varying difficulties.

As always the case, students face challenges in learning Mathematics. In 1991 the National Council of Teachers of Mathematics came up with a declaration on the need for students to spend more time on reasoning and problem solving, communicating ideas, exploring relationships among representations of mathematical forms, and making connections between concepts. These skills should be emphasized in mathematics classes so that they will succeed in undertaking tasks that require such competencies. Greater understanding of mathematics are essential to be learned by schoolchildren so that they will be ready in their future work places. As today's technology develops rapidly, success in tomorrow's job will require more than computational competence. It will also require the ability to apply mathematical knowledge to solve problems. If today's students are to compete successfully in the world of tomorrow, they must be able to learn number concepts and skills. Furthermore, they need to view mathematics as a tool that they use every day. They need to have the mathematical sophistication that will enable them to take full advantage of the information and communication technologies that permeate our homes and workplaces. Students who have excellent understanding of mathematics will have better opportunities to pursue higher levels of education, to compete for good jobs, and to succeed in daily tasks requiring numeracy. Thus, the thrust of the Department of Education is proficiency in the achievement of the learners in education.

Proficiency in learning mathematics is achieved through persistence, effort, and practice on the part of students and rigorous and effective instruction on the part of teachers. Parents and the immediate community must also provide support and encouragement. A student with positive academic motivation has a desire to learn, likes learning-related activities, and believes that school is important. Positive academic motivation not only helps a student succeed in school, but also helps the student to see that learning is rewarding and important in all aspects of life-school, work, and community (Brown, 2009). Mathematics skills will be more likely enhanced when a mathematics classroom becomes a place for a community of learners rather than a group of isolated individuals. Traditional ideas of the teacher and student roles and tightly controlled classroom management, as well as insufficient attention to emotions and relationships, do not facilitate meaningful learning (Stepanek, 2000).The science standards suggest that the characteristics of a classroom community include: respect for diverse ideas, skills, and experiences; student responsibility for their own and each other's learning; and collaboration(NRC, 1996).In such a classroom, students are encouraged to generate and share solution methods. Mistakes are valued as opportunities for everyone to learn, and correctness is determined by the logic and structure of the problem rigorously explored by the students rather than by the teacher. Questioning and discussion that elicit students' thinking and solution strategies and build on those strategies lead to greater clarity and precision. A significant amount of class time is spent developing mathematical ideas, not just practicing skills (Kilpatrick, Swafford, and Findell, 2001).

As a goal of instruction, mathematical proficiency provides a better way to think about mathematics learning than narrower views that leave out key features of what it means to know and be able to do mathematics. Mathematical proficiency implies expertise in handling mathematical ideas. Students with mathematical proficiency understand basic concepts, are fluent in performing basic operations, exercise a repertoire of strategic knowledge, reason clearly and flexibly, and maintain a positive outlook toward mathematics. Moreover, they possess and use these strands of mathematical proficiency in an integrated manner, so that each reinforces the others. It takes time for proficiency to develop fully and formally starting with K through 12. Learners are expected to be proficient in mathematics early so that as they reach the higher levels of education, they gain mastery of concepts and skills that they need to become productive citizens later on.

Other than subject mastery, Education Secretary Armin Luistro said that the enhanced K+12 program also focuses on character building and formation, with the goal of producing generations of good, responsible, and productive citizens. “Education is holistic and aims to ensure the quality of student learning with emphasis on formation and development,” Luistro said (2011).

In order for learners to achieve proficiency, education has undergone changes and innovations. The curriculum content was upgraded to be at par with the international community. Further, the teaching competencies needed to succeed are defined. Mathematics teachers should possess the competencies to teach effectively in order to achieve the goals of instruction.

The initiatives to make learners proficient in mathematics are also done in other countries. The National Research Council which is the research arm of the National Council for Mathematics Teachers of America, describes mathematical proficiency as five interconnected strands that consist of conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (Kilpatrick, Swafford, and Findell, 2001). The skills associated with the five strands are as follows:1) *conceptual understanding* refers to comprehension of mathematical concepts, operations, and relations; 2) *procedural fluency* refers to the skill in carrying out procedures flexibly, accurately, efficiently, and appropriately; 3) *strategic competence* is the ability to formulate, represent, and solve mathematical problems; 4) *adaptive reasoning* is the capacity for logical thought, reflection, explanation, and justification; and 5) *productive disposition* - is the habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy – *this should guide the teaching and learning of school mathematics. Instruction should not be based on extreme positions that students learn, on the one hand, solely by internalizing what a teacher or book says or, on the other hand, solely by inventing mathematics on their own.*

In view of these developments in education, this study was conceptualized.

That means they understand mathematical ideas, compute fluently, solve problems, and engage in logical reasoning. They believe they can make sense out of mathematics and can use it to make sense out of things in their world. For them mathematics is personal and is important to their future.

School mathematics in the United States does not enable most students to develop the strands of mathematical proficiency in a sound fashion. Proficiency for all demands that fundamental changes be made concurrently in curriculum, instructional materials, classroom practice, teacher preparation, and professional development. These changes will require continuing, coordinated action on the part of policy makers, teacher educators, teachers, and parents. Although some readers may feel that substantial advances are already being made in reforming mathematics teaching and learning, real progress toward mathematical proficiency is woefully inadequate.

Conceptual Framework

This study generally focused on the idea that the mathematics performance of students is influenced by their understanding, procedural competence, and disposition.

Understanding refers to a student's grasp of fundamental mathematical ideas. Students with understanding know more than isolated facts and procedures. They know why a mathematical idea is important and the contexts in which it is useful. Furthermore, they are aware of many connections among mathematical ideas. In fact, the degree of students' understanding is related to the richness and extent of the connections they have made. Students who learn with understanding have less to learn because they see common patterns in superficially different situations.

Knowledge learned with understanding provides a foundation for remembering or reconstructing mathematical facts and methods for solving new and unfamiliar problems, and for generating new knowledge. Understanding also helps students to avoid critical errors in problem solving—especially problems of magnitude.

The development of understanding involves seeing the connections between concepts, procedures, and having the ability to apply mathematical principles in a variety of contexts, considering the difficulties experienced by students in mastering equivalent fractions and many misconceptions they hold.

The National Research Council (2005) further stated that conceptual understanding and procedural competencies are both important in mathematics education. Teaching math with only an emphasis on procedural competency results in students having too little conceptual understanding, and when students have too little knowledge of procedures they often do not solve mathematics problems competently.

Computing includes being fluent with procedures for adding, subtracting, multiplying, and dividing mentally or with the use of paper and pencil, and knowing when and how to use these procedures appropriately. Although the word *computing* implies an arithmetic procedure, in this document it also refers to being fluent with procedures in other branches of mathematics, such as measurement (measuring lengths), algebra (solving equations), geometry (constructing similar figures), and statistics (graphing data). *Being fluent* means having the skill to perform the procedures efficiently, accurately, and flexibly.

Accuracy and efficiency with procedures are important, but computing also supports understanding.

When students merely memorize procedures, they may fail to understand the deeper ideas that could make it easier to remember—and apply—what they learn.

Developing computational skills and developing understanding are often seen as competing for attention in school mathematics. But pitting skill against understanding creates a false dichotomy. Understanding makes it easier to learn skills, while learning procedures can strengthen and develop mathematical understanding.

The National Research Council (2001) states that productive disposition refers to the tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics. If students are to develop conceptual understanding, procedural fluency, strategic competence, and adaptive reasoning abilities, they must believe that mathematics is understandable, not arbitrary; that, with diligent effort, it can be learned and used; and that they are capable of figuring it out. Developing a productive disposition requires frequent opportunities to make sense of mathematics, to recognize the benefits of perseverance, and to experience the rewards of sense making in mathematics.

Engaging in mathematical activity is the key to success. Students should have a personal commitment to the idea that mathematics makes sense and that, given reasonable effort, they can learn it and apply it, both in school and outside school. Students who are proficient in mathematics see it as sensible, useful, and worthwhile, and they believe that their efforts in learning it pay off; they see themselves as effective learners, doers, and users of mathematics.

Engaging oneself in mathematics requires frequent opportunities to make sense of it, to experience the rewards of making sense of it, and to recognize the benefits of perseverance. As students build their mathematical proficiency, they become more confident of their ability to learn mathematics and apply it. The more mathematical concepts they understand, the more sensible the whole subject becomes. In contrast, when they think mathematics needs to be learned by memorizing rather than by making sense of it, they begin to lose confidence in themselves as learners. Students who are proficient in mathematics believe that they can solve problems, develop understanding, and learn procedures through hard work, and that becoming mathematically proficient is worthwhile.

The importance of conceptual understanding, procedural competence, and productive disposition as strands of mathematics and how they are interrelated and influence performance in mathematics provided the framework for this study in the hope that the result will be of help for teachers to identify the needs of students on specific mathematics concepts and processes to become globally competitive.

The conceptual framework of this study is shown in the following diagram.

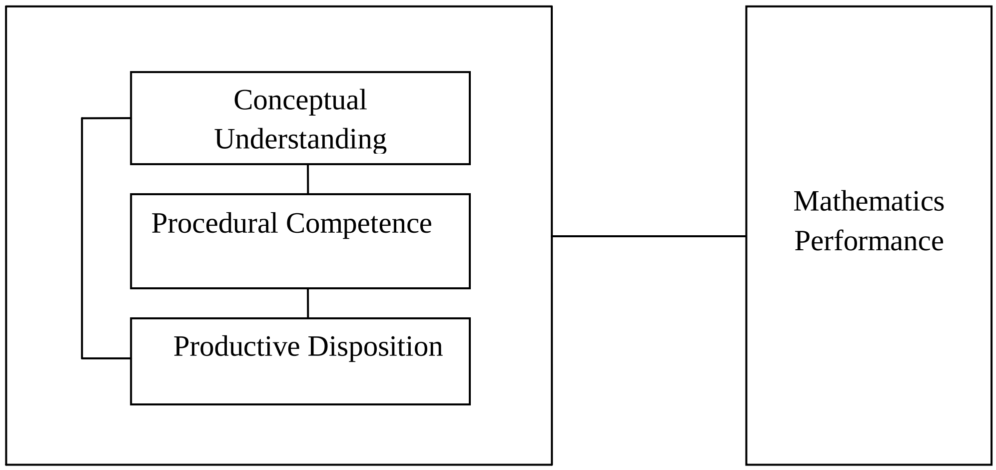

Figure 1 **Conceptual Framework**

The conceptual framework shows the three independent variables that may influence mathematics performance. These independent variables are conceptual understanding, procedural competence, and productive disposition. The dependent variable is mathematics performance.

Research Hypothesis

Conceptual understanding, procedural competence, and productive disposition influence mathematics performance.

Statement of the Problem

This study aimed to assess the understanding, procedural competence, and disposition in mathematics of Grade nine students of Carmona National High School (CNHS), Carmona, Cavite on a selected topic in Algebra.

Specifically, it aimed to answer the following questions:

1. What is the performance of the respondents in mathematics based on a quarterly test?

2. How may the respondents be described in the developed test in terms of their:

   a. Conceptual understanding of quadratic equations,

   b. Procedural competence in solving quadratic equations;

      b.1. Extracting Square Roots

      b.2. Factoring

      b.3. Completing the Square

      b.4. Quadratic Equation

   c. Productive dispositions in Mathematics

3. Is there a significant relationship among the conceptual understanding, procedural competence, and productive disposition of the respondents?

4. Which among the three variables - conceptual understanding, procedural competence, and productive dispositions best explains variability in the mathematics performance of the respondents?

Significance of the Study

The results of this study are expected to benefit the following.

Teachers. The findings of this research may provide useful tips to Mathematics teachers

in teaching quadratic equations.

Parents. This study provides parents with strong reasons to provide moral support and attention to their children learning of mathematics.

Students. The students are the ultimate recipients of the results of this study because their weaknesses in learning quadratic equations will be revealed. Such revelation may serve as the basis for remedial measures to be formulated, and hopefully improve their learning, and eventually they will perform better in Mathematics.

Future Researchers. The results of this study could serve as reference for other researchers in conducting related studies in mathematics education. It could also motivate them to investigate the other factors influencing the mathematics performance of students.

Scope and Delimitation

This study described the respondents' conceptual understanding, procedural competence, and productive disposition level in Mathematics specifically on the topic on quadratic equations. It sought to determine if these three strands of proficiency are related to mathematics performance. The respondents were the Grade Nine students of Carmona National High School, Carmona, Cavite, academic year 2014-2015. They were composed of 18 boys and 22 girls, or a total of 40 students.

The data utilized in this study were obtained through a researcher - developed test that measured understanding and procedural competence and a survey questionnaire that measured disposition in mathematics. It is assumed that the responses truly reflect the students' understanding of the concepts as well as their procedural competence on quadratic equations.

Definition of Terms

The following terms that were used in this study are hereby defined conceptually and operationally.

Conceptual Understanding. It refers to an integrated and functional grasp of mathemathical ideas. It means comprehending mathematical concepts, operations, relations, mathematical symbols, diagrams, graphs and knowing the meaning of procedures. Students with conceptulal understanding know more than isolated facts and methods. They understand why a mathematical idea is important and the context in which it is useful. They learn new ideas by connecting those ideas to what they already know (NCTM, 2011). In this study, it refers to the respondents' grasp of concepts and the applications of quadratic equations to solve problems.

Completing the Square. It is considered a basic algebraic operation, and is often applied without in any computation involving quadratic polynomials. Completing the square is also used to derive the quadratic formula.

Factoring. It refers to the process of finding the numbers or expressions to be multipled to obtain a given product. In this study, it is the first method of solving quadratic equations to which the respondents were exposed. If one is given a quadratic equation in the form $ax^2 + bx + c = 0$, the factorization has the form$(x + q)(x + s)$and one has to find two numbers q and s that add up to get$b$ and whose product is c (this is sometimes called "Vieta's rule" and is related to (Vieta's formulas). The more general case where a does not equal 1 can require a considerable effort in trial and error guess-and-checkmethod assuming that it can be factored after all.

Except in special cases such as where $b = 0$ or $c = 0$, factoring by inspection only works for quadratic equations that have rational roots. This means that the great majority of quadratic equations that arise in practical application cannot be solved through factoring by inspection.

Procedural Competence. It refers to knowledge of procedures, knowledge of when and how to use them appropriately, and skill in performing them flexibly, accurately and efficiently (NCTM, 2011). It means carrying out mathematical procedures, such as adding, substracting, multplying numbers accurately and graphing.

Productive Disposition. It refers to the tendency to see sense in mathematics , to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics. Engaging in mathematical activities is the key to success. Students should have a personal commitment to the idea that mathematics makes sense and that they can learn and apply it, both in school and outside the school. Success in athematics learning requires being positively disposed toward the subject.

Quadratic Equation. Quadratic equation (from the Latin quadratus for "square") is any equation having the form $ax^2 + bx + c = 0$ where x represents an unknown, and$a, b,$and$c$ are constants, with a not equal to 0. If $a = 0$, then the equation is linear, not quadratic. The parameters [1] $a, b,$ and c are called, respectively, the quadratic coefficient, the linear coefficient and the constant or free term. Because the quadratic equation involves only one unknown, it is called "univariate". The quadratic equation only contains powers of x that are non-negative integers, and therefore it is a polynomial equation, and in particular it is a second degree polynomial equation since the greatest power is two. Quadratic equations can be solved by factoring, by completing the square, by using the quadratic formula, or by extracting square roots. Solutions to problems equivalent to the quadratic equations were known as early as 2000 BC.

Quadratic Formula. It refers to a formula that may offer a solution to a quadratic equation. $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$. The general quadratic equation is $ax^2 + bx + c = 0$. Here x represents an unknown, and $a, b,$ and c are constants, with a not equal to 0. One can verify that the quadratic formula satisfies the quadratic equation, by inserting the former into the latter. Each of the solutions given by the quadratic formula is called a root of the quadratic equation.

Square Root of a number a. It is a number y such that $y^2 = a$, in other words, a number y whose square (the result of multiplying the number by itself, or $y \times y$) is a. For example, 4 and −4 are square roots of 16 because $4^2 = (-4)^2 = 16$.

Chapter 2

REVIEW OF RELATED LITERATURE

This chapter presents the review of related literature and studies previously undertaken which equipped the researcher with the necessary information that has significant bearing to the intended research study.

Conceptual Understanding

The National Research Council defined *Conceptual understanding* as the comprehension of mathematical concepts, operations, and procedures. People with conceptual understanding have their Mathematical knowledge organized in such a way that they can easily use it in appropriate context. Moreover, their knowledge is not in separate, disconnected pieces, but rather their knowledge builds from their old conceptions to newer ones. (NCTM, 1990).

When students delve deeply into mathematics, they gain not only conceptual understanding of mathematical principles but also knowledge of, and experience with, pure reasoning. One of the most important goals of mathematics is to teach students logical reasoning. The logical reasoning inherent in the study of mathematics allows for application to a broad range of situations in which answers to practical problems can be found with accuracy.

Fostering student's conceptual understanding of a problem or class of problems is just as important as developing students' computational and procedural competencies.

Without conceptual understanding, students often use procedures incorrectly. More specifically, they tend to use procedures that work for some problems on problems for which the procedures are inappropriate.

Conceptual competency has been achieved when students understand the basic rules or principles that underlie the items in the mathematics unit. Students with this level of competency no longer solve problems according to the superficial features of the problem but by understanding the underlying principles. Students with a good conceptual understanding of the material are more flexible in their problem-solving approaches.

Research in cognitive psychology suggests that different types of instructional activities will favor the development of procedural competencies more than conceptual knowledge, and other types of instructional activities will favor the development of conceptual knowledge more than procedural competencies.

Conceptual understanding features strands regarding comprehension of mathematics concepts, operations, and relations. Students with conceptual understanding know more than isolated facts and procedures. They know why a Mathematical idea is important and the context in which it is useful. Furthermore, students who learn with understanding have less to learn because they see common patterns in superficially different situations.

The strands of mathematical proficiency as stressed by (Kilpatrick, Swafford, and Findell) build a picture of a mathematically proficient student. Students with *conceptual understanding* know more than isolated facts and methods. They understand why a mathematical idea is important and the kinds of contexts in which it is useful. Students displaying *procedural fluency* know procedures and when to use them, and they can perform them flexibly, accurately, and efficiently. Students exhibiting *strategic competence* can formulate mathematical problems, represent them, and solve them. Students using *adaptive reasoning* can think logically about relationships among concepts and situations, consider alternatives, reason correctly, and justify conclusions. Lastly, students with a *productive dispositions* see that mathematics makes sense and is both useful and worthwhile, believe that steady effort pays off, and see themselves as effective learners and doers of mathematics (Kilpatrick, Swafford, and Findell, 2001).

Hiebert and Lefevre (2005) emphasized the importance of the relationships in conceptual understanding: It can be thought of as a connected web of knowledge, a network in which the linking relationships are as prominent as the discrete pieces of information. Relationships pervade the individual faces and propositions so that all pieces of information are linked to some network.

This connections are important, for if a person forgets a fact or procedure, she can recreate it by building on her previous understandings, making mathematical knowledge easier to use and easier to remember and providing a basis from which to build new understandings (NCTM, 2001).

The five strands provide a framework for discussing the knowledge, skills, abilities, and beliefs that constitute mathematical proficiency. This framework has some similarities with the one used in recent mathematics assessments by the National Assessment of Educational Progress (NAEP), which features three mathematical abilities (conceptual understanding, procedural knowledge, and problem solving) and includes additional specifications for reasoning, connections, and communication. The strands also echo components of mathematics learning that have been identified in materials for teachers. At the same time, research and theory in cognitive science provide general support for the ideas contributing to these five strands. Fundamental in that work has been the central role of mental representations. How learners represent and connect pieces of knowledge is a key factor in whether they will understand it deeply and can use it in problem solving. Cognitive scientists have concluded that competence in an area of inquiry depends upon knowledge that is not merely stored but represented mentally and organized (connected and structured) in ways that facilitate appropriate retrieval and application. Thus, learning with understanding is more powerful than simply memorizing because the organization improves retention, promotes fluency, and facilitates learning related material. The central notion that strands of competence must be interwoven to be useful reflects the finding that having a deep understanding requires that learners connect pieces of knowledge, and that connection in turn is a key factor in whether they can use what they know productively in solving problems. Furthermore, cognitive science studies of problem solving have documented the importance of adaptive expertise and of what is called *meta cognition:* knowledge about one's own thinking and ability to monitor one's own understanding and problem-solving activity. These ideas contribute to strategic competence and adaptive reasoning. Finally, learning is also influenced by motivation, a component of productive disposition.

Pak (2004) stated that motivating students to love Mathematics should be the goal of every mathematics teacher. It should emphasize the importance of thinking and conceptual understanding rather than the learning of procedures, rules, and facts. Suitable situations and activities should also be planned and conducted in class to help children understand concepts and relate these mathematical ideas, symbol and mathematical language to real-life experiences and their natural language.

According to Bernard (1992), Mathematical proficiency, like vocational skill or competence in daily living is not achieved suddenly but is the result of numerous successive steps and is influenced by several factors which include level of conceptual and procedural understanding, intelligence scores, and scholastic records and achievements. Knowledge of Algebra is a technique for solving problems, yet, Mathematics has been taught as a method of problem solving in general.

Procedural Fluency

In the vast field of education, Mathematics has been placed as a significant tool for effective citizenship and personal living. Basic mathematical competencies and skills particularly in the area of procedural competence in problem solving are relevant to the community for greater and higher achievement of citizenry. These mathematical abilities and skills are tools in the everyday business of living and adjusting to the changing world (PCSPE,1997).

Procedural fluency, as another important variable represents the skills to carry out procedures appropriately, efficiently, and accurately (Kilpatrick et al., 2001).

In this field as one of the strands in Mathematical proficiency, Samuelsson (2010) supported the idea that the students' procedural fluency is influenced by their mathematical knowledge and abilities, both algebraic and trigonometric knowledge.

In the field of procedural competence in Mathematics with focus on problem solving, Stover (2002), studied the structural variables affecting difficulty in solving Mathematics word problems. The study attempted to show that three variables are in part usually related to the difficulty of the problem itself. The findings suggested that diagrams, extraneous information, and order of numerical information were the three variables that contribute heavily to Mathematical problem solving difficulty. The findings further suggested that the students can be taught through direct instruction to manipulate successfully these variables within an efficient time frame.

Ambrocio (2000), in her study about problem solving skills of Grades 7-9 students in Mathematics, revealed the following findings: 1) Students find difficulty using predetermined operations to solve a problem; 2) Limited vocabulary and poor reading comprehension are the main causes of problem solving deficiencies; and 3) The difficulty in using the determined operations to solve a problem was caused by non-mastery of basic facts and carelessness in following algorithms.

Furthermore, Sotto (1990) studied the relationship between Mathematical problem solving strategies and certain learners' characteristics and performance in solving mathematical problems. He revealed that: 1) the problem solving strategies employed by the respondents were direct computation, trial and error, writing an equation, and drawing/constructing a model; 2) the choice of problem solving strategy was significantly related to the students' performance in Mathematics word problems; and 3) disposition toward mathematics was related significantly to Mathematics word problem performance.

In a related study, Brueckner (2003) stated that difficulties of the students in problem solving can be traced from:1) failure to comprehend the problem in part or in whole because of their inability to visualize them in situations; 2) lack of knowledge of the meaning of terms of the students which were wrongly interpreted; and 3) lack of knowledge of essential parts, rules, and formulas such as rules quadratic formula, completing the square method, and rules in extracting the roots of quadratic equations.

The students' competency in problem solving is one issue relative to procedural fluency in mathematics. Problem solving is defined as a Mathematical task for which the students do not have a readily available solution. Readings from the Mathematics teachers (2006) reveal that problem solving involves decision making on the part of the student as to what mathematical concepts to be used and what approach to be considered to be able to solve the problem.

Relative to the above stated reading is the idea of Polya and Bransford about procedural fluency in mathematics with focus on problem solving. They stated that it has been mystified as one of the horrifying classroom activities that hamper its efficacy towards mastery of learning outcomes. Addressing its peculiarities, Polya and Bransford had developed models to explain the solving processes. The model was based on the assumption that problem solvers can learn abstract problem solving skills (de contextualized knowledge) by transferring these skills into a functional schema of conceptual understanding (contextualized knowledge). Brandsford Ideal model (1984) as cited by Bautista (2013), in problem solving includes the following steps: 1) Identify the problem; 2) Define the problem through thinking about it and sorting out the relevant information; 3) Act on the strategies; and 4) Look back and evaluate the effects of your activity.

The way information is presented in a problem-solving task is important in finding its solution and their solution seem to follow a well ordered pattern. Pangilinan (2003) suggested the following sequences of steps in problem solving;

1. Identify the problem
2. Represent the problem
3. Plan the solution
4. Execute the plan
5. Evaluate the plan
6. Evaluate the solution

Gick (1986), as cited by Bautista (2013) on the other hand, also formulated a model for problem solving, which became a common model used by many in problem solving tasks. This model identifies a basic sequence of three cognitive activities, which include: 1) Representing the problem, which requires the ability to call up some appropriate context knowledge and the identification of goal and relevant starting conditions for the problem; 2) Solution search, which includes the refinement of the goal and the development of a plan of action to reach the goal; and 3) Implementing the solution, which refers to the execution of the plan of action and the evaluation of the results.

Butler and Wren (2001) on the other hand stated that despite the different problem solving models, most of the difficulties, which students encountered in Mathematics, could be traced to the inadequacy of the developmental work, which they suggested is very necessary in quantitative relationship and problem solving abilities. If developmental work is inadequate, then the students will not be able to make such independent progress toward the assimilation of concepts. More directed study drills and review are needed in the development of conceptual understanding and procedural fluency.

Productive Disposition

Productive disposition, as the last variable involves the tendency to make sense in Mathematics. This disposition helps the students be more confident in their knowledge and ability (Kilpatrick et al., 2001).

According to Gregorio (1996) in his book, mathematics plays a very important role in the society in matters of science, industry, and commerce. It is necessary to prepare the children for their future by providing them good foundation in Mathematics. On the strength of this, there is a great need to revitalize the subject that will offer stimulating contents and that could help prepare the children for intelligent participation in the society, which is getting more technological.

Mathematics should be regarded as a subject, which is very important and interesting in everyday life. Esteban (2000) enumerated some guidelines that the teacher should consider in order that the students will learn Mathematics better. According to him, students will learn Mathematics better when 1) they become aware and have interest in the subject, 2) they realize the application of the subject particularly in solving real life problems, 3) the environment is conducive to learning, 4) their curiosity is being aroused or properly motivated, 5) the task is simple enough, interesting, and enjoyable, and 6) they themselves do the task of constructing and manipulating concrete things.

There are numerous classroom practices that, with effective implementation, will create positive effect on students' achievement and one of which is formative assessment. A classroom environment that is conducive to effective formative assessment is one in which students are encouraged to work collaboratively; learn from one another and have the opportunity to share their work publicly; think more clearly; have opportunities to reflect on and revise their mathematical writing and oral presentations to improve the clarity of their communication; and feel encouraged to work with each member of the community through the use of flexible grouping. (NCTM, 2000)

In such classrooms, teachers know the Mathematics content and recognize key ideas and misconceptions; instruct students on appropriate protocols for working collaboratively in small groups; set clear expectations for student behaviors for individual and collaborative work; have the necessary tools to assess what their students know and can do; find ways to help students reflect on their problem solving, strategies, and writing to communicate with clarity; and know how to engage students in appropriate next steps effectively. (NCTM, 2000)

One of the significant steps towards improved instruction is that of the learners' positive disposition towards the subject. An individual who has developed positive disposition and attitudes may perform better in almost all fields of learning. Students who have productive dispositions see Mathematics not as a set of arbitrary rules that one must memorize but a system of connected conceptions that, with diligent effort, can be understood. This strand is very different from other strands; it encompasses issues such as person's affect, beliefs, and identity, whereas the other four strands focus mainly on cognitive processes. However, productive disposition is needed to build the other four strands. Moreover, the strengthening of the other four strands helps to build one's productive disposition. (NRC, 2001)

Resnick (2002), stressed his views about productive disposition when he said "The term disposition should not be taken to imply a biological or inherited trait, but that a disposition is more of a habit of thought, one that can be learned and, therefore, taught.

Productive disposition in Mathematics can be developed in all learners, and teachers can play active roles in the construction.

According to the National Council of Teachers in Mathematics (NCTM, 1990), the assessment of the students' mathematical knowledge should yield information about the following: a) ability to apply knowledge to solve problems within mathematics; b) ability to use mathematical language to communicate ideas; c) ability to reason and analyze; d) knowledge and understanding of concepts and procedures; e) disposition toward mathematics; and f) understanding of the nature of mathematics.

Dutton and Peddon (2000), in their studies, found that dispositions for or against Mathematics have been developed as early as the third grade. Moreover, Grades four to nine have appeared to be the most crucial years and that apparently lasting attitude toward Mathematics were developed at each grade level.

Diffenburger and Norton (2005) conducted another study on disposition towards Mathematics. They concluded that the development of positive disposition towards mathematics have been found to be accumulation of experiences building upon one another.

In the same way, Stright (2004) conducted a similar study on attitudes toward Mathematics. She made the following general conclusions based on the children's responses to the questionnaires used: 1) 25% of the Ninth grades could not see how Mathematics could be useful out of the school; 2) 13% felt that Mathematics was a waste of time,; and 3) 61% felt all people should know Mathematics .Manuel (2005) also conducted a national survey designed to identify the relative importance of many factors that may be affecting the students' participation in Mathematics. These factors were attitudes toward Mathematics, perceived usefulness of Mathematics for educational and career goals and positive influence of parents, teachers, counselors, and peers. The results also suggested certain areas for intervention to increase students' participation in Mathematics. These beliefs and attitudes of students were found problematic. Programs designed to instill positive disposition toward Mathematics and increase student confidence when doing mathematics could have an impact on the students' decision to continue with Mathematics. Career awareness program could also be an area for intervention to improve students' participation in Mathematics.

Educational institutions have already undertaken great strides to scrutinize and reinforce all Mathematics curriculums in all levels of instructions. The latest one is the K-12 curriculum where expected mathematical competencies are spiral in nature. Evaluation of the different programs of study, seminars and workshops for teachers, particularly in Mathematics has been sponsored by both public and private educational institutions. All of these have been done in order to clarify and revitalize mathematical ideas that may be of great help for the learner's intelligent participation in the community where he lives.

However, there are instances that no matter how effective the Mathematics teachers are, it seems that it is the said subject area where students perform the lowest.

In the light of the foregoing facts, the students' achievement in Mathematics should be given proper attention. Test results contribute to the teacher's insight of the learner's understanding and skills in a particular area. They serve as basis for checking of learning, evaluating teaching techniques, and planning instruction. These various benefits, therefore, that can be derived from tests, make it imperative that this study be conducted to determine the students' mathematical performance with focus on the Three strands of Mathematical proficiency namely conceptual understanding, procedural fluency, and disposition. A checklist was also prepared in order to evaluate the respondents' disposition in the said subject.

In addition to working as members of the classroom community, students also need to become independent learners, both inside and outside the classroom. Students should have opportunities to work independently of the teacher, individually and in pairs or groups. When homework is assigned for the purpose of developing skills, students should be sufficiently familiar with the skills so that they do not practice incorrect procedures. Only by becoming independent learners can students come to see mathematics as doable and useful.

Teaching Quadratic Equations

Students need to solve mathematical equations if they study technical subjects that require them to work with the formula. However, they can have difficulty with learning to solve equations because different types of thinking are needed: making decisions, remembering processes accurately, and applying them correctly.

VanLehn (1990) described equation solving as an example of a “multistep problem” as it requires a sequence of steps, many of which are important to reaching the solution. A multistep problem is distinct from an “ insight” problem in which only one of the steps is the key to reaching the solution. This description means that it must be more complicated to solve multistep problems than insight problems. VanLehn, attributes the difficulty of solving equations having to both choose an appropriate algebraic transformation at each step, and then remember and apply the transformation correctly.

Mayer (2003) described two sets of actions as strategy for solving mathematical equation. A “move” is an operation applied to both sides of an equation that results in a number, variable or term being moved from one side of the equation to the other. A “ compute” involves rewriting terms on one side of an equation by carrying out a computation. Different strategies consist of different combinations of moves and computes. Mayer characterized an equation by the minimum number of actions required to solve it and pointed out that there may be different strategies that consist of this minimum number of actions. Thus, students learning to solve equations need to learn how to create an equation solving strategy.

One of the strongest findings from research is that time and opportunity to learn are essential for successful learning. For all students to develop mathematical proficiency, schools should devote a substantial and regular amount of time to mathematics instruction. Instructional materials need to have teacher notes that support teachers’ understanding of mathematical concepts, student thinking and student errors, and effective pedagogical supports and techniques. Instructional materials should incorporate activities and strategies that assist teachers in helping all students become proficient in mathematics, including students low socio economic status, English-language learners, special education students, and students with special interests or talents in mathematics. (NCTM, 2001).

Like any complex task, effective mathematics teaching must be learned. Teachers need a special kind of knowledge. To teach mathematics well, they must themselves be proficient in mathematics, at a much deeper level than their students. They also must understand how students develop mathematical proficiency, and they must have a repertoire of teaching practices that can promote proficiency.

Like learning in any profession, learning to teach for mathematical proficiency is a career-long challenge. Acquiring this knowledge and learning how to use it effectively in the classroom will take not only time but resources. Professional development must become a continuing part of the teacher's workweek rather than taking the form of an occasional workshop. Teachers need extensive opportunities to learn, to observe models of effective practice, and to have access to expertise in mathematics teaching. It is not reasonable in the short term to expect all teachers to acquire the knowledge they need to teach for mathematical proficiency. To further promote effective teaching and learning, mathematics specialists—teachers who have special training and interest in mathematics—should be available in every elementary and secondary school.

(Ronda, 2012) The Department of Education (DepEd) will adopt a new assessment tool using the letter system to assess the level of proficiency of students in public schools. With the additional grade system, DepEd will stop the traditional practice in public schools of promoting students automatically to the next higher grade despite their failure to earn an acceptable level of proficiency. According to DepEd officials, the move aims to raise the quality of education in all public schools in line with the K+12 (Kindergarten+12 Basic Education Curriculum) program. Mandatory remedial classes will be given to under-achieving students at the end of each quarter, while students with poor grades at the end of the school year will have to attend summer classes. Under DepEd Order No. 31 s. 2012, five levels of proficiency were identified, namely: Beginning, Developing, Approaching Proficiency, Proficient, and Advanced. The level of proficiency will be based on the numerical grades earned by the students in a particular quarter and at the end of the school year. The Beginning (B) level will be given to students with numerical grades of 74 percent and below; Developing (D) level for those with grades of 75 to 79 percent; Approaching Proficiency (AP) for those with grades 80 to 84 percent; Proficient (P) for those with grades 85 to 89 percent; and Advanced (A) for those with 90 percent and higher."The general average shall be the average of the final grades of the different learning areas, also expressed in terms of levels of proficiency with the numerical equivalent in parenthesis," DepEd said.

To many people, school mathematics is virtually a phenomenon of nature. It seems timeless, set in stone—hard to change and perhaps not needing change. But the school mathematics education of yesterday, which had a practical basis, is no longer viable. Rote learning of arithmetic procedures no longer has the clear value it once had. The widespread availability of technological tools for computation means that people are less dependent on their own powers of computation. At the same time, people are much more exposed to numbers and quantitative ideas and so need to deal with mathematics on a higher level than they did just 20 years ago. Too few U.S. students, however, leave elementary and middle school with adequate mathematical knowledge, skill, and confidence for anyone to be satisfied that all is well in school mathematics. Moreover, certain segments of the U.S. population are not well represented among those who succeed in learning mathematics. Widespread failure to learn mathematics limits individual possibilities and hampers national growth. Therefore, school mathematics demands substantial change. Such change needs to be undertaken carefully and deliberately, so that every child has both the opportunity and support necessary to become proficient in mathematics.

The cited related literature provided the impetus for this study. The insights and experiences of concerned sectors of society in formulation of this research problem concentrating on conceptual understanding, procedural fluency, and productive disposition of students on selected topics in Algebra.

Such literature provided perspectives of mathematics education with a wide lens but missing with the details that teachers need to know to truly succeed in teaching quadratic equations. The result of this investigation may help mathematics teachers in designing curricular tasks.

Chapter 3

METHODOLOGY

This chapter presents the methods and techniques utilized in this study. It includes the research design, participants of the study, research instrument, data gathering procedure, and methods of statistical analysis. The data consist of the results of an assessment of the conceptual understanding, procedural competence, and dispositions in mathematics among grade nine students.

Research Design

The descriptive research design was used in this study. Descriptive research involves collecting data in order to test hypotheses or to answer questions concerning the current status of the subject of the study (Alcantara, 2005). It is used when the objective is to provide a systematic description of a trait that is based on factual data. A descriptive study determines and reports the way things are. It has no control over what *was*, descriptive research has no control over what *is*, and it can only measure what already exists. Specifically, this study described the correlates of performance on quadratic equations. Furthermore, with correlation found to be significant, the paired variables were subjected to regression analysis.

Participants of the Study

The participants of this study consisted of 40 Grade Nine students since the topic of the research is about quadratic equations. The respondents are enrolled at the Carmona National High School, Carmona, Cavite in the School Year 2014-2015. They are composed of a random sample of 18 boys and 22 girls.

Research Instrument

There were two instruments used in this study in order to measure the students' mathematical proficiency. The first instrument is a *Mathematics Performance Test*, a researcher – developed test to measure conceptual understanding and procedural competence on quadratic equations. The second instrument is a survey questionnaire to measure productive disposition. This instrument, *Mathematics Attitude Survey*, was developed by Servando (2014).

The following stages were used in the development of the mathematics performance test.

Stage 1 Preliminary Stage

In preparation for the development of the preliminary test to measure the respondents' conceptual and procedural knowledge of equations, literature on assessment was read. The content of the K-12 curriculum specific to Grade 9 on the topic *Quadratic Equations* was also carefully read. Books and theses on assessment were also read. Theses relevant to the methodology employed in this study were also read.

Stage 2 Writing and Validation Stage

This stage was started with the construction of a Table of Specifications to ensure that all the areas on quadratic equations were properly represented. Initially, a 60-item preliminary test was prepared (Appendix C). The items were submitted to mathematics professors for content and face validity. After this initial validation, the test was tried out to a class of Grade Nine students. The result of the test was used for its further refinement. The original item #2 *Why do you think that your answer in #1 is a quadratic equation?* was revised to *Which of the following suggests a quadratic equation?* The original item #6 *Identify the values of the constants a, b, and c of quadratic equation* $2x(x-3) = 15$ *?*was made question #8. The question was revised into *What are the values of the constants a, b, and c of the quadraticequation*$2x(x-3) = 15$ *?* Item # 13 *Can you express*$(x-4)^2 + 8 = 0$*in standard form?* was made #7 and was reworded into *Which of the following is the same as*$(x-4)^2 + 8 = 0$ *in standard form?* These questions aimed to measure Conceptual Understanding.

Some items on Procedural Competence there reworded and split into two items. Item #2 *How are you going to represent the length and the width of the pathway? How about its area?* was split into two separate items. Question #2 *How are you going to represent the length and the width of the pathway?*.Question #3 *How about its area?*.Also the question #3 *What expression would represents the area of the cemented portion of the pathway?*

was moved to question #4 *What expression showing the length and the width would represent the area of the cemented portion of the pathway?*

The preliminary form of the *Mathematics Performance Test* was composed of 60 items (Appendix C). Thirty (30) items were on conceptual understanding, 12 questions are solving quadratic equations through the four methods, and 18 items were open-ended questions. The remaining 30 questions were on procedural competence. The 60-item test was validated by two subject experts from PNU. The experts suggested deletion and rewording of some items.

The final form of the *Mathematics Performance Test* is composed of 57items (Appendix D). To measure conceptual understanding, a 25-item multiple-choice type of test was used. Procedural knowledge was measured through questions on solving quadratic equations using the four methods and open-ended questions. There were 3 items for each of the four methods, 5 open-ended items on extracting square roots, 5 items on factoring, 4 items on completing the square, and 6 items on using the quadratic formula. Altogether, the 32 items would yield a perfect score of 56 to assess the respondents' procedural knowledge on the four methods. There were four procedures looked into: *extracting square roots*, *factoring, completing the square*, and *the use of the quadratic formula.*

To measure the students' productive disposition, a *Mathematics Attitude Survey* developed by Servando (2014) was used.

Stage 3 Validation of the Research Instrument

The preliminary form of the test was shown to two PNU mathematics professors for their comments and suggestions. These comments and suggestions were incorporated in the final form of the instrument. The refined test for conceptual understanding was cut short from 30 items to 25 items and 20open-ended items instead of 30, while the test on the four methods of solving quadratic equations remained as is. The scoring rubric for the research instrument was also prepared. One point was given for every correct answer of the 25-item conceptual understanding test and for the 20 open-ended questions on problem solving under procedural competence. The 12 items on the four methods of solving quadratic equations were given three points for each correct answer, two points for partially correct answer and one point for a simple attempt to answer. To interpret the students' responses in the Mathematics Attitude Survey that measures their productive dispositions, four points were given if the student checked the option strongly agree, three points for agree, two points for disagree, and one point for strongly disagree. To give a verbal description for tables, the DepEd Levels of Proficiency was used.

Data Gathering Procedure

The research instruments were administered to the Grade Nine students of Carmona National High School, Carmona, Cavite in September 2014. The research data were collected by means of a researcher-developed test and by means of a survey questionnaire. These were administered to a random sample.

The test was administered to the respondents during the *first day* of the schedule in a well-lighted and well-ventilated classroom so that the respondents would feel at ease when taking the test.

The Attitude scale was administered the following day. After the test, an interview was conducted with a select group of students to ascertain the consistency of their responses to the questionnaire. In the interview, the students were asked to show their computations or explain their answers using a language that they were comfortable with or illustrate their knowledge with examples. Some of them found differently in answering the questions because they forgot how to do the process. Some didn’t understand what was being asked, and some didn’t really have the knowledge on how to do the process.

Data Analysis

The objective of this study was to describe the conceptual understanding, procedural competence, and productive disposition of Grade Nine students in mathematics particularly on quadratic equations. To describe these characteristics of Grade Nine students, the mean and the standard deviation were computed. To explain the variability of the characteristics, particular variables were correlated and when found significant, they were subjected to regression analysis.

Chapter 4

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

This chapter presents the data gathered, their analysis and interpretation. The data were collected from 40 Grade Nine respondents coming from Carmona National High School, Carmona, Cavite.

***Problem 1*:What is the performance of the respondents in mathematics based on a quarterly mathematics test?**

The following table shows the performance of the respondents in a 50-item quarterly test in mathematics usually administered to all Grade Nine students of Carmona National High School after the first quarter. The items on the test measure the performance of the students on lessons covered during the first quarter of the academic year. The administration of a summative test after a quarter has been a school practice for the past thirty years. The test is usually subjected to item analysis after each administration for refinement purposes.

In this study, the result of this test is the dependent variable upon which this study is hitched. The following table shows the performance of the students in the 50-item test.

Table 1 Mean Performance of the Respondents in the First Quarter Test

Gender	Mean	Percent of Correct Responses	Verbal Description
Female	18.50	37%	Beginning
Male	18.56	37%	Beginning
Over All Mean	**18.53**	**37%**	**Beginning**

Legend:

Rating	*Description*
44.76 – 50.00	Advance
42.26 – 44.75	Proficient
39.76 – 42.25	Approaching Proficiency
37.25 – 39.75	Developing
37.24 and below	Beginning

It can be noted that the performance of the respondents, both female and male, is in the *beginning level*. Female respondents got a mean of 18.50 and the male respondents got a mean 18.56. These results are way below 50% of the items. The low mean scores show that, generally, the students have low performance in mathematics. With this result, it seems that most of the respondents do not have mastery of the foundational concepts and processes that are prerequisites to learning quadratic equations. The clear implication is a need to enhance the teaching learning situation in the preparatory level.

***Problem 2*: How may the respondents be described in the developed test in terms of their:**

a. Conceptual understanding of quadratic equations,

b. Procedural competence in solving quadratic equations;

b.1 Extracting Square Roots

b.2 Factoring

b.3 Completing the Square

b.4 Quadratic Formula and

c. Productive disposition in mathematics

A test consisting of two parts (Appendix D) was developed by the researcher to measure the respondents' conceptual and procedural understanding of quadratic equations. Part I consists of 25items of the multiple choice type that measure conceptual understanding. Part II measure procedural competence consisting of 12 items on the four methods in solving quadratic equations and 20 open-ended items, for an overall total of 57 items that is equivalent to a total score of 81. In order to triangulate the information from the respondents' test scores, a representative sample of ten (10) students were interviewed and asked questions on particular items of the test.

For the students' dispositions in mathematics, the 15-item Math Attitude Survey of Servando (Appendix D) was used.

The following tables show the mean performance of the respondents in the developed test. The scores in the test were used to explain the variability of the scores in the quarterly test.

Table 2 shows the mean performance of the respondents, both male and female, on conceptual understanding of quadratic equations. The overall mean performance reveals that the students belong to the population of beginners.

Table 2 Mean Performance of the Respondents on Conceptual Understanding of Quadratic Equations

Gender	Mean	Standard Deviation	Verbal Description
Female	13.45	3.19	Beginning
Male	11.89	3.41	Beginning
Over All	**12.75**	**3.34**	**Beginning**

Legend

Rating:	*Description*
22.38 – 25.00	Advance
21.1 – 22.37	Proficient
19.88 – 21.12	Approaching Proficiency
18.63– 19.87	Developing
18.62 and below	Beginning

The mean score of 12.75 is way below 50% of the total number of items. This implies that the students are not prepared in learning quadratic equations. A closer look was done on the answers of the students. The most difficult items were item number 22 and item number 24. When students were asked to give the value of the other root in question number 22(shown below), almost all of them answered letter B which is not the correct answer. The correct answer is D. Only three (3) respondents got this item correctly. It seems that the remaining 97% are problematic with the concept of root. They might not even know why one of the roots is 4.

The students' responses to item number 24 were also examined. This item is as follows.

Question#24:

What are the roots of $x^2 + 10x + 9 = 0$?

A. $x = -1$ or $x = -9$ *C.* $x = 1$ or $x = 9$

B. $x = -1$ or $x = 9$ *D.* $x = 1$ $or x = -9$

In this item, only seven (7) students got the correct answer. When some students were interviewed regarding their answers, they said they were confused about the expression. It seems also that many students at this academic level have not fully grasped the concept of the quadratic equation. They seem to have problems with the negative sign. The concern could also be rooted in factoring trinomial squares. The problem could also be in simplifying the factors equated to zero. In this item, the correct answer is A but majority of the respondents chose letter B.

A good observation was noted in the respondents' answers to questions #3 and #4 where 90% answered the items right. Similarly, 87.5% of the students found questions #5 and #6 easy. These results showed that a good percentage of the students have a basic knowledge of the concepts of quadratic equations.

Question #3:

What is the highest degree of exponent in a quadratic equation?

A. 1	*C. 3*
B. 2	*D. 4*

It was not hard for the students to answer question number 4,may be because they were familiar with the form of a quadratic equation.

Question #4

Which of the following equations is quadratic?

A. $3m+8=15$	*C.* $12-4x=0$
B. $x^2 - 5x + 10=0$	*D.* $\frac{1}{2}(h-6) = 0$

When students were asked to represent a quadratic equation in question number 5, thirty-five respondents got the correct answer. This means that88% of them knew the form of a quadratic equation.

Question #5:

What is the standard form of a quadratic equation?

A. $ax^2 + \ b + c = 0$ C. $ax^2 + bx = c$

B. $ax^2 + bx + c = 0$ D. $ax^2 - bx = c$

The same result is evident in question number 6 where the respondents were asked to show a quadratic equation written in standard form. The students indeed know the form of a quadratic equation.

Question #6:

Which quadratic equation is written in standard form?

A. $8x + 5x^2 - 9 = 0$ C. $5x^2 + 8x = 9$

B. $5x^2 + 8x - 9 = 0$ D. $9 - 8x - 5x^2 = 0$

Table 3 reflects the performance of the respondents in terms of procedural competence. In scoring, the following rubric was used:

3 points for complete answer,

2 points for partially correct answer, and

1 point for those who attempted to answer

Each method for the procedural competence has a total score of 9 points since there are only 3 questions each. The following verbal descriptions were given to the ratings given.

Legend:

Rating:	*Description*
8.06 – 9.00	Advance
7.61 – 8.05	Proficient
7.16 – 7.60	Approaching Proficient
6.71 – 7.15	Developing
6.70 and below	Beginning

Based on the overall results in Table 3, both the male and female students were in the *beginning level* of their competency on the procedures used in the four areas studied. Among the four areas, their best performance was on extracting square roots. Their poorest performance was on the quadratic formula. Mellony and Stott (2012) pointed out that the increase in the levels of cognitive demand, mathematical complexity, and levels of attraction complement the procedural fluency and written mathematical explanations of students in a problem solving task. As problem solving is at the heart of quantitative literacy, the use of mathematics in everyday life, whether on the job or in private, cannot be taken for granted. There is a need also to look into other factors that may be crying out for systematic understanding.

Table 3 is shown as follows.

Table 3 Mean Performance of the Respondents on the Four Methods of Solving Quadratic Equations

Area	Female		Male		Row Mean	Overall Description
	Mean	Verbal Description	Mean	Verbal Description		
Extracting Square Roots	6.95	Developing	5.89	Beginning	6.48	Beginning
Factoring	5.95	Beginning	4.33	Beginning	5.23	Beginning
Completing the Square	5.45	Beginning	4.44	Beginning	5.00	Beginning
Quadratic Formula	4.23	Beginning	3.83	Beginning	4.05	Beginning
Overall Mean	**5.65**	**Beginning**	**4.62**	**Beginning**	**5.19**	**Beginning**

It is clearly reflected in the table that in all the four methods of solving equations, the performance of the students are all at the *beginning level*. Based on these results many aspects of the curriculum on quadratic equations need to be revisited. In order to have a clearer idea of the level of the respondents' capability with the four methods of solving quadratic equations, sample items are shown as follows. On *Extracting Square Roots*, the first item is

__________________________1.) $x^2 = 16$

Solution:

In this item, the students' understanding on getting the roots is very important. The procedure is basic to find the value of x. It requires the extraction of the square roots of both members of the equation. The symbol for this procedure is the radical sign. If the problem were written in words, it would be *What number when squared is equal to 16?* There were14 of the students who got a perfect score of 3 points, 16 who got a score of 2 points, and 10who got a score of 1 point. It appears as though more than half of the students do not know how to obtain the roots of a square. It may also be a lack of understanding of the square numbers. It may need a revisit to the question *Why is a number called a square?* and if a number is a square *How can the factors be determined?*

The second item is shown as follows.

____________________________2.) $r^2 - 100 = 0$

Solution:

The steps in the procedure would have been *First, write the equation in such a way that the members of the equation are both squares. Second, extract the square roots of the equation* as in number 1. Only 14of the students got a perfect square of 3 points, 17 got 2 points, and 9 got 1 point. Considering the grade level of the respondents, this is supposedly an easy task but the results pegged the students to the level of *beginners*. More discussions and supplementary activities could be a big help to improve their performance. Perhaps the basic processes of determining squares and extracting square roots should be mastered in the lower levels. With mastery of concepts and processes, they should also improve not only their performance in mathematics but also develop self-confidence in solving problems in mathematics and motivation to take on difficult tasks. According to MacGregor (2013), mastery learning is effective in building struggling students' confidence, and developing intrinsic motivation and a willingness to take the risks necessary to reach challenging goals. Mastery of a concept or a skill is very important as it affects students' performance in present or future tasks. Mastery learning is important as it will serve a purpose in later learning (Woolfolk, 2001).

The next item is solved by factoring.

________________________ 4.) $x^2 + 7x = 0$

Solution:

The solution to question number 4 is a procedure where the first step is to bring out the common factor of the given terms. Then equate both factors to 0 to determine the roots. Results showed that only 9 respondents got a perfect score for 3 points, 10 got 2 points, and 21 got a score of 1.There seems to be a confusion in the appropriate procedure to apply. As the task on quadratic equations gradually levels up to higher order processes, the students seem to recede in their capability.

The next question shows three terms in the equation.

$$6.)\ h^2 + 6\text{h} = 16$$

Solution:

The process requires the first step to be expressing the given as a perfect trinomial square followed by factoring. Then the factors are equated to 0. The values of x are obtained by simplifying each equation. In this item, only 13 respondents got a perfect score while 21 students got 1 point. The remaining students got 2 points. The students seem to be unable to deal with tasks of increased level of difficulty.

By Completing the Square

$$9.)\ t^2 + 10\,t + 9 = 0$$

Solution:

In item number 9, there are 3 students who got a perfect score of 9, 3 who got a score of 2 points and 34 got a score of 1 point. This implies that 85% of the class need more practice on completing the square.

By Quadratic Formula

____________________________ 12.) $x^2 + 5x - 14 = 0$
Solution:

Students showed a low performance in quadratic formula. Almost 27 to 34 (or 67.5% to 85%) of the class needs special focus and attention in this process especially in item number 12. This item has the lowest number of scores. Only 4 students got a perfect score of 3 points, 2 students got a score of 2 points, and 34 students got a score of 1 point. Butler and Wren (2001) stated that most of the difficulties which students encountered in Mathematics, could be traced to the inadequacy of the developmental work. This is very true in relation to procedural exercises or activity.

The following table, Table 4, presents the result of the students mean in terms of solving problems with an open-ended questions about quadratic equations.

Table 4
Mean Performance of the Respondents on the Open-ended Questions of Solving Quadratic Equations

Area	Female		Male		Overall Row Mean	Overall Description
	Mean	Description	Mean	Description		
Extracting Square Roots	0.91	Beginning	1.11	Beginning	1.00	Beginning
Factoring	0.68	Beginning	0.67	Beginning	0.68	Beginning
Completing the Square	0.41	Beginning	0.39	Beginning	0.40	Beginning
Quadratic Formula	0.00	Beginning	0.11	Beginning	0.05	Beginning
Overall Mean	**5.65**	**Beginning**	**4.62**	**Beginning**	**5.14**	**Beginning**

The result showed that both male and female of the same process in these four methods are having almost the same level of difficulties in doing problem solving. This observation is consistent as the findings of Santiago (2004) who studied the difficulties in procedural fluency (problem solving area) of the Third year students in 13 public schools in Manila. The difficulties were discovered mostly in solving geometric problems, quadratic equations, and motion problems. She found out that the causes of these difficulties were the inability to understand and analyze mathematical problems, and passed from one process to another. Perhaps there is a need to engage the students in effective learning strategies and techniques that can help students to focus attention and invest effort (elaborate, organize, summarize, connect, translate) so that they can process information deeply and monitor their understanding (Woolfolk, 2001). This would imply that procedural competency of the students depend on level of understanding and developmental activity.

In Table 5, the respondents' means on productive disposition are shown. This result evolved from the 15-item Mathematics Attitude Survey adopted from Servando (2014).

Table 5 Means of the Respondents on Productive Disposition

Item	Female		Male		Overall Mean	Overall Verbal Description
	Mean	Std. Dev.	Mean	Std. Dev.		
1. I can easily learn mathematics.	2.41	0.59	2.33	0.59	2.37	Negative
2. Mathematics is enjoyable and interesting to me.	2.87	0.77	3.18	0.38	3.05	Positive
3. Mathematics is not important in life.	1.86	0.99	1.56	0.98	1.71	Negative
4. I never liked mathematics	1.82	0.66	1.89	0.68	1.86	Negative
5. There is nothing creative about mathematics, it's just memorizing formulas and things.	2.14	0.71	2.39	1.14	2.27	Negative
6. I try to learn mathematics because it helps me think more clearly in general.	3.05	0.38	3.56	0.51	3.31	Positive
7. Using the internet is a good way for me to learn mathematics.	2.32	0.78	2.67	0.91	2.50	Positive
8. Mathematics makes me feel uneasy and confused.	2.73	0.70	2.56	0.78	2.65	Positive
9. Mathematics is needed in order to keep the world running.	2.73	0.77	3.06	0.73	2.90	Positive
10. Mathematics is a solitary activity, done by individuals than art or literature.	2.95	0.72	3.22	0.73	3.09	Positive
11. Mathematics is less important to people than art or literature.	2.32	0.65	2.56	0.86	2.44	Negative
12. Mathematics is needed in designing practically everything.	2.86	0.64	3.00	0.84	2.93	Positive
13. Communicating with other students helps me have a better attitude towards mathematics.	3.00	0.31	3.33	0.49	3.17	Positive
14. I am interested and willing to acquire further knowledge of mathematics.	3.32	0.48	3.22	0.65	3.27	Positive
15. The skills I learn in my math class will help me in solving real life problems.	3.18	0.59	3.39	0.85	3.29	Positive

Legend

Rating:	*Description*
2.50 – 4.00	Positive
1.00 – 2.49	Negative

The statements above where they show positive answers had been justified when they gave a negative dispositions of the following statements: 4) I never liked mathematics, with a mean of 1.82; 3) Mathematics is not important in everyday life, with 1.86 mean; and 5)There is nothing creative about mathematics, it's just memorizing formulas and things. This results revealed that female respondents have a positive and favorable dispositions in math.

It can be noted that female students got the highest mean of 3.32 in statement number 14which states that *I am interested and willing to acquire further knowledge of mathematics.* This is followed by statement number 15 which states that *The skills I learn in my math class will help me in solving real life problems* with a mean of 3.18.In statement number 6, *I try to learn mathematics because it helps me think more clearly in general* student got a mean of 3.05.

Male respondents also showed their positive disposition when they got 3.56 mean in statement number 6, *I try to learn mathematics because it helps me think more clearly in general*. They also revealed the same result in statement number 15 *The skills I learn in my math class will help me in solving real life problems* with a mean of 3.39. Also in statement number 13 *Communicating with other students helps me have a better attitude towards mathematics* got 3.33 of mean.

Cangas (2008), believed that the students' positive disposition towards learning Mathematics help improve their conceptual understanding of the subject. The family relation, personal and social needs of the learners, school environment, classroom atmosphere, and pupil-teacher relationship also influence their learning. Therefore school teachers must help build a good school climate to motivate the learners to study harder.

Problem 3:**Is there a significant relationship among the conceptual understanding, procedural competence, and productive disposition of the respondents?**

The table that follows shows the relationship among conceptual understanding and procedural competence; conceptual understanding and productive disposition; procedural competence and productive disposition; conceptual understanding and mathematics performance; procedural competence and mathematics performance; and productive disposition and mathematics performance .

Table 6 Relationships among Conceptual Understanding, Procedural Competence, and Productive Disposition of the Respondents

Paired Variables	Correlation Coefficient	p-value	Interpretation
Conceptual Understanding and Procedural Competence	.635**	.000	Very significant
Conceptual Understanding and Productive Disposition	-.212	.188	Not significant
Procedural Competence and Productive Disposition	-.140	.388	Not significant
Conceptual Understanding and Math Performance	.564**	.000	Very significant
Procedural Competence and Math performance	.485**	.002	Very significant
Productive Disposition and Math Performance	-.016	.920	Not significant

******Correlation is significant at the 0.01 level (2-tailed)

Table 6 reveals that there is a very significant relationship between conceptual understanding and procedural competence with a p-value of 0.000. This shows that if students understand the right concepts in quadratic equations it would not be difficult for them to perform the procedures. There is also a very significant relationship between conceptual understanding and mathematics performance with an r-value of 0.564 and a p-value of 0.000. It appears that if the students have a high level of conceptual understanding then their mathematics performance is also high. Low level of conceptual understanding will also result in low mathematics performance. Procedural competence and mathematics performance also are *very significantly* correlated as shown in the table. This is consistent with Kim and Davidenko's (2006) findings where conceptual understanding and procedural competence were found to be *very significantly correlated*.

Problem4:**Which among the conceptual understanding, procedural competence, and productive dispositions best explain variability in the mathematics performance of the respondents?**

In order to answer this question, regression analysis was conducted.

In the model summary, the adjusted R^2 of .303 indicates that 30.3% of the variability in the mathematics performance is jointly explained by conceptual understanding, procedural competence, and productive disposition. The t test resulting in a t-value of 2.581 and a p-value of .014 for conceptual understanding implies significant results.

Moreover, in the F test resulting in an F-value of 6.662 and a p-value of .001 also indicates significance of the whole model. The tests are significant at the 0.05 level. Some values in the regression analysis are found in Table 7.

Table 7
Regression Values

Model 1	***Beta***	***Std. Error***	***Beta Coefficient***	***t-value***	***p-value***
Conceptual	.825	.320	.452	2.581	.014
Procedural	.196	.159	.213	1.233	.226
Pdatt	.192	.240	.109	.800	.429

Dependent variable: math performance

As shown in the table, among the independent variables (conceptual understanding, procedural competence, and productive dispositions) the best explanation for mathematics performance is provided by conceptual understanding with a Beta value of .452.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATION

This chapter presents the summary of the important findings of the study including the conclusions and recommendations based on the given problems of the study.

Summary

This research was conducted to describe the competencies of the respondents in terms of their conceptual understanding, procedural competence, and productive dispositions of the Grade Nine students of Carmona National High School, Carmona, Cavite in school year 2014-2015. The respondents were composed of 40 students 22 were girls and 18 boys. Random sampling was used to select the respondents in this study. The aim of this study was to determine the respondents' conceptual understanding as well as their procedural competence in terms of solving quadratic equations using the four methods: extracting square roots, factoring, completing the square and by the use of quadratic formula. Other than conceptual understanding and procedural competence, the respondents' disposition in life towards mathematics was also determined.

To interpret the students' score in conceptual understanding, procedural competence and productive dispositions a developed test was used. Mathematics performance was based on students' long test result during the first quarter of the school year.

Findings

From the results gathered of this study, the following findings were obtained.

1. The students' mathematics performance based on a 50-itemquarterly test revealed a mean of 18.53 which is described as *beginning level*.
2. In the developed test, results show that the students' overall mean of 12.75 in conceptual understanding is described to be in the *beginning level*. The same is true in procedural competence where four methods were looked into both in solving equation and in answering open-ended questions. In the method of extracting square roots, students got a mean of 6.48 that is in the *beginning level*. In factoring, the mean was 5.23; in completing the square, the mean was 5.00; and in the use of quadratic formula, the mean was 4.05 mean. All these means are described as *beginning level*. However, students showed *positive dispositions* in Mathematics.
3. The results showed that there is a significant relationship exist between conceptual understanding and procedural competence with an r value of 0.635 and a p-value of 0.000 at the 0.01 level of significance. Between conceptual understanding and mathematics performance, the r value is 0.564 and a p-value of 0.000 which is very significant at the 0.01 level. A significant relationship also exists between procedural competence and mathematics performance with an r value of 0.485 and a p-value of 0.002. However, the remaining variables conceptual understanding, procedural

competence, and mathematics performance are not significantly correlated to productive disposition.

4. The result revealed that the best explanation for mathematics performance is provided by the conceptual understanding.

Conclusions

The following conclusions were drawn from the findings of the study.

1. The students' mathematics performance based on a 50-item test are in the *beginning level* of proficiency, this implies as lack of understanding of the lessons, lack of memory retention or any other factors may affect.
2. The conceptual understanding of the students is still to be nourished with more discussions, exercises, and activities applicable to real-life situations. The same is true for procedural competence. The students have positive dispositions in mathematics.
3. Conceptual understanding and procedural competence are the main factors that affect mathematics performance of the students.
4. Conceptual understanding best explains variability in the mathematics performance of the students.

Recommendations

The following recommendations are made based on the findings and the conclusions of this study.

1. Mathematics teachers must pay attention to the needs of individual students in learning quadratic equations. They should ensure that each of them understands and learns the lessons being taught.
2. Giving intervention is a big help to improve students' performance in math. Ensuring that their understanding of the concepts are clear , and providing a different multi-step problem solving which will be guided by the teacher can enhance and develop their ability to think, conceptualize, and analyze things around them.
3. Mathematics educators have a vital role in raising students' performance. Knowing that conceptual understanding and procedural competence are key variables in students' mathematics performance, teachers should emphasize these in their instructional practices. Giving more exercises and activities is a big contribution to enhance performance in mathematics.
4. Further research should be conducted to identify other variables that affect students' performance in mathematics.

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APPENDICES

CURRICULUM VITAE

Personal Information

Name:	LENETH N. AUGUIS
Date of Birth:	September 1, 1983
Place of Birth:	Bais City, Negros Oriental
Address:	Yakal, Silang, Cavite
Gender:	Female
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Educational Background

Bachelor's Degree:	University of Perpetual Help GMA – Campus (2000-2004) Bachelor of Secondary Education (Major in Mathematics)
Secondary:	Bais City High School (1996-2000) Bais City, Negros Oriental
Elementary:	Okiot Elementary School (1990-1996) Bais City, Negros Oriental
Pre-Elementary:	Okiot Day Care Center (1989-1990) Bais City, Negros Oriental

Government Examination Passed

Licensure Examination for Teachers (2004)

APPENDIX B

CARMONA NATIONAL HIGH SCHOOL
Carmona, Cavite

FIRST QUARTER TEST
Grade 9 - Mathematics

KNOWLEDGE

I. MULTIPLE CHOICE: Read the questions carefully and write your correct answer on the space provided.

_____________1. The equation $2x^2 -4x + 5 = 0$ has __________________ root(s).

a. One b. Two c. Three d. No Real

_____________2. Which number is irrational?

a. $\sqrt{81}$ b. -18 c. 7/9 d. $\sqrt{60}$

_____________3. In the quadratic equation $3x^2 + 7x – 4 = 0$, which is quadratic term?

a. x^2 b. 7x c. $3x^2$ d. -4

_____________4. If *ab* = 0, then either *a* = 0 or *b* = 0, or both *a* and *b* are 0.

a. zero product property b. zero property

c. product property d. property

_____________5.The equation $x^2 + 6 = 0$ has a degree of

a. 1 b. 3 c. 2 d. 0

_____________6. What is the domain of the function represented by the list of ordered pairs?{(0, 2), (-3, 6), (4, 8), (2, 5), (-2, 4)}

a. {2,4,5,6,8}   c. {0,4,6,8}

b.{-3,-2,0,2,4}   d. all real numbers

_____________ 7. Which of the following does not represent a quadratic function?

a. $y = (x - 3)^2 + 8$ b. $y = (x + 6) - 2$

c. $y = 3x^2 - 7x + 2$ d. $y + 3 = x^2$

II. IDENTIFICATION: Identify what is being asked.

For numbers 8 - 10, Identify the a, b, and c values for the equation $x^2 + 5x - 3 = 0$.

__ a = ____8.   _____ b = _____9.   _____ c = _____10.

For numbers 11 - 13, Given the discriminant of a quadratic, tell if it has *two solutions*, *one solution*, or *no real solution*.

_____________11**.** Discriminant = 0

_____________12. Discriminant = - 76

_____________13. Discriminant = 96

_____________14.The standard form of a quadratic equation is________

_____________15.In the equation $ax^2 + bc + c =0$ the expression ($b^2 - 4ac$) is called

PROCESS:

I. For numbers 1 -3, draw a line from each quadratic equation in Column A to an equivalent equation in Column B.

Column A	*Column B*
1. $x^2 + 3x + 18 = 5x + 11$	$2x^2 + x + 1 = 0$
2. $3x^2 + x = x^2 - 1$	$9x^2 + 30x + 25 = 0$
3. $(3x + 5)^2 = 0$	$x^2 - 2x + 7 = 0$

II. For numbers 4 – 20, choose the letter of the correct answer.

_____________4.Use the quadratic formula to find the solutions to the equation

$2x^2 + 7x + 4 = 0$

a. $\dfrac{7 \pm \sqrt{17}}{2}$ b. $\dfrac{7 \pm \sqrt{32}}{2}$

c. $\dfrac{-7 \pm \sqrt{17}}{4}$ d. $\dfrac{-7 \pm \sqrt{32}}{4}$

_____________5. Find the solutions to the equation $x^2 - 3x - 10 = 0$

a. 5 or -2 b. 1 or -1 c. 2 or 7 d. 1 or 5

_____________6. What is the sum of the roots of the quadratic equation $2x^2 + 6x - 8 = 0$?

a. -7 b. -3 c. 6 d. 8

_____________7. Which quadratic equation is written in standard form?

a. $8x + 5x^2 - 9 = 0$ b. $5x^2 + 8x = 9$

c. $5x^2 + 8x - 9 = 0$ d. $9 - 8x - 5x^2 = 0$

_____________8. What are the solutions for the equation$x^2 + 6x = 16$?

a. -2 & -8 b. -2 & 8 c. 2 & -8 d. 2 & 8

______________9. Find the discriminant of the function $x^2 – 5x = 0$

a. 25 b.21 c. 1 d. 29

______________10.Which of the following values of *x* make the equation $x^2 + 7x – 18 = 0$

true? I. -9 II. 2 III. 9

a. I and II b. II and III c. I and III d. I, II, and III

_____________11. Solve the equation using square roots. $x^2 – 15 = 34$

a. ±7 b. 7 c. no real number solutions d. ±49

_____________12.Complete the square on $y = x^2 - 6x + 10$ to write it in the

form $y = a(x - h)^2 + k$.

a. $y = (x - 3)^2 + 9$ c. $y = (x - 3)^2 - 9$

b. $y = (x - 3)^2 + 19$ d. $y = (x - 3)^2 + 1$

_____________13. What is the vertex for $y = -2(x - 1)^2 + 4$?

a. (1, 4) b. (−1, 4) c. (−2, 4) d. (2, 4)

_____________14. The larger root of the equation $(x + 4)(x - 3) = 0$ is

a. -4 b. -3 c. 3 d. 4

_____________15. Toni is solving this equation by completing the square. $ax^2 + bx + c = 0$

(where a > 0)

Step 1: $ax^2 + bx = -c$

Step 2: $x^2 + \frac{b}{a}x = -\frac{c}{a}$

Step 3: ?

Which should be Step 3 in the solution?

a. $x^2 = -\frac{c}{b} - \frac{b}{a}x$

c. $x + \frac{b}{a} = -\frac{c}{ax}$

b. $x^2 + \frac{b}{a}x + \frac{b}{2a} = -\frac{c}{a} + \frac{b}{2a}$

d. $x^2 + \frac{b}{a}x + \left(\frac{b}{2a}\right)^2 = -\frac{c}{a} + \left(\frac{b}{2a}\right)^2$

____________16. In order to complete the square, what number should be added to both sides of the equation below? $x^2 + 12x +$ ____ $= 13 +$ _____

a. 6 b. 36 c. 144 d. 169

____________17. Write $y = 2x^2 + 12x + 14$ in vertex form.

a. $y = 2(x + 12)^2 + 14$

c. $y = (x + 3)^2 + 14$

b. $y = 6(x + 9)^2 - 4$

d. $y = 2(x + 3)^2 - 4$

____________18.The length of a rectangular window is 5 feet more than its width, *w*. The area of the window is 36 square feet. Which equation could be used to find the dimensions of the window?

a. $w(w + 5) = 36$

c. $w + w + 5 = 36$

b. $w(w - 5) = 36$

d. $2w + 10 = 36$

___________19. Consider the equation $3x^2 - 44 = x^2 + 84$.Which statement is correct?

a. The equation has exactly one solution.

b. The equation has two solutions.

c. The equation has no real solution.

d. The number of solutions cannot be determined.

____________20. Describe the type of solutions: $\frac{-5 \pm \sqrt{8}}{2}$

a. 2 rational solutions

b. 1 rational solution

c. 2 irrational solutions

d. no solutions

UNDERSTANDING:

I. Answer the following questions.

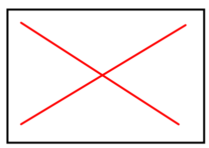
1. Is $2x - 7 = 15$ a quadratic equation? Explain why or why not.

2. Find and correct the error at the right.

$x^2 + 36 = 0$

$x^2 = -36$

$x = \pm 6$



3. Jamilla and Ryan solved $3x^2 - 5x = 6$ using the quadratic formula. Who entered the values in the formula incorrectly? Explain.

Jamilla: $x = \dfrac{-(-5) \pm \sqrt{(-5)^2 - 4(3)(-6)}}{2(3)}$

Ryan: $x = \dfrac{-5 \pm \sqrt{5^2 - 4(3)(-6)}}{2(3)}$

4. Complete the following information about the graph.

Vertex:

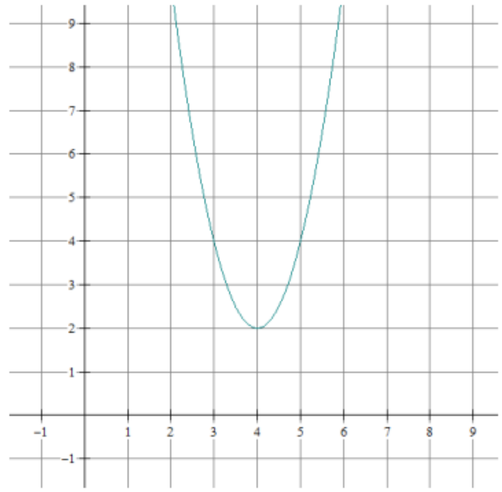
Axis of symmetry:

Direction of opening:

Maximum or minimum value:

Domain:

Range:



<u>PRODUCT:</u>

What are My Dimensions?

Directions: Use the situation below to answer the questions that follow.

The length of a rectangular floor is 5 m longer than its width. The area of the floor is 84 m^2.

Questions:

1. What expression represents the width of the floor? How about the expression that represents its length?
2. Formulate an equation relating the width, length and the area of the floor. Explain how you arrived at the mathematical sentence.
3. How would you describe the equation that you formulated?
4. Using the equation, how will you determine the length and width of the floor?
5. What is the width of the floor? How about its length?

APPENDIX A

Levels of Proficiency (DepEd, 2012)

Republic of the Philippines
Department of Education

DepEd Order No. 73, series 2012
Enclosure No. 1: General Guidelines for the Assessment and Rating of Learning Outcomes.

Levels of Proficiency

The performance of students shall be described in the report card, based on the following levels of proficiency:

a. **Beginning (B)** – The students at this level struggles with his/her understanding: prerequisite and fundamental knowledge and/or skills have not been acquired or developed adequately to aid understanding.
b. **Developing (D)** – The student as this level possesses the minimum knowledge and skills and core understanding, but needs help throughout the performance of authentic tasks.
c. **Approaching Proficiency (AP)** – The student at this level has developed the fundamental knowledge and skills and core understanding and, with little guidance from the teacher and/or with some assistance from peers, can transfer these understandings through authentic performance tasks.
d. **Proficient (P)** – The students at this level has developed the fundamental knowledge and skills and core understanding, and can transfer them independently through authentic performance tasks.
e. **Advanced (A)** – The student at this level exceeds the core requirements in terms of knowledge, skills, and understandings, and can transfer them automatically and flexibly through authentic performance tasks.

The level of proficiency at which student is performing shall be based on a numerical value which is arrived at after summing up the results of the student's performance on the various levels of assessment. The numerical values are as follows:

Levels of Proficiency DepEd Order No. 73 (2012)	
Levels of Proficiency	Equivalent Numerical Value
Beginning	74 % and below
Developing	75-79%
Approaching Proficiency	80-84%
Proficient	85-89%
Advanced	90% and above

APPENDIX D (Final Draft)

MATHEMATICS PERFORMANCE TEST

Name: ________________Grade and Section: _________________Date: _____________

I. Conceptual Understanding

Encircle the letter of the correct answer.

1. Which of the following represents a quadratic equation?

A. $2r^2 + 4\text{r} - 1$

B. $3t - 7 = 2$

C. $s^2 + 5\text{s} - 4 = 0$

D. $2x^2 - 7x \geq 3$

2. Which of the following suggests a quadratic equation?

A. The exponent of the equation is 1

B. It has the inequality sign

C. The highest degree of the exponent is 2

D. The equation is equal to zero

3. What is the highest degree of exponent in a quadratic equation?

A. 1

B. 2

C. 3

D. 4

4. Which of the following equations is quadratic?

A. $3m + 8 = 15$

B. $x^2 - 5x + 10 = 0$

C. $12 - 4x = 0$

D. ½ (h-6) = 0

5. What is the standard form of a quadratic equation?

A. $ax^2 + \ b + c = 0$

B. $ax^2 + bx + c = 0$

C. $ax^2 + bx = c$

D. $ax^2 - bx = c$

6. Which quadratic equation is written in standard form?

A. $8x + 5x^2 - 9 = 0$

B. $5x^2 + 8x - 9 = 0$

C. $5x^2 + 8x = 9$

D. $9 - 8x - 5x^2 = 0$

7. Which of the following is the same as $(x - 4)^2 + 8 = 0$ in standard form?

A. $x^2 - 4x + 24 = 0$

B. $x^2 - 8x + 24 = 0$

C. $x^2 - 8x + 16 = 0$

D. $x^2 - 4x + 16 = 0$

8. What are the values of the constants $a, b,$ and c of the quadratic equation $2x(x - 3) = 15$?

A. $a = 2,\ b = -6,\ c = -15$

B. $a = 2,\ b = 6,\ c = 15$

C. $a = 2,\ b = -6,\ c = 15$

D. $a = 2,\ b = 6,\ c = -15$

9. What is the constant term of the quadratic equation $2x^2 + 5x - 3 = 0$?

A. 5

B. -3

C. 2

D. 1

10. What is a polynomial equation of degree two that can be written in the form $ax^2 + bx + c = 0$ where $a, b,$ and c are real and$a \neq 0$?

A. Linear Equation

B. Linear Inequality

C. Quadratic Equation

D. Quadratic Inequality

11. How would you express $3x(x-2) = -7$ in standard form?

A. $3x^2 - 2 = -7$

B. $3x^2 - 6x + 7 = 0$

C. $3x^2 + 2 - 7 = 0$

D. $3x^2 - 6x - 7 = 0$

12. What expression do we use in getting the discriminant of a quadratic equation?

A. $b^2 - 4ac$

B. $b - 4ac$

C. $b^2 + 4ac$

D. $b + 4ac$

13. What is the nature of the roots of the quadratic equation if the value of its discriminant is zero?

A. The roots are not real

B. The roots are irrational and not equal

C. The roots are rational and not equal

D. The roots are rational and equal

14. What is the degree of the equation $x^2 + 6 = 0$?

A. 1

B. 3

C. 2

D. 0

15. To complete the expressions on both sides of the equation $x^2 + 12x +$ _____ $= 13 +$ _____ , what should be done?

A. Add 6

B. Add 36

C. Add 144

D. Add 169

16. If $ab = 0$, then either $a = 0$ or $b = 0$, or both a and b are 0. What property is this?

A. Zero Product Property

B. Zero Property

C. Product Property

D. Property

17. Identify the roots of an equation $x^2 = k$, if $k = 0$.

A. $x^2 = k$ has no real solution or root

B. $x^2 = k$ has three real solutions or roots

C. $x^2 = k$has two real solutions or roots

D. $x^2 = k$ has one real solution or root

18. What is the first step that you are going to do if you solve the equation

$x^2 + 3x - 18 = 0$ by completing the square?

A. add 18 to both sides

B. add 3 to both sides

C. add -18 to both sides

D. add -3 to both sides

19. What is the sum of the roots of the quadratic equation $x^2 + 3x - 18 = 0$?

A. -7

B. -3

C. 6

D. 14

20. Which of the following is the formula in getting the sum of the roots of the quadratic

equation $ax^2 + bx + c = 0$?

A. -b/a

B. b/a

C.$-a/b$

D. a/b

21. What are the roots of the quadratic equation $x^2 + x - 56 = 0$?

A. 2 and -1

B. 8 and -7

C. -8 and 7

D. 3 and -2

22. One of the roots of $2x^2 - 13x + 20 = 0$ is 4. What is the value of the other root?

A. -2/5

B. -5/2

C. 2/5

D. 5/2

23. In solving quadratic equation $x^2 + 9x = -8$ by factoring, what will be the first step that you are going to do?

A. Add to both sides of the equation the square of one-half of 9

B. Express $x^2 + 9x = -8$ as a square of a binomial

C. Transform the quadratic equation into standard form $ax^2 + bx + c = 0$

D. Determine the values of a, b, and c

24. What are the roots of $x^2 + 10x + 9 = 0$?

A. $x = -1$ or $x = -9$

B. $x = -1$ or $x = 9$

C. $x = 1$ or $x = 9$

D. $x = 1$ $orx = -9$

25. If you evaluate the $\frac{-5\pm\sqrt{8}}{2}$, the results would be

A. $x = \frac{-5\pm2\sqrt{2}}{2}$

B. $x = \frac{-5-2\sqrt{2}}{2}$

C. $x = \frac{-5+2\sqrt{2}}{2}$

D. $x = \frac{-5+3\sqrt{2}}{2}$

II. Procedural Competence

Solve the following quadratic equations using the indicated method. Show your *complete* solution on the space provided for each. Then write the answer on the blank before each item number.

***Scoring Rubric*:**

1 point	Attempted to answer
2 points	Partially correct answer
3 points	Correct answer

A. *By Extracting Square Roots*

___________________________1.) $x^2 = 16$

Solution:

____________________________2.) $r^2 - 100 = 0$

Solution:

____________________________3.) $t^2 = 81$

Solution:

B. *By Factoring*

Solution: ______________________________ 4.) $x^2 + 7\text{x} = 0$

Solution: ______________________________ 5.) $x^2 + 9x = -8$

Solution: ______________________________ 6.) $h^2 + 6\text{h} = 16$

C. *By Completing the Square*

Solution: ______________________________ 7.) $x^2 - 2x = 3$

Solution: ______________________________ 8.) $s^2 + 4\text{s} - 21 = 0$

Solution: ______________________________ 9.) $t^2 + 10t + 9 = 0$

D. *By Quadratic Formula*

____________________________10.) $x^2 + 10x + 9 = 0$

Solution:

____________________________11.) $x^2 - 12x + 35 = 0$

Solution:

____________________________12.) $x^2 + 5x - 14 = 0$

Solution:

Solve the following problem by using the indicated method.

Scoring Rubric: 1 point for every correct answer

E. Problem Solving: Extracting Square Roots

Mr. Cayetano plans to install a new exhaust fan in his room's square-shaped wall.*He asked a carpenter to make a square opening on the wall where the exhaust fan will be installed. The square opening must have an area of 0.25* m^2

1. Draw a diagram to illustrate the given situation.

____

2. What expression represents the length of a side of the square-shape wall?

____

3. Suppose the area of the remaining part of the wall after the carpenter has made the square opening is $6m^2$. What equation would describe the area of the remaining part of the wall?

____

4. How will you find the length of a side of the wall?

____

5. What is the length of a side of the wall?

____

F. Problem Solving: Factoring

A rectangular metal manhole with an area of 0.5 m^2 is situated along a cemented pathway. The length of the pathway is 8 m longer than its width.

1. Draw a diagram to illustrate the given situation.

____

2. How are you going to represent the length of the pathway?

____

3. How about the width of the pathway?

____

4. What expression showing the length and the width would represent the area of the cemented portion of the pathway?

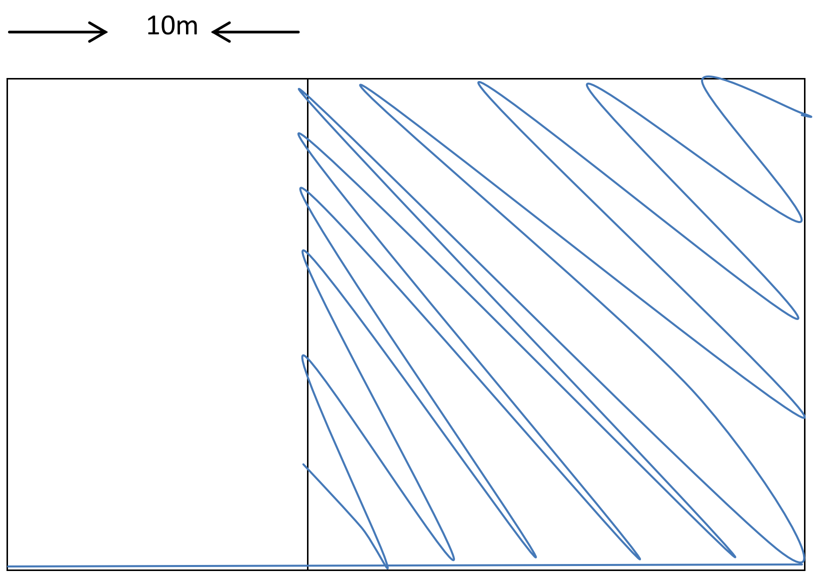
____

5. Suppose the area of the cemented portion of the pathway is 19.5 m^2, what equation would describe its area?

____

G. Problem Solving: Completing the Square

The shaded region of the diagram shows the portion of a square-shaped car park that is already cemented. The area of the cemented part is 600 m^2. Use the diagram to answer the following questions.



1. What expression represents the length of the side of the car park

2. How about the width of the cemented portion?

3. What equation would represent the area of the cemented part of the car park?

4. Using the equation formulated, how are you going to find the length of a side of the car park?

H. Problem Solving: Quadratic Formula

Mr. Bonifacio would like to enclose his two adjacent rectangular gardens with70.5 m of fencing materials. The gardens are of the same size and their total area is 180 m^2.

1. How would you express the dimensions of each garden?

2. What mathematical sentence would represent the length of fencing material to be used in enclosing the two gardens?

3. What mathematical sentence would represent the total area of the two gardens?

____

4. How will you find the dimensions of each garden?

____

5. What equation will you use in finding the dimensions of each garden?

____

6. How would you describe the equation formulated in item 4?

____

MATHEMATICS ATTITUDE SURVEY
(Servando, 2014)

Name: __________________Grade and Section: _______________Date: _____________

III. Productive Disposition

Put a check mark (/) in the box corresponding to your answer.

Question	Strongly Agree	Agree	Disagree	Strongly Disagree
	4	3	2	1
1. I can easily learn mathematics.				
2. Mathematics is enjoyable and interesting to me.				
3. Mathematics is not important in everyday life.				
4. I never liked mathematics.				
5. There is nothing creative about mathematics; it's just memorizing formulas and things.				
6. I try to learn mathematics because it helps me think more clearly in general.				
7. Using the internet is a good way for me to learn mathematics.				
8. Mathematics makes me feel uneasy and confused.				
9. Mathematics is needed in order to keep the world running.				
10. Mathematics is a solitary activity, done by individuals than art or literature.				
11. Mathematics is less important to people than art or literature.				
12. Mathematics is needed in designing practically everything.				
13. Communicating with other students helps me have a better attitude towards mathematics.				
14. I am interested and willing to acquire further knowledge of mathematics.				
15. The skills I learn in my math class will help me in solving real life problems.				

APPENDIX E

TABLE OF SPECIFICATIONS (FINAL)

Topics	Number of Days Taught	Under-standing	Pro-cess	Number of Items	Item Placement
Introduction to Quadratic Equations	3	12	0	12	1, 2, 3, 4, 5, 6,7, 10, 11, 13, 12, 22
Solving Quadratic Equations by Extracting Square Roots	3	4	5	9	16, II.A.1-3, II.E.1-5
Solving Quadratic Equations by Factoring	3	4	6	10	15, 23, II.B.4-6 II.F.1-5
Solving Quadratic Equations by Completing the Square	4	4	5	9	14, 17, II.C.7-9 II.G.1-4
Solving Quadratic Equations by the Quadratic Formula	3	5	7	12	20, 21,24, II.D.10-12 II.H.1-6
Nature of Roots	2	2	1	3	8, 9, 25
Sum and Product of Quadratic Equations	2	2	0	2	18,19
TOTAL	**20**	**33**	**24**	**57**	