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Critical Thinking Skills in Problem Solving of Grade Eight Students in Mathematics

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CRITICAL THINKING SKILLS IN PROBLEM SOLVING OF GRADE EIGHT STUDENTS IN MATHEMATICS

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Jerson D. Jolo

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APPROVAL SHEET

This seminar paper entitled **"CRITICAL THINKING SKILLS IN PROBLEM SOLVING OF GRADE EIGHT STUDENTS IN MATHEMATICS"** prepared and submitted by **JERSON D. JOLO,** in partial fulfillment of the requirements for the degree, **Master of Arts in Teaching Mathematics**, has been examined and recommended for acceptance.

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I humbly thank GOD ALMIGHTY for the strength he has given me throughout my life…

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DEDICATION

I dedicate this seminar paper to
my grandparents, Maxima and Tomas
my mother, siblings,
relatives, wife and
to my newly born daughter,
Jeanelle Marianne.

ABSTRACT

NAME:	Jerson D. Jolo
TITLE:	Critical Thinking Skills in Problem Solving of Grade Eight Students in Mathematics
KEY CONCEPTS:	critical thinking, problem solving and mathematical ability
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The study aimed to describe the critical thinking in problem solving of selected grade eight students in Mathematics particularly the level of critical thinking skill in problem solving of the participants in terms of analyzing the problem situation, making decision, monitoring progress and evaluating the completed solution. Moreover, the study sought to determine if there was a significant difference between the level of critical thinking skills in problem solving when the participants were grouped according to gender and mathematical ability. A descriptive research method was used since the data obtained were narrative descriptions and observations occurring in more natural and less controlled research setting. Stratified sampling was utilized in selecting the population of the study. There were two instruments used in this study. The critical thinking test that was given to the students as an effective basis for evaluation to show the level of their critical thinking on problem solving skills and scoring rubrics which were used to know the critical thinking on solutions made by the students. It was found out

that all students showed advanced level in analyzing the problem situation aspects of critical thinking. However, the other aspect of critical thinking was not seen in some of their solutions namely: monitoring progress, evaluating the completed solution and making decision aspects of critical thinking. Gender cannot be considered as factor affecting the critical thinking of the students and mathematical ability can be linked as a factor affecting the critical thinking of the students.

TABLE OF CONTENTS

V. Findings, Summary, Conclusions and Recommendations

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER I

THE PROBLEM AND ITS BACKGROUND

Introduction

Since time immemorial, schools have sought to develop in their students, thinking abilities that would conform to their lives as learners. The future belongs to societies which prepare students for learning. The job market is getting more difficult for the university graduates. Employers are in constant search for employees who possess innovative and creative abilities to solve problems. This includes the proper way of gathering information, its organizing and subsequent analyzing. Moreover they expect employees to be able to arrive at right conclusions and provide the appropriate feedback on the process. All these skills are vital components of critical thinking. The development of critical thinking skills is so important that most scholars believe that it is an indispensable tool for academic education.

Critical thinking is regarded as one of the tools commonly used in problem solving as logical reasoning, interpretation, analysis and evaluation of information proceed from it which will enable a learner to arrive at well-founded and accurate decisions (Barry, et. al., 2013). It is noteworthy to cite the findings of Adedayo (2014), in his study which revealed that "critical thinking is a complex concept that involves cognitive skills and affective dispositions, and this has affected the way some teachers impart the concepts to the students." It reveals that other educators find it hard in integrating the concept in their actual teaching that will make students learn how to think critically (Adedayo, 2014). A common observation is that learners find it difficult to understand the concept and obtain dismal performances specifically on tests and examinations in

Mathematics. Efforts in collecting, interpreting, analyzing and evaluating information that leads in arriving at a reliable and valid conclusion are the requirements to have a critical thinking.

Complementarily, problem solving is a mental process whereby an individual utilizes previous knowledge and experience to respond to the requirements of an unfamiliar situation. The response should seek out the conflict or ambiguity of the situation. Problem solving and critical thinking refer to the ability to use knowledge, facts, and data to effectively solve problems. This doesn't mean one needs to have an immediate answer, it means one has to be able to think on one's feet, assess problems and find solutions. The ability to develop a well - thought out solution within a reasonable time frame, however, is a skill that employers value greatly.

The art of calculation is as old as man and critical thinking has been one of the tools used in our daily lives to deal with the challenges for survival. On a daily basis people are faced with decisions that require reasoning, understanding, and interpretation, analysis and evaluation of information before them. This process involves critical thinking because it would enable one to take reliable and valid decisions, act ethically, and be able to adapt to changes in any given environment.

In teaching Mathematics in schools, critical thinking needs to be integrated and emphasized in the curriculum so that students can learn the skills and apply it to improve their performance and reasoning ability. It is this therefore imperative on teachers to infuse critical thinking skills to teach Mathematics in their classrooms.

This means that ideas and suggestions from people about a phenomenon cannot be fully accepted if it does not go through the systematic and logical process of finding the truth. In

applying critical thinking in school settings, it is necessary to develop thinking skills because people who think critically would be able to understand the logical connections between ideas construct and evaluate arguments, detect common mistakes in reasoning and solve problems systematically.

Mathematics being an important subject in modern society is useful in schools, workplaces, businesses and for personal decision-making. Mathematics is seen to be a language for everyday use whether in the market place, schools or even at home. Mathematics is fundamental to national prosperity in providing tools for understanding Science, Engineering, Technology and Economics despite the importance placed on Mathematics by the society it has been observed that some students lack interest in the subject and perform poorly in it (Kulbir, 2013). Furthermore, learning mathematics involves more than basic knowledge of facts, skills and procedures. It has a crucial involvement of conceptual structures, the general strategies in solving problems, attitudes towards the subject and appreciation of mathematics (Ernest, 2010).

The National Achievement Test results conducted from 2006 to 2012 showed that, on the average, less than 50% of the students passed Mathematics at credit level. This may be attributed to many factors traceable to the students, teachers, policy makers, content of the curriculum and the quality of the examination. Reasons for the continued poor performance of students in Mathematics could among others be attributed to the students' inability to think critically and analyze Mathematical concepts systematically (Osarenren et. al., (2010). This further bolsters the assumption that critical thinking is an essential tool required to enhance student performance in all subjects especially in Mathematics.

In a study conducted by Cabahug and Ladot (2008), they found out that students at the University of the Philippines perform poorly in Mathematics. According to their findings repetition in mathematics course is very common among UP students. However, the faculty of the UP Cebu Natural Science and Mathematics Division or NSMD have stressed out that there is a deteriorating performance in basic mathematics. It has been reiterated that attitude and achievements towards mathematics has always been a big issue.

Students have difficulty in performing critical thinking in problem solving due to the following reasons as observed by Hewson in his study "Overly Procedural thinking**;** lack of ability to translate mathematical meaning to real-world meaning**;** lack of ability to make approximations or estimations**;** lack of multi-step problem solving skills**;** lack of practice**;** lack of confidence and lack of mathematical interest" (Hewson, 2011)**.**

The present scenario prompted the researcher to conduct a study regarding the critical thinking skills in problem solving of the students in mathematics. The study underscores the importance of determining critical thinking in problem solving skills of grade 8 students in mathematics to enhance their competency as regards problem solving. Results of the study will aid the institution in coming up with a program focusing on enhancing the critical thinking of the students.

Maryhill College aims to develop top caliber students who are flexible especially in the field of calculation. However, it is a common observation that most of their students perform below par in Mathematics. This setback poses as a challenge to the teachers on how to enhance the skills of the students specifically on solving mathematical problems. Researches strongly claim

that critical thinking accounted as one of the factors affecting the skills of the students as regards mathematics. Thus, teachers need to be aware of the strategies to strengthen the critical thinking skills of the students in order to improve their performance in the same field.

The primary aim in conducting this research is to assess the critical thinking in problem solving of grade 8 students of the Basic Education Department of Maryhill College. As such, the findings of the study may contribute to the awareness of the different institution to take an action and find room for addressing the problem of the students regarding the importance of critical thinking in problem solving. Furthermore, the findings of the study will serve as an essential source of information to facilitate development of program that will facilitate the enhancement of the critical thinking skills of the students specifically with regard to improving their problem solving skills in mathematics.

Conceptual Framework

According to Lewis and Smith, "philosophy and psychology are the two primary academic disciplines of critical thinking". (Lewis & Smith, 2013). Sternberg (2006), also stressed that "A third critical thinking strand exist within the field of education." "These separate academic strands have developed different approaches to define critical thinking that reflect their respective concerns."

A philosophical approach toward critical thinking is clearly described in the writings of Socrates, Plato, Aristotle, and more recently, Matthew Lipman (2008) and Richard Paul (2012). Thayer-Bacon (2010) in his study found and stressed that "This approach focuses on the hypothetical critical thinker, enumerating the qualities and characteristics of this person rather than

the behaviors or actions the critical thinker can perform." Sternberg (2006) also shared the observation that "This school of thought approaches the critical thinker as an ideal type, focusing on what people are capable of doing under the best of circumstances." Richard Paul (1992) shared a different point of view looking at critical thinking in the context of "perfections of thought."

Facione (2010), in his work stressed that "This preoccupation with the ideal critical thinker is evident in the American Philosophical Association's consensus portrait of the ideal critical thinker as someone who is inquisitive in nature, open-minded, flexible, fair-minded, has a desire to be well-informed, understands diverse viewpoints, and is willing to both suspend judgment and to consider other perspectives."

The advocates of the philosophical model also emphasize high standards and quality of thought. For example, Bailin (2002) explains critical thinking as "Thinking of a particular quality—essentially good thinking that meets specified criteria or standards of adequacy and accuracy." Further, the formal rule of logic has been the object of focus for those who advocated the philosophical approach. One limitation of this approach to defining critical thinking is that as Sternberg confided "It does not always correspond to reality." He further stressed that "By emphasizing the ideal critical thinker and what people have the capacity to do; this approach may have less to contribute to discussions about how people actually think."

Facione (2010) in his study came up with six cognitive skills such as: in as central to the concept of critical thinking. These were: Interpretation, Analysis, Explanation, Evaluation, Self-regulation and Inference. The findings support the assumption that critical thinking skills enable a learner to analyze and synthesize information and to solve problems in broad range of areas.

Sternberg (2010), shared the following observations on his comparative analysis of the two common approaches. He stressed that "The cognitive psychological approach contrasts with the philosophical perspective in two ways. First, cognitive psychologists, particularly those immersed in the behaviorist tradition and the experimental research paradigm, tend to focus on how people actually think versus how they could or should think under ideal conditions Second, rather than defining critical thinking by pointing to characteristics of the ideal critical thinker or enumerating criteria or standards of "good" thought, those working in cognitive psychology tend to define critical thinking by the types of actions or behaviors critical thinkers can do."

According to Benjamin Bloom and his associates in 1956 the taxonomy for information processing skills "is one of the most widely cited sources for educational practitioners when it comes to teaching and assessing higher-order thinking skills." There is hierarchy in Bloom's taxonomy wherein comprehension is found at the bottom and evaluation is located in the top. Kennedy et al. in their study (2011), that "The three highest levels analysis, synthesis, and evaluation are frequently represent critical thinking."

The length of classroom experiences and the review of student learning are the basis of educational approach advances thus, it translate a greater amount of benefit to the learner compared to the other approaches. However, some have noted that the educational approach is limited in its vagueness. Sternberg however said that "concepts within the taxonomy lack the clarity necessary to guide instruction and assessment in a useful way. Furthermore, the frameworks developed in education have not been tested as vigorously as those within either philosophy or psychology" (Sternberg, 2006).

The development of critical thinking should be the cornerstone in the choice of appropriate teaching strategies as it involves an active process of promoting and enhancing the students' performance in schools. For most students, listening to lectures in the classroom, entails boredom and passivity for the students are to ask questions in the middle of the delivery of the lectures. As Schafersmen (2011), in his study stressed, "The intellectual skills of Critical Thinking -- analysis, synthesis, reflection, etc.- must be learned by actually performing them." He further suggested that "teachers should emphasize students' active participation in the teaching-learning activities in Mathematics."

(Willingham, 2007), in his study claimed that "Researchers of critical thinking typically agree on the specific abilities encompassed by the definition, which include analyzing arguments, claims, or evidence; making inferences using inductive or deductive reasoning; judging or evaluating; and making decisions or solving problems".

Furthermore (Facione, 2010), added that "other abilities or behaviors identified as relevant to critical thinking include asking and answering questions for clarification; defining terms; identifying assumptions; interpreting and explaining; reasoning verbally, especially in relation to concepts of likelihood and uncertainty; predicting; and seeing both sides of an issue." The present study focuses on determining the critical thinking skills in problem solving of grade eight students in terms of analyzing a problem situation, making decision, monitoring progress and evaluating the completed solution.

Hereford (2011) in his study suggested steps to critical thinking as it relates to problem solving which includes: a) Identification and analysis of the problem. He stressed that "The first

task is to determine if a problem exists. Sometimes when you think this point through, you may come to the conclusion that there really isn't a problem, just a misunderstanding. If that's the case, fine. If not, and you determine that there is indeed a problem; you need to identify exactly what it is. Once you've determined the problem, analyze it by looking at it from a variety of perspectives"; b) Is it solvable? Is it real or perceived? Can you solve it alone or do you need help? Sometimes by looking at it from many angles you can come up with a resolution right away; c) Decide which solution fits the situation best. Go over your list of possible solutions". He further explained that "Different situations call for different solutions. Quite often what works in one situation, may not work in a similar one. Take time to determine what will work best for the problem at hand. One solution usually does not fit all"; "and, d) Take action and evaluate the results. Implement your solution. Every problem has a solution; even if it is to accept the situation and move on. Instead of approaching problems and challenges as insurmountable obstacles, we can view them as opportunities to hone our critical thinking and problem-solving skills."

Problem solving and critical thinking refers to the ability to use knowledge, facts, and data to effectively solve problems. This doesn't mean you need to have an immediate answer, it means you have to be able to think on your feet, assess problems and find solutions. The ability to develop a well thought out solution within a reasonable time frame, however, is a skill that is needed specifically when dealing with mathematical problems.

Lastly, Szetela (1993) discussed the aspects of critical thinking in problem solving which are analyzing a problem situation, making decisions, monitoring progress and evaluating the completed solution, wherein this study was anchored.

This study aimed to describe the critical thinking of students in problem solving using problems which enhance formats based on the aspects of critical thinking in problem solving, analyzing a problem situation, making decision, monitoring progress and evaluating the completed solution to improve students' abilities to communicate their thinking and to promote critical thinking.

It is also based on the following assumptions:

- That the level of critical thinking of male students are higher than the female students.
- That all students whether beginning or advanced mathematical ability can give a correct response and solution to the word problems within their own scope and range of abilities.
- That the aspects of critical thinking are evident to the student's responses.

The conceptual paradigm of this study as shown in figure 1 illustrates the aspects of critical thinking in problem solving namely, analyzing a problem situation, making decision, monitoring progress and evaluating the completed solution. In solving a problem, a student must identify first what is being asked in the problem, what are the given facts and what solution or mathematical process to be used. Students decision based on the given facts are also being assessed and when the student arrives at a solution, the solution should be judged by how well it fits the problem's facts, condition and goals.

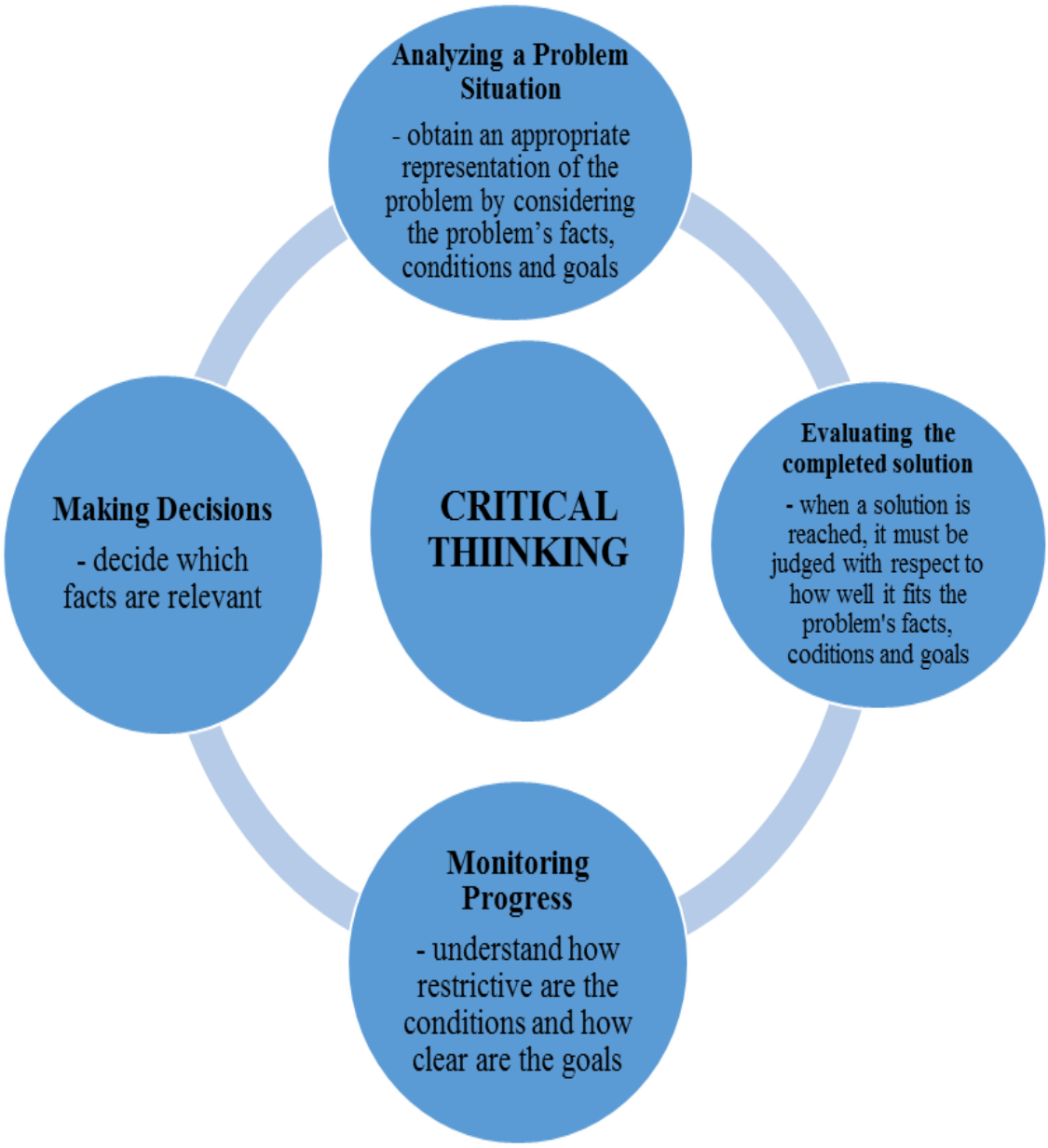

Figure 1. Conceptual Framework

Statement of the Problem

The research study aimed to describe the critical thinking in problem solving of grade eight students in mathematics. Specifically, it sought to answer the following questions.

1. What is the level of critical thinking skills in problem solving of the students in terms of the following aspects of critical thinking:
    a. Analyzing the problem situation
    b. Making decision
    c. Monitoring progress
    d. Evaluating the completed solution

2. Is there a significant difference on the level of critical thinking in problem solving when students are grouped according to
    a. Mathematical ability?
    b. Gender?

Hypothesis

The following hypothesis was at 0.05 level of significance.

There is no significant difference on the level of critical thinking in problem solving when students are grouped according to mathematical ability and gender.

Scope and Delimitation of the Study

The study was limited to the described the critical thinking of the students in problem solving in terms of analyzing a problem situation, making decisions, monitoring progress and evaluating completed solution. This also determines whether the critical thinking skills of the students differ when grouped according to mathematical ability and gender.

The study was conducted on Basic Education Department of Maryhill College. The selected population was determined using non-random purposive sampling wherein the population are chosen based on a certain criteria laid by the researcher. The criteria set by the researcher include grade eight (8) students of the stated institution both male and female enrolled on the current school year.

Significance of the Study

The result of this study has generated important information worthy of consideration by the educational sector as basis for improvement of Critical Thinking skills in teaching mathematics. Specifically, the finding of this study is beneficial to the following:

To the Learners. As the findings of the study will help them identify barriers to the employment of critical thinking in problem solving making them more aware of the likely approaches towards an easy and effective way of solving mathematical problems anchored on critical thinking.

To the Teachers. As the results of the study will serve as a guide for the individual evaluation of their students in mathematics as regard to their problem solving ability, their

strengths and weaknesses relative to the identified barriers to the use of critical thinking. Moreover, the findings would offer a wide array of options on approaches towards effective teaching of mathematics in schools.

To the School Administrators. The results of the study will provide them with the empirical basis for the acquisition and drafting of instructional materials, modules and methods that can improve the critical thinking skills of the students.

To the Future Researchers. The results of this study may serve as guide to other similar studies in the future. They can apply the concept and importance of critical thinking in their research study by exploring other aspects that are related to mathematical ability and gender.

Definition of Terms

For a better understanding of this study, the following terms were defined conceptually and operationally.

Analyzing the problem situation. This refers to the first step in problem solving wherein the students break down into components or essential features (Mendelman, 2007). In this study, it refers to the skills of examining or studying the detail in arriving on the appropriate solution for the problem.

Critical Thinking. This is a mental process of analyzing or evaluating information, particularly statements or propositions that are offered as true Critical thinking can be described as a ―gradual progression from the superficial to the increasingly complex. (Mendelman, 2007). In this study, it is defined as the ability of the students to understand, solve and answer mathematical problem.

Critical Thinking Test. This refers to the instrument that was developed and validated by the researcher which consists of 10 – item enhanced problem solving questions designed to encourage communication of critical thinking as suggested by Szetela (1993).

Evaluation. Refers to an appraisal of something to determine its worth or fitness.

Making decision. This is cognitive processes that presuppose the availability of knowledge and put it to use (Mendelman, 2007). In this study, this pertains to the process of determining the solution available to arrive at a certain answer to the problem.

Mathematical Ability. It refers to the knowledge attained or skills developed in mathematics usually measured by test scores (Chapell, 2005). In this study, it refers to the average grade of students in mathematics 7 and first quarter grade in mathematics 8.

Monitoring progress. It refers to the act of observing something or paying close attention (Mendelman, 2007). In this study, this refers to the process of observing the performance of the students to determine whether or not competency is developed.

Problem Solving. Mendelman, 2007, defined problem solving as "referring to the process of working through details of a problem to reach a solution". "Problem solving may include mathematical or systematic operations and can be a gauge of an individual's critical thinking skills." In this study, it refers to the skills of the students in answering the mathematical problem correctly.

Rubrics. It refers to a description of the standards that will be used to judge a student's work on each of the criteria or important dimensions of learning. In this study this refers to the adapted rubrics made by Szetela (1993).

CHAPTER II

REVIEW OF RELATED LITERATURE

This review provides initial insights into the possible relationship between critical thinking and problem solving skills of the students in solving mathematical problems. Recent researches have put more emphasis on how critical thinking affects the problem solving skills of the students. The foregoing included summaries of related literatures from various readings and references of local, foreign authors and unpublished studies. Limited studies from the locale related to the chosen topic headed the researcher to use foreign literatures and relate the same to the Philippine setting.

Definition of Critical Thinking

According to Richard Paul (1992) "Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In its exemplary form, it is based on universal intellectual values that transcend subject matter divisions: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness."

Lewis & Smith, 2013 said that "The literature on critical thinking has roots in two primary academic disciplines: philosophy and psychology". Sternberg 2010 also added that "a third critical thinking strand exist within the field of education." These separate academic strands have

developed different approaches to defining critical thinking that reflect their respective concerns. Each of these approaches is explored more fully below.

The philosophical approach

On the vantage point of philosophical tradition, critical thinking includes "the propensity and skill to engage in an activity with reflective skepticism" (McPeck, 2010); "reflective and reasonable thinking that is focused on deciding what to believe or do" (Ennis, 2015); "skillful, responsible thinking that facilitates good judgment because it 1) relies upon criteria; 2) is self-correcting; and 3) is sensitive to context" (Lipman, 2008); "purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or conceptual considerations upon which that judgment is based" (Facione, 2010); "disciplined, self-directed thinking that exemplifies the perfections of thinking appropriate to a particular mode or domain of thought" (Paul, 1992); "thinking that is goal-directed and purposive", "thinking aimed at forming a judgment," where the thinking itself meets standards of adequacy and accuracy (Bailin et al., 2012); and "judging in a reflective way what to do or what to believe" (Facione, 2010).

The cognitive psychological approach

The cognitive psychological approach provides different definitions of critical thinking include one of which is "the mental processes, strategies, and representations people use to solve problems, make decisions, and learn new concepts" (Sternberg, 2010); "the use of those cognitive skills or strategies that increase the probability of a desirable outcome" (Halpern, 2008); and "seeing both sides of an issue, being open to new evidence that disconfirms your ideas, reasoning

dispassionately, demanding that claims be backed by evidence, deducing and inferring conclusions from available facts, solving problems, and so forth" (Willingham, 2007).

Areas for Agreement

Ennis 2015 claimed that "despite differences among the three schools of thought and their approaches to defining critical thinking, there exist areas for agreement. First, researchers of critical thinking typically agree on the specific abilities encompassed by the definition, which include analyzing arguments, claims, or evidence." Facione (2010), shared that inductive or deductive reasoning can be used in making inferences. Ennis further added "judging or evaluating and making decisions or solving problems". Ennis mentioned that "other abilities or behaviors identified as relevant to critical thinking include asking and answering questions for clarification defining terms; identifying assumptions" (Ennis, 2015). Willingham added that "interpreting and explaining; reasoning verbally, especially in relation to concepts of likelihood and uncertainty; predicting; and seeing both sides of an issue" (Willingham, 2007).

Dispositions

In the study of Facione he revealed that most researchers are in agreement that critical thinking involves dispositions in addition to skills or abilities (Facione, 2010). While in the study of Ennis he found out that "researchers working in the area of critical thinking recognized that the *ability* to think critically is distinct from the *disposition* to do so." (Ennis, 2015). The idea of critical thinking abilities and dispositions are two different bodies which was confirmed by Empirical evidences.

Importance of background knowledge

Finally, studies have revealed unanimously the important role of background knowledge. Kennedy et al stressed that "most researchers see background knowledge as essential if students are to demonstrate their critical thinking skills" (Kennedy et al., 2011). McPeck (2010) stated, "To think critically, students need something to think critically about." Also, Bailin et al. (2009) argued "domain-specific knowledge is indispensable to critical thinking because the kinds of explanations, evaluations, and evidence that are most highly valued vary from one domain to another."

Domain specificity

Another area of disagreement lies on the determination of the degree on how critical thinking skills are domain-specific. However, there are arguments on other studies that the domain of critical thinking skills can be taught in standard way and it can be generalized in different contexts. Meanwhile, some researchers argued that the existence of generic critical thinking skills coming from particular subjects are not possible. From this argument, the researchers conclude that it is through a particular domain that critical thinking skills can only be taught (Bailin, 2009). Ennis (2015) identified a wide array of norms about "domain specificity" conducted by different scholars. Ennis said "most researchers view background knowledge as a necessary but not sufficient condition for critical thinking." In addition, some researchers see the transfer of critical thinking skills across domains as unlikely unless students are provided with sufficient opportunities to practice these skills in a variety of domains and the students are explicitly taught to transfer. Finally, an even smaller number of researchers hold the view that general instruction in

critical thinking skills is unlikely to be successful because critical thinking skills are inherently domain-specific" (Ennis, 2009). The advocates of domain specificity include Willingham (2007), who argues that "it is easier to learn to think critically within a given domain than it is to learn to think critically in a generic sense". In the same manner, Bailin (2012) debated about "domain-specific knowledge is necessary for critical thinking because what constitutes valid evidence, arguments, and standards tends to vary across domains."

Even though McPeck (2010) accepts the fact that "general thinking skills" are restricted in numbers, he discusses that "the most useful thinking skills are those that are domain-specific". Moreover McPeck claims that "the more general the thinking skill, the less helpful it is". Bailin (2009) agrees with the argument when he said that "what is common and general to the concept of critical thinking is so generic that it is not useful."

Some further argued that "critical thinking skills" and abilities are not "domain-specific", those are Halpern (2011), who determined that an instruction has a big potential after he conducted a review in the evidence of using critical thinking skills in general instruction after proven that it is effective. Lipman (2008) noted that "critical thinking facilitates good judgment because it relies on criteria. These criteria may differ across domains, but the fundamental meaning of critical thinking remains the same." Van Gelder (2005) argued that "critical thinking is intrinsically general in nature, which, paradoxically, is why critical thinking skills and abilities are notoriously difficult to transfer to new contexts."

Some researchers maintained that critical thinking includes both general and domain-specific elements. For instance Ennis (2009) noted, "In math, deductive proof is the gold standard for reason, whereas in the social sciences statistical significance is most highly regarded, and in art

subjectivity is usually acceptable." However, Ennis also acknowledged the idea that "conflict of interest" being separated from "credibility of the source" is one of the aspects of critical thinking that is parallel with other disciplines. Instead of a test rooted from the context of specific domain Facione (2010) has created a general test to think critically which is called "California Critical Thinking Skills Test" . But he stressed out the significance of "domain-specific knowledge" in critical thinking skills and abilities. Accordingly, Facione is considered as one of the researchers who consider both general and domain-specific elements of critical thinking. Lastly, Paul (2012) stated "learning to think within one's discipline by appropriating the standards and values embodied in that discipline is considered critical thinking". Thus, Paul notes that "critical thinking skills and abilities can be taught using both general critical thinking courses and infusing critical thinking instruction into discipline-specific courses."

Relationships to Other Concepts

To define the concept of critical thinking, different studies have shown its relationship to other skills such as "twenty-first century skills, including metacognition, motivation, and creativity". These concepts will be having separate discussion.

Metacognition

Metacognition has been defined most simply as "thinking about thinking". Other definitions include "the knowledge and control children have over their own thinking and learning activities" (Cross & Paris, 2008); "awareness of one's own thinking, awareness of the content of one's conceptions, an active monitoring of one's cognitive processes, an attempt to regulate one's

cognitive processes in relationship to further learning, and an application of a set of heuristics as an effective device for helping people organize their methods of attack on problems in general" (Hennessey, 2009); and "the monitoring and control of thought" (Martinez, 2011).

According to Kuhn (2009) there is a relationship between critical thinking and metacognition. He said that "critical thinking is a form of metacognition, which includes metacognitive knowing (thinking that operates on declarative knowledge), meta-strategic knowing (thinking that operates on procedural knowledge), and epistemological knowing (encompassing how knowledge is produced)." Similarly, Flavell (2009) viewed critical thinking as developing parts to form the ideals of metacognition. He further debated that "critical appraisal of message source, quality of appeal, and probable consequences needed to cope with these inputs sensibly can lead to wise and thoughtful life decisions". Meanwhile, Willingham (2007) identified metacognition as "being subsumed under critical thinking when they argue that a component critical thinking skill is the ability to deploy the right strategies and skills at the right time, typically referred to as conditional or strategic knowledge and considered part of the construct of metacognition." Halonen (2015) appear to perceive metacognition as "the ability to monitor the quality of critical thinking." In the same manner, Halpern (2008) viewed metacognition as "monitoring thinking and strategy used by asking the following kinds of questions: What do I already know? What is my goal? How will I know when I get there? Am I making progress?"

Other studies contain arguments that the relationship of critical thinking and metacognition is considered self - regulated. This is show in the report of APA Delphi which considered "self - regulation" as one of the component skills of critical thinking. Facione (2010), noted a connection among metacognition, critical thinking, and motivation which was covered by self-regulated

learning, which he define as “our ability to understand and control our learning environments”. “Self-regulated learning, in turn, is seen as comprising three components: cognition, metacognition, and motivation.”

Motivation

There is a connection between critical thinking and motivation. “The disposition to think critically has been defined as the consistent internal motivation to engage problems and make decisions by using critical thinking” (Facione, 2010). Yet, one of the conditions of critical thinking skills and abilities is student motivation and it is considered necessary. Similarly, Halonen stresses that “a person’s propensity, or disposition, to demonstrate higher-order thinking relates to their motivation” (2015). Halpern (2008) discusses that “effort and persistence are two of the principal dispositions that support critical thinking”, while Paul explains that since perseverance is one of the “traits of mind” which prompts the students to think critically, motivation is one of the factors that will make the students persevere and those students who are considered “unmotivated” will find it hard in exhibiting critical thinking. Meanwhile, some researchers have discussed that their relationship goes the other way. For instance, Turner suggested that “difficult or challenging tasks, particularly those emphasizing higher-order thinking skills, may be more motivating to students than easy tasks that can be solved through the rote application of a pre-determined algorithm” (Turner, 2005).

Critical Thinking in the Average Person

Lots of researchers in the field of "critical thinking" worry about the current status of critical thinking not only with the youth but with the adults as well. In particular, Halpern (2008) from the findings in his research shows that many adult fail to apply critical thinking in certain situations. Moreover, Van Gelder (2005) concluded that "many adults lack basic reasoning skills." Halpern (2008) points out the event wherein many people believe in "paranormal phenomena" even though they failed to show proofs for those things. Halpern supported his arguments with the reasoning "human beings are programmed to look for patterns, particularly in the form of cause-and-effect relationships, even when none exist." Van Gelder (2005) repeats this arguments, describing humans as "pattern-seekers and story-tellers". "This inclination results in a tendency to jump to the first explanation that makes intuitive sense without carefully scrutinizing alternative possibilities." Perkins, Allen, & Hafner (2013) coined "makes-sense epistemology". Furthermore, most people believe that "personal experience" is more reliable evidence than scientific study. With these issues toward reasoning and thinking critically, Halpern notifies that "we should not expect to see dramatic improvements in critical thinking over time as a result of instructional interventions. Improvements in critical thinking, when they do occur, are slow and incremental" (Halpern, 2008).

Paul insisted that "one reason for this gap in basic reasoning skills may be deficient educational experiences." He argued that the instructions given by most of the schools do not promote "higher – order thinking skills" that characterized critical thinking. Paul explained that "knowledge is coterminous with thinking, especially good or critical thinking. However, typical school instruction, with its emphasis on the coverage of content, is designed as though recall were

equivalent to knowledge." "This type of lower-order learning is simply learning by rote or association, with the end result that students memorize material without understanding the logic of it." Some students are not aware with the repercussions of their words and actions with that evidence are required as support. This is because for majority of the students, "believing, not thinking, is knowing" (Paul, 2012).

Different studies show that everyone has the capacity to be critical thinkers through the use of proper instructions despite of some proofs revealing that mediocre students find it hard to think critically. Kennedy et al. (2011) stresses that students from different walks of life will benefit from instructions rooted from critical thinking. On the same manner, Lewis and Smith (2013) point out that not only children with high intellectual ability will benefit from critical thinking but also children in general.

Critical Thinking in Children

Researchers in line with the works of Piaget revealed that adults are more inclined in applying their critical thinking abilities than the youth. It was interpreted that the youth are not capable of "abstract reasoning" which is one of the requirements for critical thinking abilities (Kennedy et al., 2011). Meanwhile, some recent works revealed that other activities about critical thinking which became part of the elementary curriculum .has made children experience the same manner like adults (Gelman & Markman, 2013). Silva (2008) argued that "there is no single age when children are developmentally ready to learn more complex ways of thinking." Furthermore, Willingham (2007) indicated that "very young children have been observed thinking critically, whereas trained scientists occasionally fall prey to errors in reasoning."

Bailin et al. (2009) argued that "critical thinking instruction at the primary grade levels can include teaching students to value reason and truth; respect others during discussion; be open-minded; be willing to see things from another's perspective; perceive the difference between definitions and empirical statements; use cognitive strategies, such as asking for examples when something is unclear; and use principles of critical thinking, such as considering alternatives before making a decision."

Similarly, the APA Delphi report recommended that "from early childhood, people should be taught, for example, to reason, to seek relevant facts, to consider options, and to understand the views of others."

There however exist a finding where practical proofs encourages the idea that youth has the ability to think critically. Koenig and Harris (2005) have mentioned in their study that "3-and 4-year-old children will differentiate the credibility of various sources of information." The findings from their studies was parallel with other studies. Likewise, Lutz and Keil (2012) revealed in their study that a y – year old child is already aware with the different "domains of expertise" those areas are connected with the credibility of different discipline. Lastly, the capacity to realize that some people have the tendency to alter the reality was fostered by children with ages of 7 to 10.

Critical Thinking over Time

Records about how critical thinking was developed was very few. Investigation conducted about the evolution of critical thinking in one's life which is until he reached college yields only several facts. O'Hare and McGuinness (2009) said that "the critical thinking scores of third-year university students in Ireland were significantly higher than the corresponding scores of first-year

students." Researchers believed there is a progressive effect on critical thinking when one attended universities. Meanwhile, Gellin (2013) found out that "college students who engaged in activities such as interacting with faculty and peers, living on campus and participating in college clubs or organizations increased their measured critical thinking skills by 0.14 standard deviations as compared to college students who did not participate in such activities."

One of the researchers which serve as the proponent of "developmental progression of critical thinking skills and abilities" is Kuhn (2009), who give the synthesis of how rich empirical research about cognitive development that it can cause progression. Kuhn's definition of critical thinking is based on metacognition. She differentiates three kinds of metacognition such as metacognitive understanding, meta-strategic knowing and epistemological understanding. According to her "Metacognitive understanding is thinking that operates on declarative knowledge, Meta-strategic knowing is thinking that operates on procedural knowledge and epistemological understanding is concerned with philosophical questions."

Metacognitive understanding have two stages which are Realism which is happening from 3 – 5 years old. In this stage identification of truthfulness and fallacy of statement are achieved. Prior to reaching this stage, children regard beliefs and assertions as isomorphic with reality. The second stage which happens by the age of 6 enable the child to gain awareness about the sources of knowledge and to differentiate the theory from evidence. Therefore, during the first stage the child find it hard to know the evidences that a certain event has occurred and during the second stage children are able to make this distinction already.

Similarly meta-strategic knowing has two stages as well. That the first stage happens during middle childhood wherein the value of cognitive strategies was understood by children. In this stage, recognition of memory strategy like categorization is effective in managing cognitive resources during problem solving. The second stage is achieved during adolescents and adulthood wherein it involves consistent and appropriate strategies selection. In this stage, a person evaluates the success of strategies used. (Kuhn, 2009).

Epistemological understanding has three stages which are absolutist position, as the most sophisticated level of critical thought. According to Kuhn, this level is characterized by three distinct stages. The first stage, called the Absolutist position, Multiplist epistemological position and epistemological meta-knowing. According to Kuhn "Absolutist position is the norm during childhood and is common during adolescence, and can even persist into adulthood for some individuals." Meanwhile the "Multiplist Epistemological position, tends to be prevalent during adolescence. During this stage, the individual acknowledges that experts can disagree and actually relinquishes the idea of certainty." Lastly the "Epistemological Metaknowing is the stage that the individual is able to balance the subjective and objective, recognizing a multiplicity of valid representations of reality". (Kuhn, 2009).

The Teachability of Critical Thinking

Many researchers about critical thinking claimed that the ability to think critically can be acquired. Accordingly Halpern (2008) offered proofs whose purpose is to improve the abilities of college students. The study conducted by Kennedy et al. (2011) recommended the use of

intervention materials that leads to improvement of students skills yield a better result. In addition, Abrami et al. (2008) concluded that the impact made by intervention materials is positive.

Challenges in Assessing Critical Thinking

Assessment of critical thinking skills and disposition in learners have numerous challenges. Scholars enumerated the challenges related with the reliability and validity of critical thinking. Yet, Moss and Koziol (2011) found out that "students' abilities to use topic statements, evidence, explanations, conclusions, and logical organization did not generalize across tasks, suggesting that idiosyncratic and perhaps construct-irrelevant features of each passage or task were more salient aspects of student performance than any general ability to think critically." Moreover, Silva (2008) has mentioned "that performance-based assessments of creativity introduce, rather, subjectivity and error." Furthermore, to assess the progress of critical thinking skills usage of performance tasks was employed. (Moss & Koziol, 2011).

Norris (2009) argued that "the fact that the degree of domain specificity in critical thinking remains unresolved makes assessment of critical thinking difficult." These difficulties are the failure on the researcher's part to distinguish whether critical thinking as general or subject specific and difficulty in assessing the transfer of critical thinking. Lastly, Norris argued that "traditional assessment formats are ill-suited for testing even limited aspects of the construct. Standardized instruments using multiple-choice formats to assess credibility judgment or deductive reasoning are as likely to reflect extraneous constructs—such as test-makers' empirical, religious, or political beliefs and judgments—as they are to reflect critical thinking."

There are lots of assessment for critical thinking like “California Critical Thinking Skills Test” (Facione, 2010), the “Cornell Critical Thinking Tests” (Ennis 2009), the “Ennis-Weir Critical Thinking Essay Test” (Ennis &Weir, 1985), and the “Watson-Glaser Critical Thinking Appraisal” (Watson & Glaser, 1980). Accordingly, Ku (2009) stressed out that the cited instruments widely varies. Nevertheless Kennedy et al. (2011) point out that these instruments are not applicable for grade four students and below. Therefore there are some instruments that can be used for grade eight students. Likewise, the cited tests are for general critical thinking evaluation and not made for specific subjects.

Summary

Critical thinking is a mental process, strategy and representation people use to facilitate good judgment. It has long been seen by educators as a necessary tool to gain a positive educational result. Although bereft of a concrete definition, where majority of the scholars can approve the different methods related to critical thinking, typically, it is used to solve problems. In doing so, prior knowledge is necessary to make valid arguments. Cognition, dispositions and abilities are the components of critical thinking. Dispositions, which is viewed as attitudes, or habits of mind towards a certain aspect to meet a diverse viewpoints. There are two aspects of critical thinking namely: general and domain-specific.

Critical thinking skills relate to several other important student learning outcomes, such as metacognition, motivation, collaboration, and creativity. Metacognition (or thinking about thinking) supports critical thinking in that students who can monitor and evaluate their own thought processes are more likely to demonstrate high-quality thinking. In addition, the ability to

critically evaluate one's own arguments and reasoning is necessary for self-regulated learning. Motivation supports critical thinking in that students who are motivated to learn are more likely to persist at tasks that call for critical thinking. In turn, learning activities and assessment tasks that call for critical thinking may spark student motivation because they are more challenging, novel, or interesting. Students possessing critical thinking dispositions, such as willingness to consider diverse perspectives, may make better collaborators, and opportunities for collaboration may promote higher-order thinking. Finally, creativity requires the ability to critically evaluate intellectual products, and critical thinking requires the open-mindedness and flexibility that is characteristic of creative thinking.

The gap lies on whether critical thinking skills and abilities can actually be taught or simply acquired on time. In addition, if everyone has the capacity to become critical thinkers, how is it manifested among learners? The challenge lies on the assessment which would be most appropriate to gauge one's critical thinking skills.

In this study, critical thinking in problem solving of grade eight students was assessed through a research instrument formulated by the researcher and validated by the experts in the field of Mathematics. It is similar to the study conducted by Stein, Haynes, and Understein (2003) in the instrument used to assess critical thinking which is an own test that was developed and validated. The test made by Stein, Haynes, and Understein (2003), and the test made by the researcher have the similar objective which is to encourage communication skills and leave opportunities for creative answers to questions that do not always have a single correct response.

CHAPTER III

METHODOLOGY

This chapter covers the research design, research instruments, sampling method, data gathering procedure and the statistical treatment that were used in the study.

Research Design

Descriptive study was used since the principal aim in employing this method was to describe the nature of the situation and to explore the causes as it naturally occurs (Greenfield, 2012).

Since data are narrative descriptions and observations occurs in more natural and less controlled research setting (Lauer, 2006) qualitative research design was also used.

In this case the researcher needed to set reliable information about the critical thinking in problem solving skills of grade eight students in mathematics. Thus, these research methods were necessary to this study because its primary purpose was to describe the critical thinking of students in problem solving.

Research Locale

The study was conducted at Maryhill College, a Catholic Educational Institution owned and administered by the Diocese of Lucena, located at M.L. Tagarao and Quezon Avenue Streets, Lucena City. Specifically, the study was conducted at the Basic Education Department.

Maryhill College offers the following program at the Basic Education Department: pre-elementary, elementary and high school department. The researcher will selected the grade eight (8) students as the primary respondents of the study.

The researcher chose this locale for the following reasons: a) the increasing number of low performing students are highly evident on this locale as a result of pre-survey; b) the researcher is currently connected to this institution making the results of this study beneficial for the improvement of school program to enhance the skills of the students regarding critical thinking.

Participants of the Study

Stratified sampling is a strategy for selecting samples wherein the basic idea is to divide the population into strata or groups based on characteristics and the resulting sample is made more efficient by ensuring that units from each population group are appropriately represented in controlled way.

From 175 grade eight students of Basic Education Department of Maryhill College enrolled during the current school year, twenty (20) students were selected as participants using stratified sampling. The final grades in elementary algebra and intermediate algebra were averaged and only those who passed were considered as members of the population.

Students were classified into three ability groups based on the average of their final grades in elementary algebra and intermediate algebra. The data were taken from the office of the Registrar. The classification of students according to mathematical ability followed this guide:

Grade Point Average	Mathematical Ability
90-100	Advanced
85-89	Proficient
80-84	Approaching Proficiency
75-79	Developing
74 & Below	Beginning

Source: K-12 Grading System (2013)

Table 1. Distribution of the Students of the Study According to Mathematical Ability.

Mathematical Ability	Number of Students	Number of Participants	Percent (%)
Advanced	7	5	71
Proficient	22	5	23
Approaching Proficiency	51	5	10
Developing	95	5	5
Beginning	0	0	0
Total	175	20	100

Aside from the mathematical ability, gender was also considered in comparing the critical thinking skill of the students in problem solving. The table below shows the distribution of the students according to gender.

Table 2. Distribution of the Students According to Gender.

GENDER	NUMBER OF STUDENTS	PERCENT
Male	6	30
Female	14	70
Total	20	100

Research Instrument

It is a 10 – item word problems with supplementary questions developed by the researcher using a table of specification shown in (see Appendix E, p. 67) comprising the topics of Special Products and Factoring. Rational Expressions, Linear Functions and Systems of Linear Equation. The research instrument is shown in (see Appendix F, p.68).

There were two instruments used in this study. The critical thinking test that was given to the students as an effective basis for evaluation to show the level of their critical thinking on problem solving skills. Scoring rubrics were used to know the critical thinking on solutions made by the students.

Validation

The critical thinking test was presented to the research adviser, three professors from the mathematics department of the PNU and two mathematics educators from the Division of Lucena City for content and face validation. Their comments were incorporated in the questionnaire to improve and secure its validity. The tool was pilot tested to a group of 20 students. After the pilot testing, questions that appeared vague to the respondents were revised.

Critical Thinking Test

The Critical thinking test composed of the ten mathematical problems regarding algebra strands of the K-12 curriculum with supplementary questions served as the basis for assessment of the critical thinking in problem solving. It was designed to encourage communication of critical thinking. The interpretation of the critical thinking followed this guide.

Percentage Score	Interpretation
80% -100%	Advanced Critical Thinking
50% - 79.99%	Proficient Critical Thinking
Below 50%	Developing Critical Thinking

Development

To assess the progress of the students, the researcher developed the test on any of the following form:

1. A problem wherein the question or fact in the problem is withheld. The students examine the problem's facts and conditions and write their own questions and solutions
2. Students are asked to write the procedure on how to solve the problem based on the analysis of facts presented by the problem
3. A complete solution for the problem needs to be presented by the students
4. Students are asked to create a problem for which they must communicate an explanation without actually solving the problem.

The ten-item word problem was taken from the topics in algebra consisting of "Special Products & Factoring, Linear Function, Rational Expressions and Systems of Linear Equation in two variables.

Scoring Rubrics

Rubrics were used to evaluate program courses & individual student's performance. It is also use to assess the higher order of thinking (Pierce, 2006). Hence, the scoring rubrics were used to assess the critical thinking in the problem solving of the students.

The scoring rubrics were based from Szetela, (1993), in which the descriptive criteria for various levels of critical thinking were relatively simple for the purposes of assessment.

Table 3 below shows the adapted rubrics that were used in evaluating the critical thinking test.

Table 3. Scoring Rubrics for Assessing Critical Thinking in Problem Solving.

Scores	Description
0	The student makes no attempts at critical thinking, indicated by a blank response or a negative comment.
1	The student attempts to answer the question, but the response is illogical or irrelevant
2	The student understands the question and addresses it with a pertinent comment, but the response is incomplete or confused.
3	The student understands the question and addresses most relevant aspects with correct and logical observations or inferences, or the student addresses all relevant aspects with minor flaws.
4	The student understands the question and addresses all relevant aspects with completely correct logical observations and inferences.

Source: Walter Szetela (1993)

Data Gathering Procedure

The study followed two steps in gathering data which specifically includes preparatory stage and administration stage

Stage 1

In preparatory stage, letter seeking permission to conduct the study was sent to the director of Maryhill College to allow the researcher to conduct the study on selected grade eight students of the institution. A pilot study was conducted on a group of twenty (20) students to check for the validity and reliability of the tool created and to find out the length of time needed to finish the test. Moreover, the reliability of the scoring rubrics was established through the aid of two math teachers.

Test Administration

The test was administered on the 1st week of September school year 2015-2016 at Basic Education Department of Maryhill College among a group of selected grade eight students. Students were given specific instructions on what to do and the type of questions they were to answer were carefully explained. The importance of the concept of critical thinking was stressed, consistent with the belief that mathematics will train the mind to think logically. The maximum time allotted to finish the test was two and a half hours. Individual time of submission was recorded. All the remaining papers were collected upon the expiration of the time allotted for the exercise.

Data Analysis Procedure

This part presents the way the researcher collated and analyzed the data gathered as well as the employment of statistical tools applied on the study. The adapted scoring rubrics was used to analyze the solutions of the students based on the aspects of critical thinking specifically analyzing a problem situation, making decision, monitoring progress and evaluating the completed solution. The number of points given to the students' solution depended on the way they presented their solutions in accord with the points stated in the scoring rubrics. Four (4) is the highest point for the solution which addressed all relevant aspects with complete logical observations and inferences while a zero point (0) is given for wrong solutions, lacking in all the relevant aspects relative to the question posted. The total scores of each students in the critical thinking test were obtained by adding the number of points they got in each question. A high total score corresponds to a high critical thinking skill while low total score corresponds to a low critical thinking skills.

For gender, since there were two variables male and female, the variables were correlated since their variances are not independent, the T- test was applied. This statistical treatment was utilized to determine whether the responses differ across gender. The t-test for correlated/independent variable was useful for comparing the two means of correlated samples.

CHAPTER IV

PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This chapter analyzed and interpreted the results based on research questions. It described the critical thinking skills in problem solving of grade eight students in mathematics.

Problem # 1. What is the level of critical thinking skills in problem solving of the students in terms of the following aspects of critical thinking?

a. Analyzing the problem situation

b. Making decision

c. Monitoring progress

d. Evaluating the completed solution

On the level of critical thinking in problem solving in terms of analyzing the problem situation, making decision, monitoring progress and evaluating the completed solution data disclosed information regarding the critical thinking performance of the students on a given problem which was analyzed using the adapted scoring rubrics.

The following tables show the level of critical thinking in problem solving of students.

Table 4 below shows the level of critical thinking in problem solving in terms of analyzing the problem situation. The data reveal that majority of the students are on the Advanced level of critical thinking with an overall mean of 87.50%. It only shows that students know how to

analyze the given problem situation. It also shows that they could easily analyze problems on the application of special products and on the problems in algebra that are related to area and perimeter as reflected in the mean of questions numbers 1, 2 and 4 wherein they obtained 100%.

Table 4. Level of Critical Thinking in Problem Solving (Analyzing the Problem Situation)

Questions	Mean (%)	Verbal Description
Item 1	100	Advanced
Item 2	100	Advanced
Item 3	90	Advanced
Item 4	100	Advanced
Item 5	75	Proficient
Item 6	90	Advanced
Item 7	80	Advanced
Item 8	70	Proficient
Item 9	75	Proficient
Item 10	95	Advanced
Overall	87.50%	Advanced

Figure 2 and 3 are example of student's responses applying critical thinking through analyzing the problem situation. Based on their responses they able to analyze the problem accurately thus, they got the correct solutions to the problem.

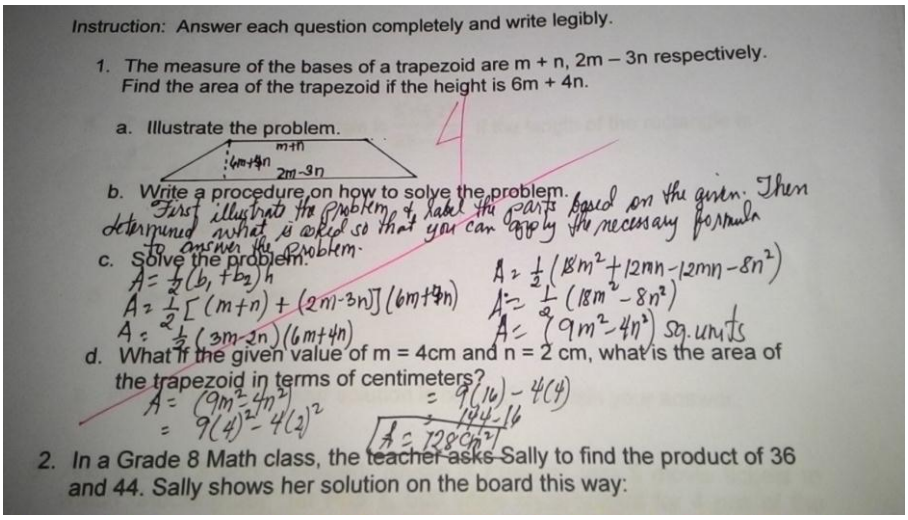

Figure 2. Example of Student's Response showing Analyzing the Problem Situation

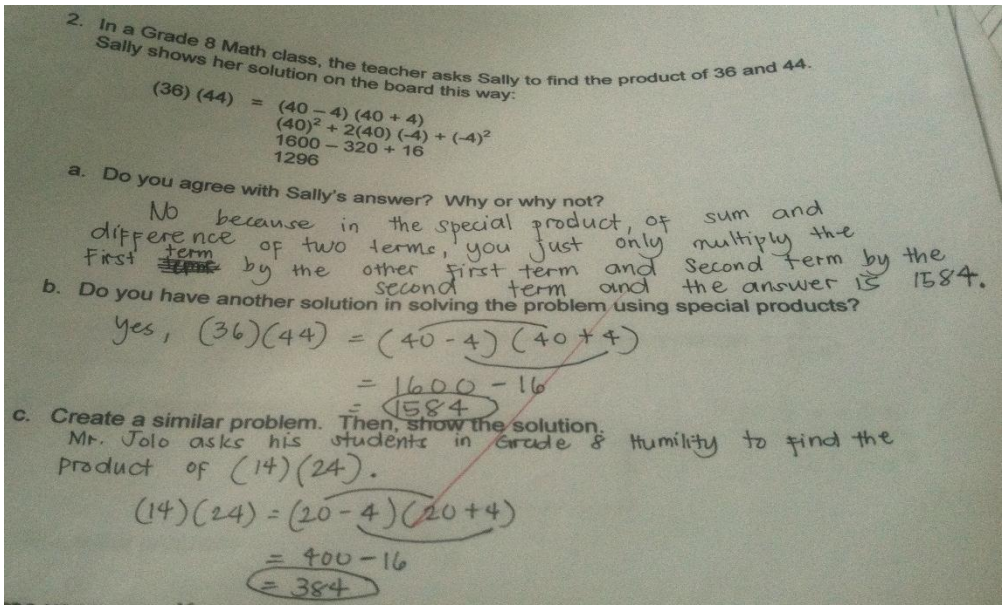

Figure 3. Example of Student's Response showing Analyzing the Problem Situation

In terms of monitoring progress aspects of critical thinking in problem solving, Table 5 shows that majority of the population are on the developing level which is supported by an overall mean of 24%. It shows that students have analyzed the given problem but they have difficulty in applying the concepts needed in the problem. Only two students have proficient level of critical thinking in terms of monitoring progress.

Table 5. Level of Critical Thinking in Problem Solving (Monitoring Progress)

Questions	Mean (%)	Verbal Description
Item 1	25	Developing
Item 2	50	Proficient
Item 3	10	Developing
Item 4	10	Developing
Item 5	30	Developing
Item 6	50	Proficient
Item 7	10	Developing
Item 8	10	Developing
Item 9	20	Developing
Item 10	25	Developing
Overall	24%	Developing

Considering the responses of most of the students, it was identified that they made an attempt to illustrate the problem but failed to show the appropriate figure required by the problem as seen in the sample responses of the students. Students were also unable to write the procedure on how to solve the problem. Most of them did not present the necessary procedure but instead wrote the formula on how to solve the problem. As a result the students failed to arrive at a particular solution and failed to apply the correct concept to arrive on the correct answer.

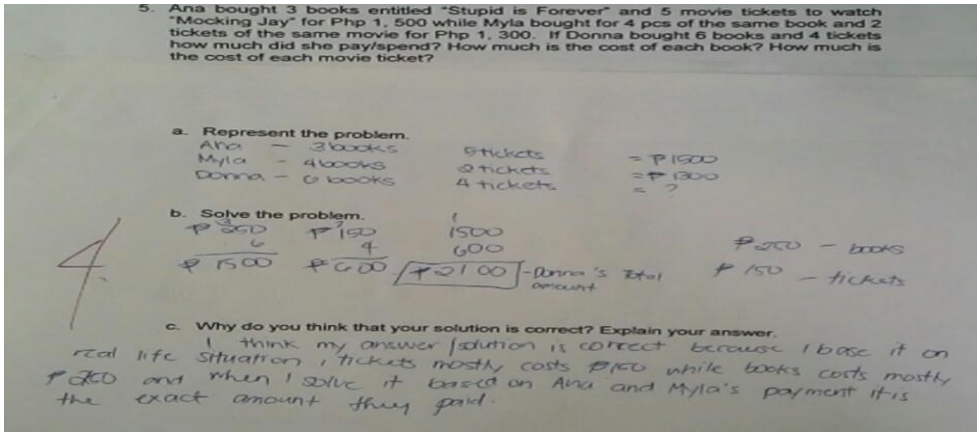

Figure 4. Example of Student's Response showing Monitoring Progress Aspect of Critical Thinking

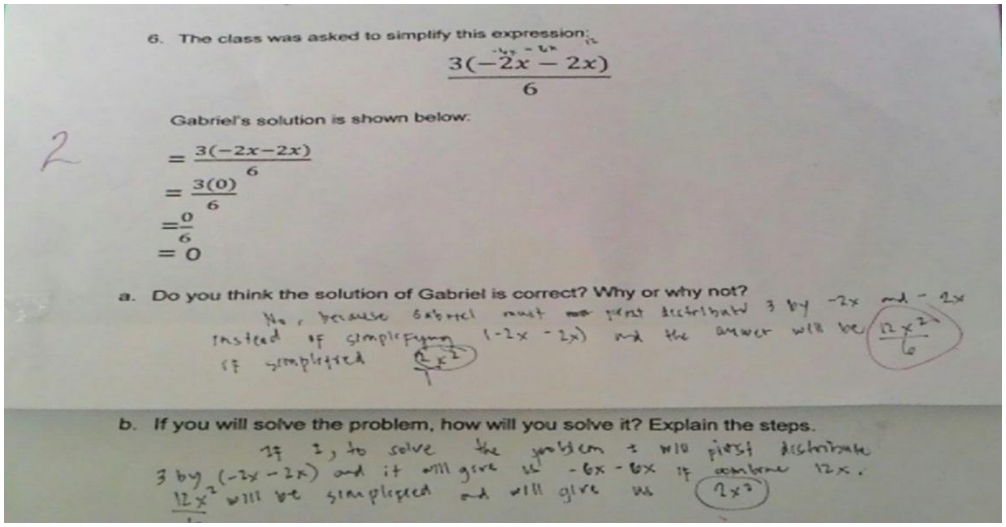

Figure 5. Example of Student's Response showing Monitoring Progress

Aspect of Critical Thinking

Table 6 shows the level of critical thinking in problem solving of students in terms of evaluating the completed solution. In this aspect, almost all of the students are on the developing level with a mean of 24. 5% except for question number 2 wherein 95% of the solution of the respondents reached the advanced level. It only shows that the competencies of special product for the algebra strand was mastered by grade eight students wherein they able to evaluate their solutions and created similar problem applying the concept. Figure 6 exhibited response of the students showing one aspect of critical thinking which is evaluating the completed solution. The figure also showed the only item where the respondents exemplify better judgment in evaluating a completed solution to the problem.

Table 6. Level of Critical Thinking in Problem Solving (Evaluating the Completed Solution)

Questions	Mean (%)	Verbal Description
Item 1	20	Developing
Item 2	95	Advanced
Item 3	10	Developing
Item 4	5	Developing
Item 5	40	Developing
Item 6	35	Developing
Item 7	10	Developing
Item 8	5	Developing
Item 9	5	Developing
Item 10	20	Developing
Overall	24.5%	Developing

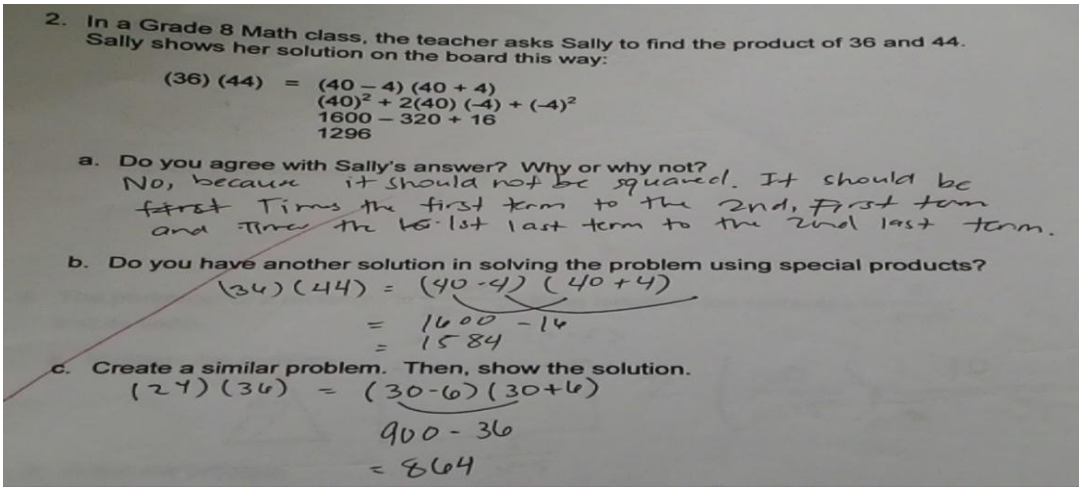

Figure 6. Example of Student's Response showing Evaluating the Completed Solution Aspect of Critical Thinking

Table 7 shows the level of critical thinking in terms of making decision. In this level the students had an overall mean of 22. 5%. It indicates that the students were on the developing level. Only in questions number 2 & 6 did the students show proficient level of critical thinking in terms of making decision. They were able to decide and justify whether the solution given on the problem are correct or not as reflected in figure 7. Expectedly, they were able to give the correct solution on the problem.

Table 7. Level of Critical Thinking in Problem Solving (Making Decisions)

Questions	Mean (%)	Verbal Description
Item 1	10	Developing
Item 2	60	Proficient
Item 3	10	Developing
Item 4	0	Developing
Item 5	25	Developing
Item 6	60	Proficient
Item 7	25	Developing
Item 8	0	Developing
Item 9	20	Developing
Item 10	15	Developing
Overall	22.5%	Developing

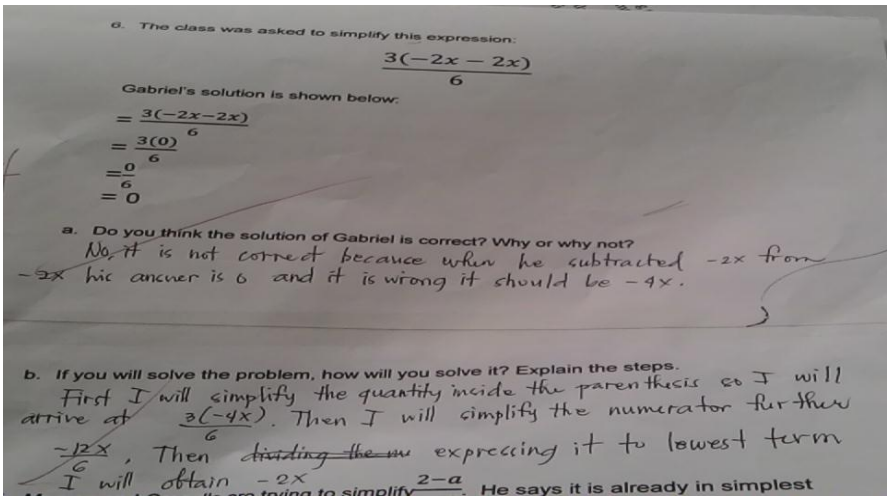

Figure 7. Example of Student's Response showing Making Decision Aspect of Critical Thinking

The table below shows the summary of levels of critical thinking in problem solving. It shows that the students were on the advanced level when it comes to analyzing a problem situation. Nonetheless, when it comes to monitoring progress, evaluating the completed solution and making decision they fall on the developing level with a mean of 24%, 24.5% and 22.5% respectively. It shows that the students know how to analyze problem situation but failed to continue to process and communicate the correct solution to the problem.

Table 8. Summary of Levels of Critical Thinking in Problem Solving

Questions	Mean (%)	Verbal Description
Analyzing a Problem Situation	87.5	Advanced
Monitoring Progress	24	Developing
Evaluating the completed situation	24.5	Developing
Making Decisions	22.5	Developing
Overall	39.63%	Developing

The result of this study is similar to the studies conducted by Yu, Lin, Ho and Wang (2015) that a student can possess the skills or ability to think critically but lack the will or motivation to use those skills. However, their findings and this study also agreed that assessing the critical thinking of students is difficult and complex especially if little has been communicated to process their thinking. (Szetela, 1993).

Problem # 2. Is there a significant difference on the level of critical thinking in problem solving when students grouped according to

a. Mathematical ability?

b. Gender?

Table 9 shows the mean scores of each mathematical group, percentage and interpretation.

The advanced mathematical ability group obtained 22.8 mean score indicating that the level of critical thinking of students under this group has proficient critical thinking while proficient, approaching proficiency and developing mathematical groups fall under the developing critical thinking level with a mean score of 15.6, 12.8, and 12.4 respectively.

Table 9. Critical Thinking Scores According to Mathematical Ability

Mathematical Ability	Mean Score	Percent %	Interpretation
Advanced	22.8	57%	Proficient Critical Thinking
Proficient	15.6	39%	Developing Critical Thinking
Approaching Proficiency	12.8	32%	Developing Critical Thinking
Developing	12.4	31%	Developing Critical Thinking

Table 10 shows the difference of each mathematical group using One – Way ANOVA.

Table 10. Difference of Mathematical Ability Groups Using One – Way ANOVA

Source of Variation	SS	Df	MS	F	p-Value	F – crit.	Interpretation
Between groups	347.8	3	115.93	4.254	0.022	3.239	Significant
Within groups	436	16	27.25				

The One – Way ANOVA results on finding the significant difference between critical thinking in problem solving when students are grouped according to mathematical ability, data revealed that the obtained absolute critical f-value were 4.254. Since the computed F-value was greater than the critical F- value therefore the findings showed that there is a significant difference between critical thinking skills in problem solving when grouped according to mathematical ability. The group who obtained the highest score was the advanced group followed by the proficient group then by the approaching proficiency group and the group who got the lowest score is the developing group. This implies that the advanced group has the proficient critical thinking skills in answering all the problems while the proficient, approaching proficiency and developing have the developing critical thinking skills.

Table 11. Critical Thinking Scores When Grouped According to Gender

Gender	Mean Score	Percent %
Male	15.1667	37.92
Female	16.2143	40.54

Table 12. Difference between levels of Critical Thinking Skills When Grouped According to Gender

Gender	Mean	Standard Deviation	Mean difference	df	t – value	p - value	Interpretation
Male	15.167	5.27	1.047	18	-0.326	0.748	Not Significant
Female	16.214	7.02					

Table 11 & 12 show the mean score of the male and female groups, total scores, percentage of each group and the t – test result in the Critical Thinking Test. Using t-test for correlated independent variables to test the null hypothesis that there is no significant difference between levels of critical thinking skills in problem solving when students are grouped according to gender, the following results were obtained. From the result of the t-test the obtained computed t-value is 0.33. Using a degree of freedom of 18 and 0.05 level of significance the critical t-value is 2.101. Since the t-value obtained is less than the critical value and falls within the region of acceptance, the null hypothesis is accepted. Therefore, there is no significant difference between the levels of critical thinking skills in problem solving when students are grouped according to gender. In other words male and female cannot be accounted for the difference of their critical thinking. Moreover, based on the study conducted by Ghadi, Bakar, Alwi, and Talib (2013) entitled "Gender Analysis of Critical Thinking Disposition Instrument among University Putra Malaysia Undergraduate Students" concluded that "there was no significant difference between male and female students."

CHAPTER V

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter discusses the findings of the study, conclusions derived from the finding, and the corresponding recommendations

Summary

The primary objective of the study was to describe the level of critical thinking in solving word problems in algebra of grade eight students. This study used descriptive and qualitative research methods in gathering and analyzing data. Twenty (20) students were selected as participants using stratified sampling. Students were classified into three mathematical ability groups based on the average of their final grades in elementary and intermediate algebra. There were two instruments used in this study: a.)The critical thinking test that was given to the students as an effective basis for evaluation to show the level of their critical thinking on problem solving. There were ten (10) word problems in the critical thinking test with supplementary questions. This was validated by experts and pilot tested to twenty grade eight students to check the validity and reliability of the test. b.) Scoring rubrics which were used to know the critical thinking on solutions made by the students.

Findings

The following are the findings of the study:

1. The students showed advanced level in analyzing the problem situation aspect of critical thinking.
2. Monitoring progress, evaluating the completed solution and making decision aspects of critical thinking were not seen in some of the solution of the students in the Critical Thinking Test.
3. Most of the students garnered a low score in the critical thinking test and exhibited developing critical thinking skills.
4. Students showed all the aspects of critical thinking in the topic special products wherein they were able to evaluate their solutions and created similar problem applying the concept.
5. The *advanced mathematical ability group* got the highest score in the critical thinking test, followed by the *proficient, approaching to proficiency and the developing mathematical ability group* got the lowest score.
6. Students showed mastery of the competencies but they have difficulty in applying it to the word problems.
7. The male group obtained lower score than the female group in the critical thinking test however the difference of their scores is not significant.

Conclusions

Based on the findings of the study, the following conclusions were drawn:

1. Solving word problems could be a way to deepen critical thinking skills for the students to be able to connect, analyze the problem situation and make a reasonable decision.
2. Grade 8 students of Maryhill College possess a low critical thinking skills in problem solving as shown in their answer to the questions in the critical thinking test.
3. Students are not used in answering word problems with supplementary questions that described the aspects of critical thinking.
4. Gender cannot be considered as factor affecting the critical thinking of the students.
5. Mathematical ability can be one of the factors affecting the critical thinking of the students.

Recommendations

Based on the findings of the study and the conclusions drawn, the following are hereby recommended:

1. School Administrators must provide seminars focusing on various teaching strategies and techniques that would enhance the students' critical thinking.Encourage and support the professional growth of the teachers by sending them to seminars, trainings, and continuing their post graduate studies.
2. Teachers should take the lead in developing a well – crafted program and curriculum which ensures the enhancement of students' critical thinking in problem solving. They must also expose students in answering word problems with supplementary questions which will

constantly improve their critical thinking. Teachers should also employ diverse teaching strategies and provide student activities which focus on building students' ability to solve problems and think critically.

3. Teachers should incorporate critical thinking in creating lesson objectives and teaching strategies. This is important to ensure that students will be able to develop the necessary critical thinking skills to be applied in every concept being taught by the students.
4. Students must enable themselves to become effective problem solvers and critical thinkers by being open – minded and equipped with mathematical competence.
5. Future researches may be conducted to further explore the usefulness of using word problems with supplementary questions to evaluate the level of critical thinking in problem solving skills of students.

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APPPENDIX A

LETTER TO THE EXPERTS

July 21, 2015

Dear Sir / Ma'am,

Greetings!

I am Mr. Jerson D. Jolo, a student of Master of Arts in Teaching Mathematics at Philippine Normal University who is working on my seminar paper entitled: "Critical Thinking Skills in Problem Solving of Grade Eight Students in Mathematics".

In this regard, I would like to request for your help as an expert to validate my research instruments. Thank you and God Bless!

Respectfully yours,

Jerson D. Jolo
MAT – Math Student

Seminar Paper Adviser:

Dr. Rene R. Belecina

APPENDIX B

LETTER TO THE SCHOOL DIRECTOR

August 31, 2015

Rev. Fr. Edwin V. Baruelo
Director
Maryhill College

Dear Fr. Edwin,

Greetings!

I am a graduating student of Philippine Normal University and presently working on my seminar paper entitled "Critical Thinking Skills in Problem Solving of Grade 8 Students in Mathematics". Related with this, I need the final grades of grade 8 students in Mathematics 7 for the school year 2014 – 2015. I need to assess their mathematical ability.

In this regard may I ask the office of the Registrar to provide me with the copy of the grade of the said group? I am hoping for your kind approval. Rest assured that all information that I am going to use in my study will be treated with utmost confidentiality.

Thank you very much.

Yours,

Jerson D. Jolo
MAT – Math Student

Approved by:

Rev. Fr. Edwin V. Baruelo
Director

cc: Mrs. Erma Cruzabra
Registrar
Maryhill College

APPENDIX C

LETTER TO THE PRINCIPAL

August 31, 2015

Dr. Enriqueta E. Alcoreza
BED Principal
Maryhill College

Dear Dr. Alcoreza,

Greetings!

May I request your good office to allow me to administer a questionnaire to selected grade 8 students? This is in connection with my seminar paper entitled "Critical Thinking Skills in Problem Solving of Grade 8 Students in Mathematics" which I am presently working on as partial fulfillment of the requirements for the degree of Master of Arts in Teaching Mathematics. Rest assured that classes will not be disturbed in the conduct and administration of the questionnaires. All responses will be treated confidentially.

I will deeply appreciate your favorable action on this request.

Yours,

Jerson D. Jolo
MAT – Math Student

Approved by:

Dr. Enriqueta E. Alcoreza
BED Principal

APPENDIX D

LETTER TO THE RESPONDENTS

August 31, 2015

Dear Respondents,

Greetings!

The undersigned is presently conducting a study entitled “Critical Thinking Skills in Problem Solving of Grade 8 students in Mathematics”.

Please answer all the items honestly and as completely as you can. Rest assured that all your answers will be kept in strict confidentiality

Thank you very much.

Yours,

Jerson D. Jolo
MAT – Math Student

APPENDIX E

TABLE OF SPECIFICATION

TOPICS	KNOWLEDGE	PROCESS	UNDERSTANDING	ITEM PLACEMENT
Special Products & Factoring			////	$I_{1,}$ I_2, I_8, I_{10}
Rational Expressions			////	$I_{4.}$ I_6, I_7, I_9,
Linear Functions			/	I_3
Systems of Linear Equation			/	I_5
TOTAL	0	0	10	10

Legend:

I_n – Item number in the part of test

APPENDIX F

CRITICAL THINKING SKILLS IN PROBLEM SOLVING OF GRADE EIGHT STUDENTS IN MATHEMATICS

Name _____ Grade & Section _____
Gender _____

Instruction: Answer each question completely and write legibly.

1. The measure of the bases of a trapezoid are m + n, 2m – 3n respectively. Find the area of the trapezoid if the height is 6m + 4n.

   a. Illustrate the problem.

   b. Write a procedure on how to solve the problem.

   c. Solve the problem.

   d. What if the given value of m = 4cm and n = 2 cm, what is the area of the trapezoid in terms of centimeters?

2. In a Grade 8 Math class, the teacher asks Sally to find the product of 36 and 44. Sally shows her solution on the board this way:

$$
\begin{aligned}
(36)\,(44) &= (40 - 4)\,(40 + 4) \\
&\quad (40)^2 + 2(40)\,(-4) + (-4)^2 \\
&\quad 1600 - 320 + 16 \\
&\quad 1296
\end{aligned}
$$

   a. Do you agree with Sally's answer? Why or why not?

   b. Do you have another solution in solving the problem using special products?

c. Create a similar problem. Then, show the solution.

3. Three years ago, Karen was five times as old as Ethel. Three years from now, she will be twice as old as Ethel. Find their present ages.

   a. Represent the problem.

   b. Formulate a mathematical equation on the given problem.

   c. Solve the equation.

   d. Explain your solution.

4. The perimeter of a rectangle is $\frac{5x+25}{25-x^2}$. If the length of the rectangle is $\frac{5}{x-5}$, find its width.

   a. Illustrate the problem.

   b. Solve the problem.

   c. Why do you think your solution is correct? Explain your answer.

5. Ana bought 3 books entitled "Stupid is Forever" and 5 movie tickets to watch "Mocking Jay" for Php 1, 500 while Myla bought for 4 pcs of the same book and 2 tickets of the same movie for Php 1, 300. If Donna bought 6 books and 4 tickets how much did she pay/spend? How much is the cost of each book? How much is the cost of each movie ticket?

   a. Represent the problem.

   b. Solve the problem.

   c. Why do you think that your solution is correct? Explain your answer.

6. The class was asked to simplify this expression:

$$\frac{3(-2x - 2x)}{6}$$

Gabriel's solution is shown below:

$$= \frac{3(-2x-2x)}{6}$$
$$= \frac{3(0)}{6}$$
$$= \frac{0}{6}$$
$$= 0$$

a. Do you think the solution of Gabriel is correct? Why or why not?

b. If you will solve the problem, how will you solve it? Explain the steps.

7. Marven and Creselle are trying to simplify $\frac{2-a}{a-2}$. He says it is already in simplest form but she says the answer is -1. Who do you think gives the correct answer? Explain.

8. A square piece of land with a dimension of (2x – 1) meters was rewarded by a master to his servant. They agreed that a portion of it represented by the rectangle inside whose dimensions are 2 meters by (5 – 2x) meters, should be used to construct a grotto. How large is the area of the land that is available for the other purposes?

   a. Illustrate the problem.

   b. Solve the problem.

9. Lanie added two rational algebraic expressions and her solution is presented below:

$$\frac{4x+3}{2}+\frac{3x-4}{3}$$

$$=\frac{4x+3+3-4}{2+3}$$

$$=\frac{7x+1}{5}$$

   Is there something wrong in her solution? If your answer is yes, explain why and give the correct solution. If your answer is no, explain why.

10. The height of a triangle is 4x + 5 and its base is congruent to its height. Find its area?

    a. Is the given problem hard or easy for you? Explain why.

    b. Illustrate the problem.

    c. Solve the problem. Then, explain your solution.

APPENDIX G

CRITICAL THINKING TEST RESULT

Student	Gender	Mathematical Ability	Scores	Percent (%)	Interpretation of Critical Thinking Skills
1	Female	Approaching proficiency	13	32.5	Developing
2	Male	Proficient	17	42.5	Developing
3	Female	Developing	10	25	Developing
4	Male	Approaching proficiency	11	27.5	Developing
5	Female	Proficient	12	30	Developing
6	Female	Proficient	9	22.5	Developing
7	Female	Advanced	28	70	Proficient
8	Female	Advanced	23	57.5	Proficient
9	Male	Advanced	14	35	Developing
10	Female	Advanced	16	40	Developing
11	Female	Advanced	33	82.5	Advanced
12	Male	Approaching proficiency	12	30	Developing
13	Male	Developing	12	30	Developing
14	Female	Approaching proficiency	12	30	Developing
15	Female	Approaching proficiency	16	40	Developing
16	Female	Developing	12	30	Developing
17	Female	Proficient	15	37.5	Developing
18	Female	Developing	12	30	Developing
19	Male	Proficient	25	62.5	Proficient
20	Female	Developing	16	40	Developing
		Mean	15.9	100	

APPENDIX H

CERTIFICATION FOR LANGUAGE EDITING

Philippine Normal University
The National Center for Teacher Education
Faculty of Arts and Languages

17 Dec. 2015

CERTIFICATION

This is to certify that I have read and edited in its entirety the Seminar Paper MR. JERSON D. JOLO on " Critical Thinking Skills in Problem Solving of Grade Eight Students in Mathematics."

Prof. Ma. Concepcion Y. Raymundo

Name and Signature of Editor

APPENDIX I

CERTIFICATION OF AUTHENTICITY TEST (ANTI-PLAGIRISM)

Philippine Normal University
College of Graduate Studies and Teacher Education Research
PUBLICATION OFFICE

AUTHENTICITY RESULT

Date of Release: December 17, 2015
Result Code: 2015-027
Submission ID: 616080432
Title of Output: Critical Thinking Skills In Problem Solving Of Grade Eight Students In Mathematics
Author(s): Jerson Jolo

Authenticity Report:

- ***Similarity Report: 16%***
- ***Interpretation***: A similarity report of 16% means that 16% of the whole paper is similar to sources in Turnitin's (authenticity software) online repository. The colored bibliographical references denote the sources of similarity to previously published work which maybe from internet sources (15%), publications (3%) and student papers (10%) for the remaining similarity percentage.
- ***Highlighted text in the Manuscript***:
  - Red marks and highlights are set of texts directly or exactly copied from online sources
  - Other color marks and highlights are set of text exactly copied from other sources (student papers and publications).

Recommendations:

- Use of quotations for exactly copied text is suggested.
- For assumed to be cited parts of the manuscript but highlighted, it is recommended that authors rephrase these portions.

Rio Anne R. Maño
(Authenticity Administrator)

Noted by:

Dr. Marie Paz E. Morales
Director, Publications Office

publications.office@pnu.edu.ph
Taft Avenue, Manila, 1000, Philippines

APPENDIX J

CURRICULUM VITAE

JERSON DINGLASAN JOLO
#147 Abellasnosa Street
Lucena City
Cel. # 09398680038/09224079636

I. PERSONAL INFORMATION

Nickname:	Jerson
Place of Birth:	Lucena City
Nationality:	Filipino
Status:	Married
Religion:	Roman Catholic
Languages Spoken:	English and Filipino
Spouse:	Ann Michelle M. Jolo

II. EDUCATIONAL ATTAINMENT

Graduate Studies:
Master of Arts in Teaching Mathematics
Philippine Normal University
Manila, Philippines

Others:
Certificate in Teaching Program - Mathematics
Philippine Normal University
Manila, Philippines
18 units

Bachelor of Science in Secondary Education
Maryhill College
Lucena City
9 units

Bachelor of Science in Secondary Education
Sacred Heart College
Lucena City
9 units

Tertiary:	Bachelor of Science in Commerce Major in Banking & Finance Sacred Heart College Lucena City March 2000
Secondary:	Quezon National High School Lucena City March 1996
Elementary:	Lucena East II Elementary School Lucena City March 1992

III. ELIGIBILITIES

Examination Taken	Date	Rating
SUKEN JAPAN Mathematics Proficiency Examination	May 10, 2008	Passed
Licensure Examination for Teachers major in Mathematics	August 14, 2005	77.60%

IV. TEACHING EXPERIENCE

2002 – present	Math Teacher Maryhill College Lucena City

APPROVAL SHEET

This seminar paper entitled **"CRITICAL THINKING SKILLS IN PROBLEM SOLVING OF GRADE EIGHT STUDENTS IN MATHEMATICS"** prepared and submitted by **JERSON D. JOLO,** in partial fulfillment of the requirements for the degree, **Master of Arts in Teaching Mathematics**, has been examined and recommended for acceptance.

Date: December 10, 2015

RENE R. BELECINA, Ph.D.
Adviser

Accepted in partial fulfillment of the requirements for the degree, Master of Arts in Teaching Mathematics.

Date: December 10, 2015

RENE R. BELECINA, Ph. D.
Program Coordinator
Mathematics and Science Education

Date: December 17, 2015

TERESITA T. RUNGDUIN, Ph.D.
Director
Graduate Research Office

Date: 18 January 2016

ZENAIDA Q. REYES, Ph.D.
Dean
College of Graduate Studies and
Teacher Education Research