

# **THE EFFECT OF REFLECTIVE JOURNAL WRITING TO STUDENTS' CRITICAL THINKING AND MATHEMATICAL COMMUNICATION SKILLS**

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## **ABSTRACT**

The objective of this quasi-experimental study was to investigate the effects of reflective journal writing to the students' critical thinking and mathematical communication skills. There were two teaching strategies under investigation in this study: the lecture-discussion approach and the reflective journal writing approach. A total of 60 participants, 30 prospective teachers from two comparable classes underwent the two teaching approaches. The students' critical thinking and mathematical communication skills were measured using researcher-made tests, which were content-validated and reliability tested. The lecture-discussion approach involved five phases: introduction, presentation, comprehension monitoring, integration, and review and closure. The reflective journal writing approach involved initializing, exploring, and connecting processes. Findings revealed that the performance of students in mathematical communication skills exposed to reflective journal writing approach was significantly higher than the performance of students exposed to the lecture-discussion approach. In contrast, there was no significant difference in the mean gain scores in critical thinking for both lecture-discussion and reflective journal writing groups.

## CHAPTER I

### INTRODUCTION

#### *Background of the Study*

Math hurts. This is the reality that most students have to endure in their academic life. In fact, students' learning difficulty in mathematics has long been a resounding issue in education especially in the Philippines as proven by several national and even international testing results. The Trends International Mathematics and Science Studies (TIMSS, 2003) spelled out a very dismal evidence of how our country fared with other countries. The Philippines ranked behind on the 41st spot among forty-five (45) participating countries.

Many would agree that mathematics is not just a subject which is difficult to learn but difficult to teach as well. Not so many students like mathematics no matter how convincing the opportunities would be for mathematically inclined students and students who have inadequate knowledge of mathematics would be greatly disadvantaged especially in this highly competitive and modernized world.

The problem is not only among elementary and high school students. Even college students in prestigious schools face the same dilemma. One college student even vehemently asked, "Who invented math and why did he invent it?," to which he shrugged and added, "My life could have been pleasing without it." To math teachers who do everything in their power to make the lesson interesting, this could be frustrating to hear from their student. There are more of these students who view mathematics in a similar way. The sad thing is even education students who will be future teachers are not spared from this predicament, especially Bachelor in Elementary Education students who are expected to teach all subjects.

Obviously, the above stated situation does not only present mathematics as a subject with difficult concepts, processes, and language but it also shows students' remote attitude towards mathematics. Where does the problem lie? According to some experts, the problem arose primarily because of the poor implementation of educational approaches. Bruner (1960), a mathematics reformist, said that the way students naturally learn is in conflict with how mathematics is taught in school. This conflict, he added, results to learning deficit among students.

In the Philippines, the educational sector is currently facing a dilemma more than ever. Added to the challenge of the country's educational milieu is the implementation of the K to 12 Curriculum in school year 2012-2013 which is considered to be a major educational reform in the history of the Philippine educational system. This brought with it curricular reforms which when not properly understood and implemented will worsen the educational set up of the country.

Central Philippine University is not spared from this predicament. This is the reason why the University had done enough preparations before the implementation of the K to 12 Curriculum. As a premiere University committed to equip graduates to be more competitive in the global market, it strongly advocates innovations in teaching strategies to enhance the learning process of the students especially in the field of science and mathematics.

As a field necessary for economic progress and national development, mathematics competence is a must. Sadly, students generally find mathematics difficult. Primarily because it deals with abstraction of concepts and it demands higher level of cognitive processes. As a result, performance in these areas remains disappointing. There were some research studies conducted to determine the performances of students in mathematics. Likewise, strategies in teaching mathematics were also the focus of some researchers with the purpose to help improve performances in mathematics. The results of the studies conducted by Calibjo (2005), Magno (2005), and Jaspe (2005) revealed that students acquired only mediocre abilities (average of satisfactory performance) in mathematics.

Moreover, the result of the respective study conducted by Vibas (2012) on cooperative learning using Team Game Tournament and Patacsil (2006) on creative problem solving in mathematics were found effective than the traditional methods because these strategies increased significantly students' scores in the teacher-made test after the students were exposed to these innovative approaches. In contrast, the use of games (Jaspe, 2005) and cooperative learning (Magno, 2005) in teaching mathematics revealed opposite results. These teaching approaches proved to be equally effective as the traditional method.

The studies mentioned were some of the efforts that were geared towards determining teaching approaches and methods to improve the learning of mathematics. However, there was no deliberate attempt to investigate about the use of journals to improve student's critical thinking and mathematical communication skills. This study is an ambitious exploration of the possible effect of reflective journal writing to the two important mathematical skills which are critical thinking skills and mathematical communication skills.

#### Why critical thinking and mathematical communication skills?

The need for critical thinking in classrooms has long been established in the mathematical world but very little has been materialized so far as evidenced by various studies. In the book *Research Ideas for the Classrooms* by the NCTM (2000), it was found out that high school students did not perform very well the tasks that have been used to indicate critical thinking competence.

In the report of the Association of American Colleges and Universities (AACU, 2005) which was based on Educational Testing Services standardized assessments from 2003 to 2004, it showed that only 6% of the undergraduate seniors demonstrated critical thinking proficiency. This result shows that there is indeed a great discrepancy between what should students possess and the real score in terms of critical thinking.

NCTM (2000) had spelled out the need for students to communicate their mathematical ideas. In grades 5-8 for example, it stated that the study of mathematics should include opportunities to communicate so that students can model situations using oral, written, concrete, pictorial, graphical and algebraic methods. Likewise, it emphasized that students reflect on and clarify their own thinking about mathematical ideas and situations; develop common understandings of mathematical ideas, including the role of definitions; use the skills of reading, listening and viewing to interpret and evaluate mathematical ideas; discuss mathematical ideas

and make conjectures and convincing arguments; and appreciate the value of mathematical notation and its role in the development of mathematical ideas.

In the mathematics framework of the K to 12 curriculum, reflective learning and constructivism are highly emphasized frames for critical thinking and problem solving. These frames call for teaching methods that require the use of reflective thinking, through journals which promote deeper learning and optimize students' awareness as they are structuring and constructing knowledge. These approaches allow students to make sense of their experiences as they think and process their experiences (K to 12 Toolkit).

In 2013, one of the researchers ventured to an approach of teaching which involved students to reflect about their learning, understanding and even their feelings and emotions including their anxieties about a specific lesson. Although not properly documented as a formal study, the researcher had found out positive results in terms of performance, participation, openness of ideas and students' responses. Students became more active in doing assignments and activities, reciting and were excited to receive their journals back in anticipation of the teacher's feedback.

The desire to improve mathematics achievement motivated the researchers to focus on more effective strategies and learner-centered classroom approaches. Journal writing has been used by teachers in Humanities and English subjects to improve the performances of students in their communication skills. It must be noted that mathematics also requires good communication skills specifically in discussing and understanding principles and concepts in every process. The researchers believed that with the use of journal writing in teaching mathematics, students will appreciate the beauty of mathematics as a course and can help them acquire knowledge, develop their critical thinking skills and improve their mathematical communication skills.

The aforementioned situations give the researchers enough reason to give serious effort to apply journal writing as an approach which targets the framework of the K to 12 curriculum highlighting both reflective learning and constructivism as primary forces that drive out critical thinking and mathematical communication skills.

### *Statement of the Problem*

This study investigated the effects of reflective journal writing approach to students' critical thinking skills and mathematical communication skills among freshmen students during the first semester of academic year 2014 - 2015.

Specifically, it sought to answer the following questions:

1. What are the critical thinking skills and mathematical communication skills of the students before their exposure to the lecture-discussion approach and reflective journal writing approach?
2. What are the critical thinking and mathematical communication skills of students after their exposure to the lecture-discussion approach and reflective journal writing approach?

3. Are there significant differences in the students' critical thinking and mathematical communication skills before and after exposure to the lecture-discussion approach and reflective journal writing approach?

4. Are there significant differences in the mean gain in the critical thinking and mathematical communication skills of students who underwent the lecture-discussion approach from those who underwent the reflective journal writing approach?

### *Hypotheses*

Based on the aforementioned inferential research questions, the following hypotheses were tested:

1. There are no significant differences in the students' critical thinking and mathematical communication skills before and after exposure to the lecture-discussion approach and the reflective journal writing approach.

2. There are no significant differences in the mean gain in the critical thinking and mathematical communication skills of students who underwent the lecture-discussion approach from those who underwent the reflective journal writing approach.

### *Theoretical Framework of the Study*

This study was anchored upon various theories on constructivism which focused on the learner as the key player in the generation of knowledge specifically the one espoused by Jerome S. Bruner (1960). He stressed that student's active participation in the teaching and learning process is vital. In support, Omstein & Hunkins (2009) emphasized that learning is optimized when students are aware of the process that they are structuring, inventing, and employing.

At the heart of the constructivist approach is the sensitivity on the part of the teacher to be able to feel as the learner feels, to put himself in the learner's shoes, not only in the cognitive sense, but also in the emotional sense (Macnab & Cummine, 1986). This is where reflective writing enters in. Students are given the chance to express out their inner sentiments not just about the difficulty of the subject matter but also their personal encounter as to their feelings, joys, anxieties and challenges as they learn mathematics. Macnab and Cummine (1986) pointed out that the mathematical conceptions of many children may often be beyond our grasp; that there are such misconceptions borne out of anxiety and confusion which can disastrously affect the learning process, should never be forgotten.

This study explored the possible effects of reflective journal writing and the lecture-discussion approach to the critical thinking and mathematical communication skills of the freshmen students in Math 2 of Central Philippine University during the first semester of academic year 2014 – 2015 as shown in the diagram.

Figure 1 shows the variables that were investigated in this study.

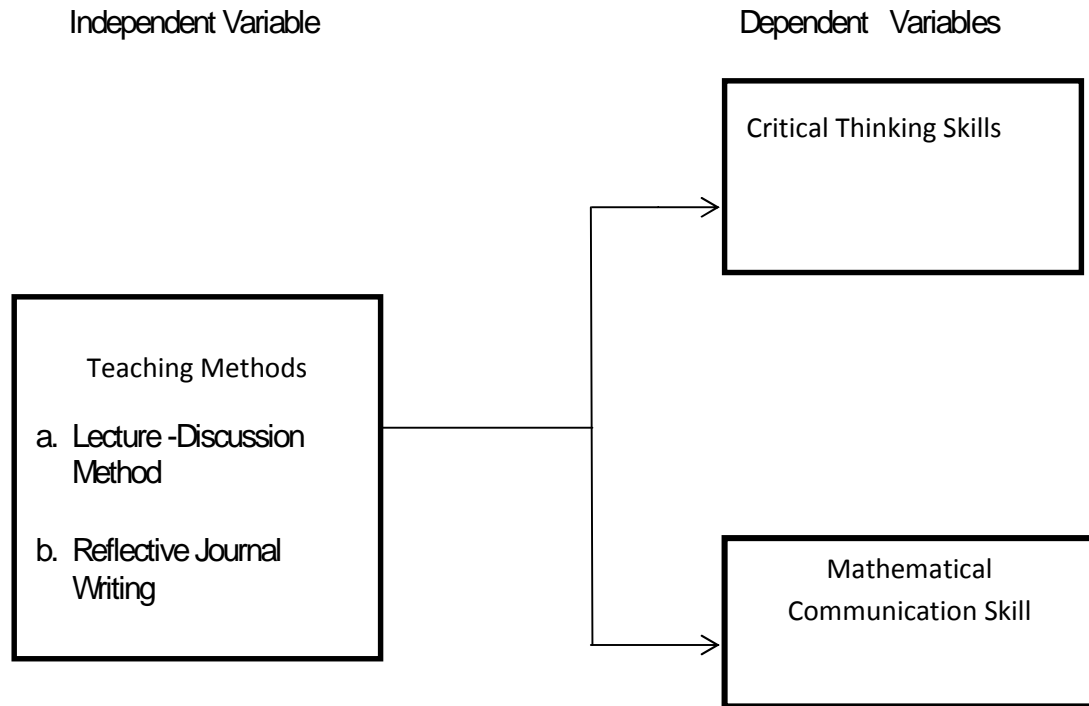


Figure 1. The conceptual framework of the study

### *Definition of Terms*

Important terms in this study were defined as follows.

*Critical Thinking Skill.* The purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based (Delphi Research Team and Facione, 2013).

In this study critical thinking refers to the skill that the students possess when they can interpret, analyze, evaluate, explain, self-regulate and infer in a given problem. It was one of the dependent variables which was measured using a teacher-made test involving multiple-choice questions. It involves six (6) core critical thinking skills: interpretation, analysis, inference, evaluation, explanation and self-regulation.

*Reflective Journal Writing.* This is a type of learning where students reflect through writing their learning from an experience and puts the reflection into a more permanent and structured format of a written account and linking it to academic theory.

In this study, it is the intervention used in the experimental group where the students write about their experience while learning basic mathematics. The reflective journal writing that was implemented followed these three reflective processes: the initializing process where students recall prior knowledge, difficulties encountered in the past, reasons for such difficulty and how they were able to improve; the second was the exploring process where students are building or developing knowledge and relearning previous knowledge, thinking about the best way to learn and how the learning was applied to real-life situations; and the last was the connecting process where students link their knowledge to other fields and to future tasks and strengthen this knowledge.

*Mathematical Communications Skill.* Student's ability to organize and consolidate his mathematical thinking through communication; communicate his mathematical thinking coherently and clearly to peers, teachers, and others; analyze and evaluate the mathematical thinking and strategies of others; and use the language of mathematics to express mathematical ideas precisely NCTM (2000).

As used in the study, mathematical communication is a skill by which students articulate thoughts and ideas effectively using written communication. It was one of the dependent variables in this study and was measured through performance-based tasks. A rubric was used to score the students' outputs.

*Lecture-discussion.* A teaching method concerned with the teacher being the controller of the learning environment. Power and responsibility are held by the teacher who plays the role of instructor (in the form of lectures) and decision maker (in regards to curriculum content and specific outcomes). The teacher regards students as having 'knowledge holes' that need to be filled with information. In short, the traditional teacher views that it is the teacher that causes learning to occur (Novak, 1998).

The traditional teaching method that was used in this study was the lecture-discussion model as described by Eggen and Kauchak (2006) which involves five phases: introduction, presentation, comprehension monitoring, integration and review, and closure. According to Eggen and Kauchak (2006), in the introduction phase, the teacher reviews and presents a form of focus for the lesson to attract attention and activate background knowledge. This is continued in the presentation stage where teacher presents an organized information which serves to provide background knowledge and begin schema (form of understanding that represents the way knowledge is organized in long-term memory) production. The third phase which is comprehension monitoring, checks students' understanding of the present material for perception check and put learners in active roles. The fourth phase, the integration phase connects new learning to existing understanding where students elaborate schemas and achieves equilibrium. The last phase involves review and closure which completes schema production and promotes perception of competence.

### *Delimitation of the Study*

This study investigated the effects of journal writing to student's critical thinking and mathematical communication skills. A quasi-experimental pre test-post test control group (experimental and control) design was employed in this study utilizing two intact sections of first year education students of Central Philippine University enrolled in Mathematics 2 (Basic Mathematics) during the first semester of the school year 2014-2015. Each class is composed of 40 education students regardless of area of specialization.

The included basic number theory (factors, multiples, prime and composite numbers, divisibility, greatest common factor and least common multiple); fractions and their operations; rate; ratio and proportion; and basic geometry.

Students' critical thinking and mathematical communication skills were determined using their pretest and posttest scores. The instruments used to measure the two skills were content validated and multiple choice items were item analyzed. Reliability was also established using internal consistency utilizing Kuder-Richardson.

### *Significance of the Study*

This study obtained results that would be beneficial to:

*Students.* The result of this study can provide data for students to consider reflective journal writing in improving their critical thinking and mathematical communication skills. This study can lead students to examine their personal learning habits, difficulties, and strategies in learning to address these difficulties. As future teachers they can also be made aware that they need to think and apply appropriate strategies to effect learning in their classrooms.

*Teachers.* Results of this study can offer baseline on the use of journal writing for teachers. They may consider implementing it in their classrooms and share it with their colleagues as well. They can design the learning environment in their classrooms that promotes better learning; produce active learners and eventually good mathematics performers. Teachers may likewise gain insights on how to provide relevant and meaningful learning experiences that are anchored upon constructivist point of view in their classrooms.

*Parents.* Knowing the possible effects of journal writing to their children's mathematical learning, parents can provide appropriate support, motivation and encouragement to their children. As potent partners of teachers in educating their children, parents do well if they establish conducive home environment that will help their children do better in their academic performance.

*Principals and supervisors.* School heads are compelling instruments to make change happen. Knowing the positive effects of journal writing to students' varying mathematics needs, school heads have better influence on their teachers in promoting better learning environment in their school. They can meet, plan, include in their learning agenda, and eventually implement a more student-centered classroom in their school.

*Future researchers.* Results of this study will provide insurmountable contribution to the general knowledge where teachers who hunger for discovery and learning can fit themselves in.

## CHAPTER II

### METHODOLOGY

#### *Research Design*

This quantitative study employed a quasi-experimental pre test-post test control group design. Such design applied because random selection of individual sample was quite impossible, so intact groups were used (Fraenkel & Wallen, 2009). The matching-only pretest-posttest control group design specifically suited the design used since subjects were matched on certain variables, in this case, the students were matched according to sex and placement exam result. Although this is not a substitute for random assignment, this provided adequate control of sources of invalidity

(Fraenkel & Wallen, 2009).

The assignment as to what group was under the experimental or control group was done randomly. Each group was given a pretest and then treatment was administered to the experimental group while the control group was exposed to the traditional method of mathematics instruction. After the term, a posttest was given to each group and the results were analyzed.

#### *The Participants*

The participants of the study included first year education students of Central Philippine University taking Mathematics 2 (Basic Mathematics) during the first semester of the school year 2014-2015. Out of five sections enrolled in the subject, two sections

composed of 44 students each were chosen because of three reasons: the two sections utilized only one room; the schedule of classes were successive; and only one teacher (one of the researchers) handles the two classes. Since this study applied the matching of students, their grades in the prelim and midterm exams and sex were the bases for matching. Only the students in the control group whose required characteristics match with the characteristics of students in experimental group were included in the analysis and interpretation of results. The performance of the paired samples in the two sections were treated and analyzed at .05 level of significance. To reduce the biases in determining the eligible samples, students were not informed who among them were included.

### *Instruments*

The study utilized researcher-made questionnaires which underwent content validation, item analysis, and reliability testing. The instrument to measure critical thinking skills was composed of 12 multiple-choice questions which were based upon the domains of critical thinking suggested by Facione (2013).

The mathematical communication skill, which included only written communication, was measured using fifteen performance-based questions. It required students' explanation which used a rubric in scoring. The rubric was reliability tested using rater's consistency.

### *Critical Thinking.*

The instrument used for critical thinking in this study utilized the six-core critical thinking skills known as the Expert Consensus Statement on Critical Thinking which was made possible through a two-year collaboration by snail mail of forty-six experts from Canada and the United States. These panel of experts represented many different scholarly disciplines in the humanities, sciences, social sciences, and education in a research project that was conducted on behalf of the American Philosophical Association. This method of collaboration was popularly known as the Delphi Research Method as cited by Peter A. Facione in many of his critical thinking works. These six (6)-core critical thinking skills were interpretation, analysis, inference, evaluation, explanation and self-regulation.

The six-core thinking skills mentioned above have their specific evidences as quoted by Peter A. Facione from the result of the Delphi Method as shown in the following paragraphs.

*Interpretation* means to comprehend and express the meaning or significance of a wide variety of experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures, or criteria. Interpretation includes the sub-skills of categorization, decoding significance and clarifying meaning. Some questions to be considered in measuring student's interpretation skills are: What does this mean? What's happening? How should we understand that? (What he or she just said?) What is the best way to characterize, categorize, classify this?

*Analysis*, on the other hand, means to identify the intended and actual inferential relationships among statements, questions, concepts, descriptions, or other forms of representation intended to express belief, judgment, experiences, reasons, information, or opinions. Moreover, Facione (2013) and other experts include examining ideas, detecting arguments as sub-skills of analysis. Some lines which suggest analysis among students are: Please tell us again your reasons for making that claim. What is your conclusion? What it is that you are claiming? Why do you think that? What are the arguments' pro and con? What assumptions must we make to accept that conclusion? What is your basis for saying that?

As defined by Delphi Research Method quoted by Facione (2013), *evaluation* means to assess the credibility of statements or other representations which are accounts or descriptions of a person's perception, experience, situation, judgment, belief, or opinion; and to assess the logical strength of the actual or intended inferential relationships among statements, descriptions,

questions or other forms of representation. Some questions that lead to evaluation are: How credible is that claim? Why do we think we can trust this person's claim? How strong are those arguments? Do we know our facts right? How confident can we be in our conclusion, given what we now know?

As used in the study, *inference* means to identify and secure elements needed to draw reasonable conclusions; to form conjectures and hypotheses; to consider relevant information and to deduce the consequences flowing from data, statements, principles, evidence, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation. Inference can be shown by students if they are able to answer the following: Given what we know so far, what conclusions can we draw? Given what we know so far what can we rule out? What does this evidence imply? If we abandoned/accepted that assumption, how would things change? What additional information do we need to resolve the question? If we believed these things, what would they imply for us going forward? What are the consequences of doing things that way? What are the alternatives we haven't yet explored? Let us consider each option and see where it takes us. Are there any undesirable consequences that we can and should foresee?

As elaborated in the Delphi research, *explanation* means being able to present in a cogent and coherent way the results of one's reasoning. This means being able to give someone a full look at the big picture: both "to state and to justify that reasoning in terms of the evidential, conceptual, methodological, criteriological, and contextual considerations upon which one's results were based; and to present one's reasoning in the form of cogent arguments. Explanation requires students to answer questions such as: What were the specific findings/results of the investigation? Please tell us how you conducted the analysis. How did you come to that interpretation? Please take us through your reasoning one more time. Why do you think that was the right answer/solution? How would you explain why the particular decision was made?

*Self-regulation* on the other hand according to the same group of experts means self-consciously monitor one's cognitive activities, the elements used in those activities, and the results educed, particularly by applying skills in analysis and evaluation to one's own inferential judgments with a view toward questioning, confirming, validating, or correcting either one's reasoning or one's results. For students to show self-regulation, they must answer questions such as: Our position on this issue is still too vague, can we be more precise? How good was our methodology and how well did we follow it? Is there a way we can reconcile these two apparently conflicting conclusions? How good is our evidence? Ok, before we commit, what are we missing? I'm finding some of our definitions a little confusing, can we revisit what we mean before making any trial decisions?

The actual scores of the students during the test were the basis for their performance in critical thinking and were used for the interpretation of the result of the study. Critical thinking skill of students was measured using a 12-item set of questions and were categorized as "beginning" ( 0 – 3.00), "developing" (3.01 – 6.00), "competent" ( 6.01 – 9.00), and "accomplished" ( 9.01 – 12.00).

*Mathematical communications skill.* As used in the study, mathematical communication is a skill where students articulate thoughts and ideas effectively using written communication. The instrument used to measure student's mathematical communications skill was based upon the NCTM (2000) standards which included the following competencies: organize and consolidate

mathematical thinking through communication; communicate mathematical thinking coherently and clearly to peers, teachers, and others; analyze and evaluate the mathematical thinking and strategies of others; and use the language of mathematics to express mathematical ideas precisely. Mathematical communication skill of students was measured using a 15-item set of questions and was categorized as “beginning” (0 – 15.00), “developing” (15.01 – 30.00), “competent” (30.01 – 45.00), and “accomplished” (45.01 – 60.00).

### *Validity of the Instrument and Reliability Test*

There were two test instruments used in the study: the test instrument to measure critical thinking skills and the test instrument to measure mathematical communication skills of students.

*Test instrument to measure critical thinking.* The instrument used to measure students' critical thinking skills was composed of twelve (12) multiple choice questions. These items were chosen from eighteen (18) questions validated by three (3) experts in the field of mathematics. The questions were tested for reliability using internal consistency utilizing Kuder-Richardson ( $r_{KR20} = .75$ ).

It was pilot-tested to fifty (50) freshmen students who were enrolled in the College of Arts and Sciences, Business and Accountancy and the College of Engineering.

*Test instrument to measure the mathematical communications skill.* The mathematical communication skill instrument utilized in this study was researcher-made. It was composed of fifteen (15) performance-based tasks that asked students to answer in the problem. Performance-based tasks were submitted for content validation and were scored using a rubric which was subjected to inter-rater consistency ( $r = .94$ ,  $p = .001$ ). Each item in the test merits a highest score of 4 (four) points.

The instrument to measure student's mathematical communications skill was based upon the NCTM (2000) standards which include the following competencies: organize and consolidate mathematical thinking through communication; communicate mathematical thinking coherently and clearly to peers, teachers, and others; analyze and evaluate the mathematical thinking and strategies of others; and use the language of mathematics to express mathematical ideas precisely. A rubric was used to score the students' outputs. A score of four (4) was given when all the needed concepts and ideas are correctly presented; mathematical thinking is logical and clear and can easily be understood even in just one reading; and all necessary mathematical symbols, terms and notations are found. A score of three (3) was given when all the needed concepts and ideas are correctly presented; mathematical thinking is either logical or clear and can be understood; and most of the necessary mathematical symbols, terms and notations are used or most of the needed concepts and ideas are correctly presented; mathematical thinking is logical and clear and can easily be understood even in just one reading; and most of the necessary mathematical symbols, terms and notations are used correctly. A score of two (2) was given when most of the needed concepts and ideas are not correctly presented; mathematical thinking is neither logical nor clear; and some mathematical symbols, terms and notations are used. A score of one (1) was given when at most one of the needed concepts and ideas is/are correctly

presented; and mathematical thinking is neither logical nor clear. A score of zero (0) was given when there is no evidence of mathematical thinking.

### *The Intervention*

The study was done from the first week of September until the third week of October of 2014 to two classes of Mathematics 2 students which met twice a week for 90 minutes each meeting. Before the formal conduct of the study, a pretest was conducted for both classes then researcher-made lesson plans were implemented.

There were fourteen (14) detailed lesson plans prepared, each for the lecture discussion group and the experimental group covering the following topics: basic number theory (prime and composite numbers and divisibility; least common multiple and greatest common factor; equivalent fractions and ordering of fractions; operations on fractions; writing rational numbers in different forms; and Introduction to Geometry.

The lesson plans were based upon the syllabus in Mathematics 2 of Central Philippine University duly approved by the Math and Physics Department of the University.

The reflective journal writing that was implemented followed three reflective processes which were done in order but may not be mutually exclusive of each other: initializing process, exploring process and the connecting process.

In the initializing process, the students recalled their prior knowledge, difficulties encountered in the past, reasons for such difficulty and how they were able to improve. The second was the exploring process where students were building or developing knowledge and relearning previous knowledge, thinking about the best way to learn and how the learning was applied to real-life situations. The last process was the connecting process where students link their knowledge to other fields and to future tasks and strengthen this knowledge.

Every meeting, students were expected to write their reflections and the teacher wrote down feedback on the students reflective output.

On the other hand, the lecture discussion method that was used in this study applied the suggestion of Eggen and Kauchak (2006) which involves five phases: *introduction, presentation, comprehension monitoring, integration and review and closure*.

In the *introduction phase*, the teacher reviewed and presented a form of focus for the lesson which is to attract attention and to activate background knowledge. It was followed by the *presentation stage* where the teacher presented an organized information which served to provide background knowledge and to begin a schema (form of understanding that represents the way knowledge is organized in long-term memory) production. In the third phase which was *comprehension monitoring* the teacher checked students' understanding of the present material for perception check and put learners in active roles. In the fourth phase, *the integration phase*, the teacher let students connect new learning to existing understanding for them to elaborate schemas

and achieve equilibrium. Lastly, the teacher *reviewed and closed* the lesson for the completion of schema production and promotion of perception of competence.

Journal writing and traditional methods were implemented using the following outline and framework:

Table 1 . The similarities and differences of the journal writing method and traditional teaching method.

Components of the lesson	Journal Writing Approach	Traditional teaching (Lecture-discussion)
Learning outcomes /objectives and subject matter	Based on the course syllabus	Based on the course syllabus
Materials	Worksheets Charts Journals Bubble charts	Worksheets charts
Preliminary activities :	<p><b>Initializing Process</b></p> <p>Initializing questions: What have you learned about the topic?</p> <p>What were your difficulties about the topic?</p> <p>How do you think will you be able to improve your knowledge about it?</p> <p>How will our topic today be related to our previous lesson?</p>	<p><b>Introduction</b></p> <p>Review questions: What numbers do you multiply to give a product of ...?</p> <p>What are the factors of ...?</p> <p>What is the difference between ....?</p>
Lesson proper	<p><b>Exploring Process</b></p> <p><b>Inductive in nature and applies constructivist approach of teaching.</b></p> <p>The teacher facilitates discussion for students to discover the concepts and principles : Basing upon the examples, when can we say that...?</p>	<p><b>Presentation</b></p> <p><b>Deductive method of teaching.</b></p> <p>The teacher lectures, provides examples and discusses with students.</p> <p>Definitions are presented.</p>

	<p>What have you noticed with numbers ...?</p> <p>Basing upon the preceding ideas that you have mentioned, when can we say that ....?</p> <p>Is the rule that you have made, applicable for other higher numbers also?</p> <p>Could you think of others ways to tell ....?</p> <p>Which is the best way to use?</p>	<p>Examples are given.</p> <p>The teachers ask students also but no “reflective questions” are thrown.</p>
Enhancement activity	<p><b>Exploring Process</b></p> <p>Same activities with traditional teaching but processing questions for reflection are integrated:</p> <p>Students think of real-life situations where ... is applied. They construct problems and solve them.</p>	<p><b>Comprehension Monitoring</b></p> <p>Same activities with reflective learning.</p> <p>Teacher tells of real-life situations where ... is applicable and lets students solve problems related to ...</p>
Generalization	<p><b>Exploring Process</b></p> <p>Summary of the concepts and principles learned but with “realizations” for reflection</p>	<p><b>Integration</b></p> <p>Teacher asks about the concepts and principles learned</p>
Evaluation	<p><b>Connecting Process</b></p> <p>Same evaluation with traditional teaching but with reflective questions.</p> <p>How do you use your knowledge about ... to solve tasks in the future?</p>	<p><b>Integration/ Review and Closure</b></p> <p>Same evaluation with reflective learning</p>
Assignment	<p><b>Connecting Process</b></p> <p>Same assignment but reflective journals.</p> <p>In the lesson, what were some areas that you still find difficult?</p> <p>How will you be able to overcome it?</p> <p>Why is it necessary to study about ...?</p>	<p><b>Review and Closure</b></p> <p>Same assignment as the reflective group but with no reflection. Instead, questions such as the following will be given:</p> <p>If <math>n</math> is a number ..., what other numbers is <math>n</math>...?</p>

	How will you be able to use your knowledge about ... in other areas?	
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### *The Reflective Journal Writing Process*

*Initializing process* – Recalling prior knowledge, difficulties, reasons for such difficulty, how students will be able to improve it.

*Exploring process* – Learning and relearning previous knowledge, thinking about the best way to learn it, how the learning is applied to real life situations.

*Connecting Process* – linking, relating how the knowledge is applied to other fields.

### *Data Collection Procedure*

Since this study was experimental in nature, data collection posed no problem because only test scores were the primary data which were readily available after the tests. Before and after the conduct of the study, pretest and posttest were done, respectively, to measure the two areas which the researcher was interested in, namely: critical thinking skill and mathematical communication skill.

### *Data Analysis Procedure*

This study investigated the effects of reflective journal writing to students' critical thinking and mathematical communication skills. The data gathered from the sources were coded and encoded for computer processing.

The Statistical Package for Social Sciences (SPSS Version 17) for Windows was used for the statistical analysis of the study. Analysis of all data was done using descriptive-comparative analysis.

Frequency distribution, mean and standard deviation were used to measure central tendencies and dispersion of data, respectively. To determine the significance of the differences between means, the t-test for independent samples and t-test for paired samples were computed and analyzed. Significance level was set at .05 using two-tailed tests.

## CHAPTER III

### RESULTS AND DISCUSSIONS

This chapter is divided into two parts: (1) Descriptive Data Analysis, and (2) Inferential Data Analysis.

The Descriptive Data Analysis describes the pretest and posttest scores of the students in critical thinking and mathematical communication. It includes the descriptive analysis of data such as mean, and standard deviation.

The Inferential Analysis presents the result of hypotheses testing for the significant difference that involves the pretest, posttest, and mean gain. The *t* test for independent samples and *t* test for paired samples were the statistical tools in the inferential analysis. All these statistical inferences were tested at 5% level of significance.

#### *Descriptive Data Analysis*

The focus of the descriptive analysis answers the questions: (1) What are the critical thinking and mathematical communication skills of the students before their exposure to the lecture-discussion approach and reflective journal writing approach?; and (2) What are the critical thinking and mathematical communication skills of the students after their exposure to the lecture-discussion approach and the reflective journal writing approach?

*Pretest Scores.* Table 1 shows the result of the pretest scores of the students in critical thinking and mathematical communication before their exposure in lecture-discussion approach and the reflective journal writing approach. Results showed that the pretest scores in critical thinking for both the lecture-discussion and reflective journal writing were 3.57 and 3.63, respectively from a perfect score of 12. The two groups were quite similar in their critical thinking skills for both of them belong somewhere in the developing level. The students from the lecture-discussion group ( $sd = 1.50$ ) were somehow as homogeneous as the students from the reflective journal writing group ( $sd = 1.71$ ) in terms of their critical thinking.

The table also reveals that the mathematical communication skill pretest result of the students in the lecture-discussion group ( $M = 7.97$ ) and the reflective learning group ( $M = 7.8$ ) had mean scores which can be interpreted as beginning. The data represent a very low result considering that the perfect score is 60.

As a whole, based on the pretest results, the prospective teachers from both teaching approaches had developing level in critical thinking and beginning level in mathematical communication skill.

This result confirms the findings of TIMSS (in Gonzales et.al., 2003) and the analysis of Ogena et.al. (2010) of the result of TIMSS in 2008, which both found a poor performance of Filipino students in mathematics compared to the performance of students in other countries. This result shows that the students' foundation of basic mathematics is still far behind than what is expected of them as college students and as prospective teachers.

Table 1. Pretest Scores in Critical Thinking, and Mathematical Communication of Students before their Exposure in Lecture-Discussion Approach and Reflective Journal Writing Approach

	Lecture-Discussion Approach				Reflective Journal Writing Approach			
	N	sd	M	Description	N	sd	M	Description
<b>Critical Thinking</b>	30	1.50	3.57	Developing	30	1.71	3.63	Developing
<b>Mathematical Communication</b>	30	5.68	7.97	Beginning	30	7.16	7.80	Beginning

*Note:* Interpretation is based on the following scale. Critical Thinking – beginning (0 - 3.00), developing (3.01- 6.00), competent (6.01 – 9.00), accomplished (9.01 – 12.00); Mathematical Communication – beginning (0 – 15.00), developing (15.01 – 30.00), competent ( 30.01 – 45.00), accomplished (45.01 – 60.00)

*Posttest Scores.* Table 2 summarizes the results for posttest scores of the students in critical thinking and mathematical communication skills. It presents the data for both the lecture-discussion approach and the reflective journal writing approach.

*Critical Thinking.* From the data gathered, it can be seen that the mean scores of the students from the lecture-discussion group in critical thinking ( $M=5.20$ ) and the reflective journal writing group ( $M=5.93$ ) were both developing. This simply means that even if both groups had undergone treatments, their critical thinking scores were still short of the passing score, which is 6. Noticeably, however, both groups had improved in their posttest scores.

The standard deviation of the lecture-discussion group ( $sd=1.79$ ) was slightly higher than that of the reflective journal writing group ( $sd=1.62$ ). Such measure of dispersion reveals that the students in the lecture-discussion group were somehow heterogeneous in their posttest critical thinking scores.

*Mathematical Communication Skill.* In the area of mathematical communication skill, posttest scores show that the students from the lecture-discussion group had lower scores ( $M=16.67$ ) than the students from the reflective journal writing group ( $M=21.47$ ). Both groups, however, had mean scores in the developing level of mathematical communication skill. On the other hand, posttest standard deviations reveal that the students from the lecture-discussion group had less variable scores ( $sd=9.51$ ) than the students from the reflective journal writing group ( $sd=12.22$ ).

The results seem to suggest that although the students' performance had improved for both groups, their scores were still low and behind the passing score in each of the skills measured. Aside from the students' poor mastery of the content, one probable reason for this dismal result may be the students' exposure to the type of test given by the teacher. The questions which measured the students' critical thinking and mathematical communication skills assessed meaningful learning and were beyond rote learning.

Table 2. Posttest Scores in Critical Thinking and Mathematical Communication of Students before their Exposure in Lecture-Discussion Approach and Reflective Journal Writing Approach

	Lecture-Discussion Approach				Reflective Journal Writing Approach			
	N	sd	M	Description	N	sd	M	Description
<b>Critical Thinking</b>	30	1.79	5.20	Developing	30	1.62	5.93	Developing
<b>Mathematical Communication</b>	30	9.51	16.67	Developing	30	12.22	21.47	Developing

Note: Interpretation Is based on the following scale. Critical Thinking – beginning (0 - 3.00), developing (3.01- 6.00), competent (6.01 – 9.00), accomplished (9.01 – 12.00); Mathematical Communication – beginning (0 – 15.00), developing (15.01 – 30.00), competent ( 30.01 – 45.00), accomplished (45.01 – 60.00)

### *Inferential Data Analysis*

The study has two objectives for the inferential part. The results and discussions are each shown below.

#### *Difference in the Scores in Critical Thinking, and Mathematical Communication Skills of Students Before and After Using Lecture-Discussion Approach*

Table 3 shows the difference in pretest and posttest scores of the students exposed in lecture-discussion method. The students in this group had increased their scores in critical thinking and mathematical communication skills. Such differences in the scores were significant in all areas.

*Critical Thinking Skills.* As to the students' pretest and posttest scores in critical thinking, it is shown that there was an improvement in the mean scores of 1.63 ( $M_{pretest} = 3.57$ ,  $M_{posttest} = 5.2$ ). The mean difference was verified to be significant,  $t(29) = 5.42$ ,  $p = .000$ , which implies that the students' performance in critical thinking had significantly improved.

*Mathematical Communication Skills.* In the area of mathematical communication, it is shown that the students' mean score improved ( $M_{pretest} = 7.97$ ,  $M_{posttest} = 16.67$ ). Such improvement shows more than 100% (mean difference of 8.70) increase. Consequently, this mean difference was significant, ( $t = 9.25$ ,  $p = .000$ ). This result implies that the posttest scores of the students in mathematical communication skills were significantly higher than their scores in the pretest.

As a universal and time-tested strategy in teaching which encompasses time and place, optimization of the lecture-discussion method of teaching had significantly improved the students' critical thinking and mathematical communication skills. Lecture discussion in its noblest sense

can also lead the students to develop their mathematical skills provided the students do not just settle as passive absorbers of facts inside the classroom.

Table 3. Difference in the Scores in Critical Thinking, and Mathematical Communication Skills of Students Before and After Using Lecture-Discussion Approach

Lecture-Discussion Approach	Scores of Prospective Teachers						
	N	Mean	sd	Mean Difference	df	t-value	p-value
<b>Critical Thinking</b>							
Pretest	30	3.57	1.50				
Posttest	30	5.20	1.79	1.63	29	5.42***	.000
<b>Mathematical Communication Skills</b>							
Pretest	30	7.97	5.68				
Posttest	30	16.67	9.51	8.70	29	9.25***	.000

Note: \*\*\*  $p < .001$

*Difference in the Scores in Critical Thinking, and Mathematical Communication Skills of Students Before and After Using Reflective Journal Writing Approach*

Table 4 shows the difference in the scores in critical thinking and mathematical communication skills of students before and after exposure to the reflective journal writing approach.

*Critical thinking skills.* The result of the students' pretest and posttest scores in critical thinking showed that there was also an improvement in the mean scores of 2.30 ( $M_{pretest} = 3.63$ ,  $M_{posttest} = 5.93$ ). The improvement in scores was significant at .001 level as shown by the  $t$ -value of 6.52 and  $p$ -value of .000, which means that, the scores of the students in critical thinking had significantly increased after having been exposed to the reflective journal writing approach of teaching.

*Mathematical Communication Skill.* Based on the findings, the same result was found in the area of mathematical communication skill. A significant increase of 14.67 ( $M_{pretest} = 7.80$ ,  $M_{posttest} = 22.47$ ) shows that the pretest score had tripled in the posttest which consequently was verified to be significant at .001 level as shown by the  $t$ -value of 11.34 and  $p$ -value of .000. This result implies that the students' performance in mathematical communication had significantly improved.

This result was evident in the students' answers as shown in one of the test items in mathematical communication. Here is an example:

Question: Julio says that 1,131 is a prime number while Ana says that it is a composite number. Who is correct? Explain your answer.

Student 1:

Pretest Answer: Julio is correct because 1,131 has 1 and itself as its factors, therefore 1,131 is a prime number.

Posttest Answer: Ana is correct. 1,131 is a composite number. It is divisible by 1; 3; 377; 1,131 and more if there is. It is a composite number because it has more than two different factors.

Student 2:

Pretest Answer: Ana, simply because 1,131 is an odd number. So it is a composite number.

Posttest Answer: Anna because 1,131 has more than two factors in which it is a composite number.

Student 3:

Pretest Answer; [Blank. No answer.]

Posttest Answer: Ana is correct because 1,131 is a composite number. 1,131 has more than 2 factors, these are 1, 1,131, 3, and 377. Therefore, 1,131 is a composite number and a composite number is a number having more than two factors.

It is seen in the answer of the students that they had improved in expressing their mathematical ideas in writing, clarified their own thinking, argued, used words to convince their ideas, used definitions to communicate their thoughts, and developed common understandings of mathematical ideas. The students also showed confidence in conveying their ideas as they used more words to clarify what they mean and to make sure they had answered the questions correctly and completely.

As a summary of the difference in the pretest and posttest scores of students exposed in reflective learning in critical thinking and mathematical communication skills, the students' performance in these areas had significantly improved. Evidently, this result affirms constructivism's contention that the students' active participation in the teaching and learning process is vital where they control their own learning process, and they lead the way by reflecting on their experiences (Brunner, 1977). Simply put, it is when the students construct knowledge that they learn more.

Likewise, this result confirms the Experiential Learning Theory by Kolb which asserts that knowledge is created through the transformation of experience which serves as a basis for reflection. Through these reflections, the students assimilated the information and formed abstract concepts which they used to develop new learning (Kolb, Boyatzis, Mainemelis, 1999).

Furthermore, Albert Bandura's Social Cognitive Theory gives a relevant explanation of the findings of the study as it acknowledges the idea that human beings as "agentic operators" need to maximize their self-reflective and self-regulative mechanisms in order to achieve something meaningful in their life (Bandura, 1986).

Table 4. Difference in the Scores in Critical Thinking, and Mathematical Communication Skills of Students Before and After Using Reflective Journal Writing Approach

Reflective Journal Writing Approach	N	Mean	sd	Scores of students			
				Mean Difference	df	t-value	p-value
<b>Critical Thinking</b>							
Pretest	30	3.63	1.71				
				2.30	29	6.52***	.000
Posttest	30	5.93	1.79				
<b>Mathematical Communication Skills</b>							
Pretest	30	7.80	7.16				
				14.67	29	11.34***	.000
Posttest	30	22.47	12.22				

Note: \*\*\*  $p < .001$

*Difference in the Main Gain Scores in Critical Thinking between Students who Underwent Lecture-discussion and Reflective Journal Writing Approach.*

*Difference in the Mean Gain Scores.* The following discussions included the result of the inferential statistical analysis that tests the hypothesis: There are no significant differences in the mean gain scores in the critical thinking and mathematical communication skills of students who underwent the lecture-discussion approach from those who underwent reflective journal writing approach.

*Critical Thinking Skills.* Table 7 displays the difference in the mean gain scores in critical thinking between students who underwent the lecture-discussion approach and the reflective journal writing approach. The comparison of the mean gain scores in critical thinking between students in the lecture-discussion group and the reflective journal writing group showed a mean

gain difference of 0.67. This is because the mean gain scores of the students in the lecture-discussion group was 1.63 and those in the reflective journal writing group was 2.30. It appeared that the difference in the mean gain scores between the two groups was not significant at .05 level as shown by the t-value of 1.43 and p-value of .163. This result implies that the mean gains of the two groups were comparably the same.

This result does not support the findings of Pugalee (in Urquhart, 2009) who found that writing supports mathematical reasoning and is not in consonance with the study of Quitadamo and Kurtz (2006) which revealed a positive impact of writing in students' critical thinking skills.

Table 5. Difference in the Main Gain Scores in Critical Thinking of Prospective Teachers who underwent Lecture-Discussion Approach and Reflective Learning Approach.

Teaching Methods	N	Mean Gain	sd	Mean Gain in Critical Thinking			
				Mean Difference	df	t-value	p-value
Lecture-Discussion Approach	30	1.63	1.65				
				0.67	29	1.432	.163
Reflective Learning Approach	30	2.30	1.93				

*Difference in the Main Gain Scores in Mathematical Communication Skills between Students who Underwent Lecture-Discussion and Reflective Journal Writing Approach*

*Mathematical Communication Skills.* It is shown in Table 8 that the difference in the mean gain scores in mathematical communication skills between students who underwent lecture-discussion approach ( $M= 8.70$ ) and the reflective journal writing approach ( $M= 14.67$ ) was 5.97 in favor of the latter. This big difference was significant at .001 level as shown by the t-value of 4.58 and p-value of .000. This result means that the performance in mathematical communication of the students who underwent the reflective journal writing approach had better improvement than the performance of the students who underwent the lecture-discussion approach. This result is a confirmation of the findings of Ligue and Lahoylahoy (2012) who stated that writing activity during Geometry periods helped students' writing skill. Moreover, this study was in consonance with the work of Pugalee (Urquhart, 2009) and Banker (2004) who both found a positive effect of writing to students' communication skills.

Table 6. Difference in the Main Gain Scores in Mathematical Communication Skills between Prospective Teachers who underwent Lecture-Discussion and Reflective Learning Approach.

Teaching Methods	Mean Gain in Mathematical Communication Skills						
	N	Mean	sd	Mean Difference	df	t-value	p-value
Lecture-Discussion Approach	30	8.70	5.15				
				5.97	29	4.582***	.000
Reflective Learning Approach	30	14.67	7.09				

In summary, the students who were exposed to the reflective journal writing approach were most of the time involved in more active roles as generators of knowledge. In all the processes involved in the reflective journal writing cycle, the students took part either individually, by pair or the whole class in making learning happen. The situation captured the heart of the constructivist approach which puts the students at the center of the teaching and learning process (Bruner, 1977). Through reflection, the students were able to improve the skills expected of them, namely: critical thinking and mathematical communication skills. This means that by active reflection, if one skill was developed, other mathematical skills of the students were not far from developing also. It is worthy to mention that when the students were involved in reflection through the various activities given, any of the skills mentioned would hardly be pinpointed as the target skill to be developed in a specific activity since the process of reflection involves more of metacognition. The entire process implies that when the students reflected, they were most likely inclined to rethink, go back to the process, think more deeply, and eventually improve (Bruner, 1977).

This study likewise is an affirmation of the Experiential learning by Kolb, et.al. (1999) who espoused the idea that knowledge is created through the transformation of experience and this knowledge results from the combinations of grasping and transforming experience. In this study, the process of reflection had provided the students with meaningful learning experiences that led them to assimilate information and form abstract concepts which they used to develop new theories about the world.

Moreover, the finding of this study is in congruence with the theory, the Social Cognitive Theory embraced by Albert Bandura Theory. This theory stated that human agency is embedded in a self-theory encompassing self-organizing, pro-active, self-reflective and self-regulative mechanisms. The entire process of reflection in this study has no doubt, helped the students to link all their mathematical skills specifically, their critical thinking and mathematical communication skills. This is in line with what Bandura (1986) said that human beings are “agentic operators’ in their life course endowed with reflective minds that direct and give meaning to their lives.

## CHAPTER IV

### SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

#### *Summary*

The objective of this quasi-experimental study was to investigate the effects of reflective journal writing to students' critical thinking and mathematical communication skills. Specifically, this study aimed to answer the following questions:

5. What are the critical thinking skills and mathematical communication skills of students before their exposure to the lecture-discussion approach and the reflective journal writing approach?
6. What are the critical thinking and mathematical communication skills of students after their exposure to the lecture-discussion approach and reflective journal writing approach?
7. Are there significant differences in the students' critical thinking and mathematical communication skills before and after exposure to the lecture-discussion approach and reflective journal writing approach?
8. Are there significant differences in mean gain in the critical thinking and mathematical communication skills between students who underwent the lecture-discussion approach and those who underwent the reflective journal writing approach?

There were two teaching strategies under investigation in this study: the lecture-discussion approach and the reflective journal writing approach. A total of 60 participants, 30 prospective teachers from two comparable classes (match-paired in terms of preliminary examination scores, midterm examination scores, and sex) underwent the two teaching approaches.

The students' critical thinking and mathematical communication skills were measured using a researcher-made tests, which were content-validated and reliability tested. The analysis of data involved several statistical tools. The inferential part of the analysis included *t test* for independent, and *t test* for paired samples. All inferential analyses were subjected to 5% level of significance.

#### *Findings*

The study has the following findings:

1. The pretest scores in the mathematical communication skills of the students in both the lecture-discussion approach and reflective journal writing approach were in the beginning level. On the other hand, the critical thinking pretest scores for both groups were one level higher (developing) although all these pretest scores were considered way behind the passing score (half of the perfect score).
2. The posttest scores of the students in critical thinking and mathematical communication skills for both the lecture-discussion approach and the reflective journal writing approach had shown big improvement. As observed, both groups were in the developing level and the scores of the students were not able to reach the passing score (half of the perfect score).

3. For both the lecture-discussion and reflective journal writing groups, there were significant differences in their pretest and posttest scores in critical thinking and mathematical communication skills.

4. There was a significant difference in the mean gain scores in the mathematical communication skills between students who were exposed to the lecture-discussion approach and reflective journal writing approach. The latter group performed better in mathematical communication than the lecture-discussion group. On the other hand, between the two groups, there was no significant difference in the mean gain scores in critical thinking.

### *Conclusion*

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

1. The students did not possess adequate critical thinking and mathematical communication skills before their exposure to the lecture-discussion approach and the reflective learning approach.

2. Although the posttest scores in critical thinking and mathematical communication skills for the lecture-discussion group and reflective learning group showed big improvement, the students were not able to pass the test to measure the aforementioned skills. They were short of the ability to apply concepts and mathematical principles; they lacked the ability to analyze, evaluate, interpret, infer, explain, and self-regulate; they needed to enhance their skills to solve problems; and they were deficient in expressing their ideas mathematically.

3. Both the lecture-discussion approach and the reflective journal writing approach effectively enhanced the students' performance in critical thinking and mathematical communication skills.

4. The reflective journal writing approach was a better approach than the lecture-discussion approach in improving the mathematical communication skills of the students. However, the reflective journal writing approach was as good as the lecture-discussion approach in developing critical thinking skills of the students.

### *Recommendations*

Based on the findings and conclusion of the study, the following recommendations are advanced:

1. It is recommended that basic education institutions look into the poor mathematics performance of their students specifically in critical thinking and mathematical communication and find ways how to improve it. Teachers in all levels are encouraged to apply appropriate and varied assessment techniques to measure students' learning. Teachers should also be reminded that students' learning competencies can be best gauged using high quality assessment not just tests that measure rote learning or lower level thinking skills. One probable cause for the very low pretest scores might be the students' less familiarity and exposure to the types of test given.

As recipients of learning, the students themselves are encouraged to seriously consider to improve their mathematics performance. A well-developed study habit along with inner motivation to learn life-long lessons is a good start.

2. It is recommended that teacher education institutions consider screening their students for admission so that the quality of future teachers will somehow be assured.

It is likewise recommended that agencies concerned in formulating the curriculum consider decongesting the course content so that quality learning will occur and desired learning outcomes will be achieved. Like any other constructivist teaching approach, reflective journal writing is best appreciated with adequate time.

3. It is recommended that teachers maximize the use of reflective journal writing in attaining the objectives of their lesson since it is found out to be effective in improving students' mathematical communication skill. Reflective journal writing requires a lot of time on the part of the teacher, thus, it is recommended that the teacher should start gradually, one output at a time, so that students' concerns in their written outputs will be properly addressed.

Most importantly, students in all levels are recommended to apply the habit of reflection on their studies, especially on their mathematics subjects. They can start by having simple daily logs, journals, or even diaries.

Parents are likewise encouraged to provide positive motivation and learning environment at home to promote reflection among their children. Since reflective journal writing approach has been found effective in this study, it is recommended that parents must also encourage their children the use of reflective journal as a strategy in enhancing their performance in the subject.

4. For teachers in all levels, it is recommended to maximize the use of reflective learning in attaining the objectives of their lessons since reflective journal writing as a teaching approach has been found to be more effective in improving the students' performance in mathematical communication skills than the lecture-discussion approach.

5. Feedback is another important aspect that makes reflective learning more student-centered because the teachers individually comment, critique, suggest, and respond to their students. It is therefore recommended that teachers who plan to implement reflective learning should allot time to give immediate feedback to their students' reflective entries. They should likewise be prepared to invest time to check, review, and make extra effort to respond to students' queries and entries in reflective journals.

6. It is likewise recommended that the administrators, curriculum planners and textbook writers of learning institutions should include reflective learning and other forms of reflective activities in their curriculum as an approach along with other constructivist teaching strategies.

Because reflective learning has positive effects to students' mathematical skills, it is recommended that principals, school supervisors and educational institutions include reflective learning in their curriculum as a teaching approach for it is included as one of the frames in the teaching approach of the K to 12 Curriculum.

Moreover, it is recommended that the Department of Education, Commission on Higher Education and other agencies concerned in formulating the curriculum consider decongesting the course content so that quality learning will occur and desired learning outcome will be achieved. Like any constructivist teaching strategy, reflective learning is best appreciated with adequate time. With many topics to be discussed and cope with, the teachers may not have enough time to do some reflective activities; hence, quality is compromised.

