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Original Paper

Instructional Practices of Teachers in Integrating Critical Thinking and Problem Solving Skills in Mathematics Instruction

Emolyn M. Iringan[1]

[1] St. Paul University Philippines, Tuguegarao City, Philippines

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Abstract

This qualitative research aimed to document the instructional practices, problems encountered, and suggestions offered by mathematics teachers in integrating critical thinking through problem-solving. To obtain the data, series of Focus Group Discussions (FGD) were conducted with seven (7) mathematics teachers and sixty (60) students in the Senior High School. Through the thematic analysis, four key themes were derived to present teachers' teaching practices, problems encountered, and suggestions to intensify critical thinking promotion through problem-solving tasks. A Proposed Enhancement Plan for Mathematics Teachers was developed to hasten students' exposure to activities that promote critical thinking and problem-solving. These activities involve enrichment sessions for mathematics teachers the problem-solving and refinement of instructional plans, particularly on strategies, assessment techniques, and instructional materials.

Keywords

critical thinking, instructional practices, problem-solving, instructional intervention

1. Introduction

The 21st-century education dramatically changes its focus to meet the students' needs to survive the challenges brought about by the complexities of the 21st-century world and workplace (Monge & Frisicaro-Pawlowski, 2014; Bevins, Carter, Jones, & Moye, 2012; Campbell Jr & Kresyman, 2015; Paul, & Binker, 1990). Instruction is designed for mastery of relevant content and acquire the desired skills for lifelong learning. The curriculum standards in Basic Education as defined by the Department of Education and the higher education sector, target critical thinking promotion (Peter, 2012; Maričić & Špijunović, 2015, Aizikovitsh-Udi & Cheng, 2015). These curricula require teachers to fix students' critical thinking and problem-solving skills necessary for 21st-century survival and workplaces (Suarta, Suwintana, Sudhana, & Hariyanti, 2017; Hodge, & Lear, 2011; Short & Keller-Bell, 2019; Kivunja,

2014).

For mathematics, all learning targets are geared towards the attainment of Critical Thinking and Problem Solving Skills. Teaching critical thinking (CT) in mathematics is done by elevating students' mental flow beyond just memorization or getting them to use their higher-order thinking skills while learning (Miri, David, & Uri, 2007). Critical thinking (CT) is characterized by processing information logically and constructing their understanding and knowledge (Miri, David, & Uri, 2007).

In mathematics instruction, there are many strategies to promote the acquisition of critical thinking. These strategies include those that encourage inquiry (Magnussen, Ishida, & Itano, 2000; Golding, 2011; Kitot, Ahmad, & Seman, 2010), establish meaningful connections (Orsini & Evans, 2016), encourage exploration and creativity (Collard & Looney, 2014), and promote the value of collaboration and teamwork (Walker, 2003; Brunt, 2005).

Problem Solving is an essential aspect of mathematics learning and is one of the best avenues to teach critical thinking (Walker, 2003). Through problem-solving, students can see the real-life application of mathematics concepts; students are tasked to process information in the given problem task, get through the data, and reflect on effective ways to tackle the problem. Critical thinking and problem-solving are interconnected. Series of critical reflections and decisions are the requirements for successful problem-solving. Students will manifest reasoning skills, communication skills, connections and representation, and decision-making skills through critical thinking. Critical thinking is a means for successful problem-solving (Atlas, 1995). One cannot exist without the other. As students go through each phase in solving the problem, they go through reasoning out, making decisions, evaluating, and applying knowledge. On the other hand, problem-solving is a fundamental means of developing critical thinking. As students tackle problems from the first and last phases, they develop the ability to think critically.

Working with the premise that the K-12 mathematics curriculum guide laid down the specific content topics to be covered, the target competencies to be attained in each grade level, range of strategies to realize the set goals, it is expected that the implementation of the Senior High School mathematics curriculum was expected to have been smoothly implemented. Mathematics instruction utilizes the spiraling approach and introduces innovative strategies, assessment techniques, and useful materials to promote critical thinking and problem-solving skills (Radzi, Abu, & Mohamad, 2009; Marcut, 2005; Aizikovitsh & Amit, 2010; Kennedy, Fisher, & Ennis, 1991).

The K-12 mathematics curriculum was first implemented during the academic year 2012-2013 and is already in its 6^{th} year of implementation. Within the duration of the eight years of implementation of the K-12 Curriculum, teachers have initiated teaching practices for the effective implementation of the curriculum. Further, with their actual teaching experiences, they have encountered rich experiences as well as difficulties which could be analyzed to further enhance the implementation of the curriculum.

This study was conceptualized to document the teaching practices of mathematics teachers in promoting critical thinking through problem-solving. The investigation results bring useful information

for the enhancement of instruction at the senior high school level to ensure students' acquisition of critical thinking through problem-solving skills.

1.1 Conceptual Framework

This study emerged from the conglomeration of the following theories, concepts, and frameworks:

1.1.1 Framework for 21st Century Learning (Bates, 2009)

This framework describes the specific skills, content knowledge, expertise, and literacies that students must master to succeed in work and life.

1.1.2 K-12 Mathematics Framework

The framework underscores the twin goals of mathematics in the basic education levels, namely, critical thinking, and problem-solving. Critical thinking (Paul & Elder, 2008) is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. On the other hand, according to Polya (1962), mathematical problem solving is finding a way around a difficulty, around an obstacle, and finding a solution to a problem that is unknown. These two goals are to be achieved with organized and rigorous curriculum content, a well-defined set of high-level skills and processes, desirable values and attitudes, and appropriate tools, taking into account Filipino learners' different contexts. As adopted from the framework prepared by SEI & MathEd (2011), there are five curriculum content areas. These are Numbers and Number Sense, Measurement, Geometry, Patterns and Algebra, and Probability and Statistics. The specific skills and processes to be developed are: knowing and understanding, estimating, computing and solving; visualizing and modeling; representing and communicating; conjecturing, reasoning, proving, and decision-making; applying, and connecting mathematical ideas. Mathematics instruction must be an avenue where students' values and attitudes such as accuracy, creativity, objectivity, perseverance, and productivity are honed. Further, it is recognized that the use of appropriate tools is necessary for teaching mathematics. These tools include manipulative objects, measuring devices, calculators and computers, smartphones and tablet PCs, and the internet. Context is a locale, situation, or set of Filipino learners' conditions that may influence their studies and use of mathematics to develop thinking and problem-solving skills critically. Contexts refer to beliefs, environment, language, and culture, including traditions and practices and the learner's prior knowledge and experiences. The framework is supported by the following underlying learning principles and theories: experiential and situated learning, reflection learning, constructivism, cooperative learning, discovery, and inquiry-based learning.

1.1.3 Critical Thinking Framework (Mansbach, 2015)

The framework stressed that critical thinking is utilized during a learning situation that involves self-regulation, interpretation, analysis, drawing inference, explanation, and evaluation. These thought processes deal with higher-order thinking skills.

1.1.4 Polya's Problem Solving Framework

Polya (1940) presents a four-way linear iterative process in solving problems, which include the See, Plan, Do, and Check phases.

Figure 1 presents the paradigm in which the study was anchored.

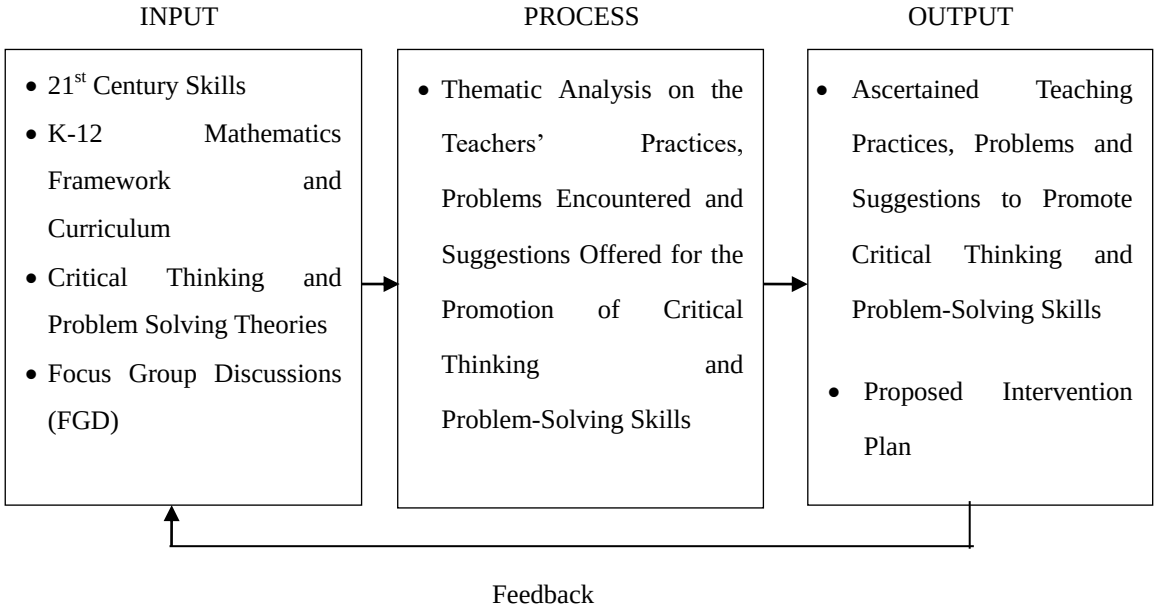

Figure 1. The Paradigm of the Study

As its inputs, the study considered the 21st Century Framework, K-12 Mathematics Framework and Curriculum, relevant theories on critical thinking and problem-solving, and participants' responses to the focus group discussions. The frameworks and theories served as supporting literature to analyze the participants' responses to the focus group discussions. The study outputs are the baseline information on the teachers' teaching practices, problems encountered, and suggestions for promoting critical thinking and problem-solving skills. The study further endeavored to develop an intervention plan to enhance students' skills as defined in the mathematics framework.

1.2 Statement of the Problem

This study aimed to document instructional practices as well as the problems encountered, and suggestions offered by teachers and students to promote the acquisition of critical thinking and problem-solving skills. Results were used as bases for a proposed mathematics teaching-learning intervention plan.

More specifically, the study aimed to answer the following sub-problems:

1. What are the instructional practices of mathematics teachers as regards the promotion of critical thinking and problem-solving skills?
2. What are the problems encountered by the teachers and students in the integration of critical thinking and problem-solving skills?

3. What do students and teachers suggest to enhance the integration of critical thinking and problem-solving skills?

4. What proposed teaching-learning intervention plan can be implemented for mathematics instruction to strengthen students' critical thinking skills through problem-solving?

2. Method

2.1 Research Design

This qualitative research utilized the descriptive research design. It documented the instructional practices, difficulties encountered, and teachers' suggestions to integrate critical thinking skills and problem-solving in mathematics instruction.

2.2 Participants of the Study

The study participants include the population of mathematics teachers and a cluster sample of students (n=60) at St. Paul University Philippines handling mathematics subjects for the first and second semesters of 2017-2018. There were seven (7) teachers who were involved in the study. Of the 20 sections of G-12 students, there were 3 students taken for each section, thus, the study covered 60 students for the FGD. One FGD session was conducted for teachers and 6 FGD sessions for the students. Each FGD cluster covered 10 members.

2.3 Instrumentation

The study utilized the *Focus Group Discussion (FGD) Guide* to elicit information on the teachers' teaching practices, difficulties encountered, and suggestions to facilitate the integration of critical thinking and problem-solving skills in mathematics instruction.

2.4 Data Gathering Procedure

To obtain the data needed for the investigation, the following procedures were undertaken by researchers:

1. The researcher sought permission and endorsed by the principal of the Basic Education Unit (BEU).
2. Upon the principal's approval, the researcher met with the participants, sought their consent, and conducted the Focus Group Discussion (FGD).

2.5 Data Analysis Tools

The thematic analysis was used to organize participants' responses in the FGD, particularly on the teaching practices, the difficulties encountered, and suggestions on integrating critical thinking and problem-solving skills in mathematics instruction.

3. Result

3.1 Instructional Practices in the Integration of Critical Thinking and Problem-Solving in Mathematics Instruction

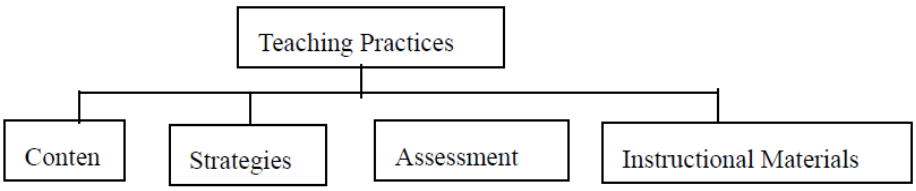

Figure 2. Teachers' Instructional Practices

Teachers' instructional practices are clustered into four instructional areas, namely: content, strategies, assessment, and instructional materials. For the area of content, teachers' notable practices were on the establishment of connections among concepts, presentation of logically organized content, and considering problem-solving as an integral part of the content. Teachers' practices on the use of instructional strategies were the use of problem-solving as a teaching strategy. In the area assessment, the following practices are noted: (a) Group and Individual Assessment, (b) Feedbacking, (c) Problem Posing, (d) Creative Projects, (e) Rubric-based Assessment. Teachers' practices along with instructional materials were on the use of online mathematics resources, visualization materials, calculators, and worksheets.

3.2 Difficulties Encountered by Teachers in the Integration of Critical Thinking and Problem-Solving in Mathematics Instruction

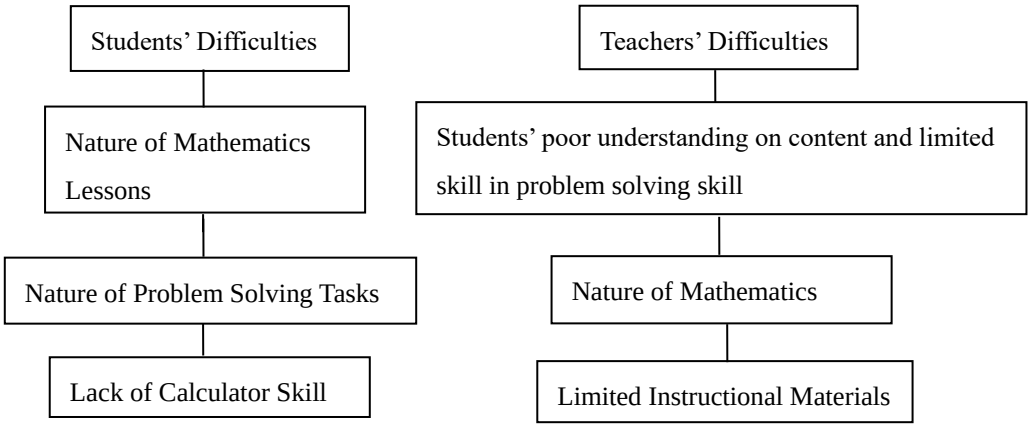

Figure 3. Difficulties Encountered by Teachers and Students in Integrating Critical Thinking and Problem Solving

As the figure shows, students' difficulties in acquiring critical thinking are traced on the nature of mathematics lessons, the nature of problem-solving tasks, the lack of skill in the use of calculators in case of problems with complex computations. Teachers' difficulties in integrating critical thinking through problem-solving are traced to the students' poor understanding of the basic mathematics concepts and poor problem-solving skills. Moreover, just like the students, teachers consider the nature of mathematics and limited instructional materials as their sources of difficulties in promoting critical thinking.

3.3 Students' Suggestions on the Integration of Critical Thinking and Problem-Solving Skills in Mathematics Instruction

Table 1. Suggestions of Teachers and Students in the Integration of Critical Thinking and Problem-Solving Skills in Mathematics Instruction

Teachers' Suggestions	Students' Suggestions
• Teachers should take initiatives in unlocking students' difficulties • Teachers should sustain the use of the integrative approach in teaching mathematics • Teachers should maintain the practice of promoting students' understanding and mastery of the concepts • Teachers should sustain the use of the discovery method and use of instructional materials	• Establishment of meaningful connection between and among mathematics concepts • Groupwork must be assessed both individually and as a group • Teachers must use innovative strategies to elevate students' level of critical thinking • Teachers' must use appropriate instructional materials to enhance the visualization of problems • Teachers must continue modeling the logical process in attacking problems

As the table presents, teachers suggest that mathematics teachers should unlock students' difficulties in dealing with mathematical problems, sustain the use of integrative approach and discovery method, maintain the practice of promoting students' understanding and mastery of concepts, and use appropriate instructional materials.

Furthermore, the students suggest that teachers should establish a meaningful connection among mathematics concepts, consider individual assessments for group work, use innovative strategies to enhance students' level of critical thinking, use appropriate instructional materials for visualization purposes and model the logical process in solving problems.

3.4 Proposed Teaching-Learning Plan to Promote Critical Thinking through Problem Solving

A proposed teaching-learning plan was conceptualized to hasten students' exposure to instructional activities that promote critical thinking and problem-solving. This proposed plan was based on the extent of students' exposure to content, strategies, assessment, and instructional materials that promote critical thinking; students' level of critical thinking based on their solution to problems; teaching practices, difficulties encountered, and suggestions offered by students and teachers to intensify the promotion of critical thinking through a problem-solving approach.

4. Discussion

4.1 Instructional Practices in the Integration of Critical Thinking and Problem-Solving in Mathematics Instruction

4.1.1 Content

With regards to content, teachers promote the establishment of connections between and among mathematics concepts in problem-solving situations. Emphasis on the connection between previous and current topics, current topics with other mathematics-related concepts, and current topics with other related disciplines are reflected in the problem-solving scenarios explored during instruction. In this manner, students can see a meaningful link among mathematics concepts. Moreover, the teachers present logically organized mathematics content. Lessons are carefully planned to reflect the logical order of content presentation such that prerequisite topics are rehearsed first before the presentation of new topics, problems to illustrate the application of the topics are presented in an easy-difficult or simple-complex continuum. Furthermore, teachers consider problem-solving as an integral part of the content. The integration of problem-solving in the content presentation is done by presenting problems that shall serve as a springboard in generating the lesson content.

4.1.2 Instructional Strategies

Notable teaching practice of teachers along instructional strategies is the use of Problem Solving as a strategy in promoting Critical Thinking. Teachers mainly apply problem-solving strategies in teaching mathematics. The problem-solving approach refers to the teaching technique where teachers use problems to provide students with rich experiences that allow them to see practical situations that embody the explored mathematics content. Using a problem-solving strategy exposes students in learning activities that would enable them to utilize their higher-order thinking skills. This strategy also promotes rigorous interaction in class, allowing students to brainstorm, share and consolidate their ideas, and evaluate other students' ideas or solutions to given problems. Along with students' exposure to problem-solving is the modeling of the Polya's Plan of Attack and various techniques in Problem Solving. Problem Solving strategies during the instructional process were either carried out individually or in groups.

4.1.3 Assessment

Among the teachers' assessment practices is the use of group and individual assessments. Group assessment was used to allow students to share and evaluate every member of the group's ideas. The individual assessment was used to train students for independent learning. Also, a feedbacking scheme was used in the assessment process. This includes an evaluation of students' solutions to problems. This practice provides feedback to students regarding their answers to the problems. Moreover, the use of rubrics facilitates rating students' performance in problem-solving. Through rubrics, teachers can easily determine what students can do and cannot do. Rubrics generate data to show evidence of their students' mathematical thinking and how they use that evidence to monitor students' progress and guide instructional decision making (Thompson & Senk, 1998).

Problem posing activities were also undertaken during the instructional process. Through this, students can create or construct problems that allow them to provide problem situations that are real to them, making learning more meaningful. Students' critical thinking skills are acquired as they must think of

problem scenarios that fit the given content, creating strategies for students to understand the value of and schemes for posing problems on their own (Silver, 1994; El Sayed, 2002).

Creative projects were also required for mathematics assessment. These projects train students to solve practical problems that allow them to gather pertinent data (i.e., perform actual measurements (Cherif & Gialamas, 2000; Huckstep & Rowland, 2000).

4.1.4 Instructional Materials

The teachers maximize the use of Mathematics Resources such asscholarly sources (i.e., books, journals and mathematics websites). These materials are rich sources of problems to illustrate varied mathematics content topics (Hohenwarter, Hohenwarter, Kreis, & Lavicza, 2008). Teachers also practiced the use of visualization materials (Makina, 2010). Manipulatives were used to help students visualize problems (Carbonneau, Marley, & Selig, 2013; Sarama & Clements, 2009; Clements & McMillen, 1996; Uttal, Scudder, & DeLoache, 1997). Mathematics software was also used for problems involving graphs (Kilicman, Hassan, & Husain, 2010; Zengin, 2017). The use of calculators is also a notable practice of teachers when giving problems involving complex and tedious computations. Allowing the use of calculators in the classroom eliminates students' burden of doing lengthy calculations. Using a calculator gives them adequate time to process their thoughts and ideas to come up with an accurate answer (Gómez, 1998; Wheatley, 1980; Thomas, Hong, Bosley, & Delos Santos, 2006). Teachers' use of worksheets and activity sheets were also commended. The worksheet is an excellent resource for practicing problem-solving as this provides ready-at-hand problems of varying contexts and difficulty levels (Toumasis, 1995; Zulyadaini, 2017).

4.2 Difficulties Encountered by Teachers in the Integration of Critical Thinking and Problem-Solving in Mathematics Instruction

Among the students' difficulties encountered by the students were related to the nature of Mathematics lessons. These are their difficulty to visualize abstract mathematics, difficulty to recall formulas, properties, rules, and algorithms; difficulty in dealing with numerical and algebraic expressions; difficulty in establishing the connection between and among mathematics topics; trouble in understanding Mathematics language; and poor mastery of the basic mathematics. When dealing with problem tasks, students find difficulty understanding mathematics terms used in problem-solving tasks; and students struggle to deal with problems involving many mathematics concepts. In the assessment area, students find some problems as very difficult to tackle: students consider unsupervised group problem-solving assessment as difficult to accomplish; students find problem-solving difficult when working within a limited time allotment, and students find difficulty in dealing with too long problem sets.

For instructional aids, students are not skillful in using the calculator.

Teachers' difficulty is traced from the nature of students (i.e., handling students with poor basic mathematics foundation and conceptual understanding, with varying instructional exposure in their basic education, with poor comprehension skill, who were used to routine problems, and those who

lack skills in using the calculator); nature of mathematics (i.e., mathematics concepts are abstract and hard to contextualize, broad coverage of mathematics content, and limited time for deepening and remediation activities); and instructional materials (i.e., shortage of instructional materials to concretize mathematics concepts, and little reading resources to substantiate lessons).

4.3 Students' Suggestions on the Integration of Critical Thinking and Problem-Solving Skills in Mathematics Instruction

Among the students' suggestions in integrating critical thinking in mathematics are as follows: Teachers should strive to teach Mathematics with meaning and establish a meaningful connection between and among mathematics concepts, relate terms to the vernacular, and find time to activate prior knowledge. Students further suggest that group work must be evaluated both as a group and individually; and the use of oral and written assessment. As to instructional approaches and strategies, students suggest that: (1) Teachers should present problems from easy to hard tasks; (2) Problem-solving activities should be conducted to allow students to reason out; (3) Teachers should continue exploring more strategies to assist students in tackling difficult topics and problem tasks, and (4) Teachers must be critical in the selection of problems. Regarding the use of instructional materials, teachers should continue using appropriate materials to visualize concepts (Makina, 2010), provide interesting PowerPoint presentations, not just texts, and to continue modeling the logical processes and heuristics in problem-solving. Furthermore, students suggest for the increased time allotment in dealing with complicated problems, devote more time to process the lessons, promote student-engagement, accommodate students' questions or clarifications, promote student-teacher interactions, and conduct remediation activities.

Among the teachers' suggestions on the integration of critical thinking and problem-solving skills in mathematics instruction include the following: (1) Teachers should take initiatives in unlocking students' difficulties (i.e., promote advanced reading, activate prior knowledge, employ scaffolding activities); (2) Teachers must sustain the use of integrative teaching approach (e.g., relating topics with other topics, establish a connection among topics, and (3) Teachers must integrate interesting activities; maintain practices that promote students' understanding and mastery of the concepts (e.g., allowing students to explain their work, encouraging students to explore alternative solutions, giving sufficient examples/drill work for practice, promoting visualization strategies (Makina, 2010) and drawing problems from students' experiences (Kurniati, Kusumah,, Sabandar, & Herman, 2015); (4) Teachers must sustain the use of discovery method to train students to process their thinking; (5) Teachers should sustain the use of instructional materials to visualize mathematics concepts and substantiate lessons through online books and materials.

4.4 Proposed Teaching-Learning Plan to Promote Critical Thinking through Problem Solving

A proposed teaching-learning plan was conceptualized to hasten students' exposure to instructional activities that promote critical thinking and problem-solving. This proposed plan was based on the following: (1) extent of students' exposure to content, strategies, assessment, and instructional

materials that promote critical thinking; (2) students' level of critical thinking based on their solution to problems; (3) teaching practices; and (4) the difficulties encountered, and suggestions offered by students and teachers to intensify the promotion of critical thinking through a problem-solving approach.

5. Conclusion and Recommendations

Based on the findings of the study, the following conclusion was drawn:

Actively engaging students in problem-solving activities from the motivation phase to the assessment phase encourages students' critical thinking development. Constant exposure of students to problem-solving activities is an avenue for modeling the thinking process, which is considered an efficient way to promote the acquisition of critical thinking. Fostering critical thinking is made possible when students are engaged in meaningful and challenging problem-solving activities that require them to reflect, brainstorm, explore alternatives, evaluate, and make decisions.

From the results of the investigation, the following recommendations are generated:

1. Mathematics organizations may consider the study's findings in conceptualizing seminars and conferences that will provide inputs on strategies, activities, and instructional tools that foster students' acquisition of critical thinking skills.
2. Mathematics teachers at all levels must find time to model problem-solving heuristics and strategies in their mathematics classroom to acquaint the students with the process involved in problem-solving.
3. Mathematics teachers handling G11 and G12 mathematics subjects through the principal's support will consider integrating the suggested activities in the proposed plan to promote critical thinking and problem solving among students.
4. The proponent shall disseminate the results of the study to the identified beneficiaries for maximum utilization.
5. Researchers may conduct more studies to explore more effective strategies in promoting critical thinking and problem-solving skills.

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