# COMPARING PROBLEM SOLVING ABILITY OF STEM AND NON-STEM ENTRANTS TO BACHELOR OF SCIENCE IN MATHEMATICS EDUCATION PROGRAM

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***ABSTRACT*: *The purpose of this study was to compare the problem-solving ability of Science, Technology, Engineering, and Mathematics (STEM) and non-STEM graduates enrolled in the Bachelor of Science in Mathematics Education (BS MathEd) program. The problem-solving ability of the participants was examined using the researchers-made Mathematics Problem Solving Ability Test with Cronbach alpha equal to 0.80. The findings indicated that there was no significant difference between the problem-solving ability of the students graduated from STEM (Mean = 2.07, SD = 0.47) and non-STEM (Mean = 2.08, SD = 0.48) strands. The participants were found to be apprentice in problem-solving, able to obtain a partly correct solution but were not able to give the final correct answers. Thus, the researchers recommended that basic education program may be enhanced for the successful implementation of K to 12. Quality instructional materials may be provided to teachers and students, various teacher-training program may be conducted, and teachers' qualifications may be considered in hiring. Moreover, BS Mathematics Education Program will not be exclusive for STEM strands graduates only, and mmathematics education faculty may provide remedial activities to improve the problem solving abilities of the pre-service mathematics teachers.*

**Key Words***: mathematics Problem solving ability, routine problems, non-routine problems*

## INTRODUCTION

Recently, K to 12 program becomes a hot topic in the Philippines. In 2012, the country's Basic Education through the Department of Education (DepEd) launched the Enhanced K to 12 Basic Education Program through Republic Act 10533 [1]. It aimed to provide a comprehensive reform in the country's educational system in terms of structure, curriculum and assessment, congested curricula and shortness of secondary education, and to catch up with the global standards in the basic education [2]. Through this program, senior high school was opened with various strands. STEM is one of the strands that students can choose to pursue in their senior high school (SHS).

STEM education stands for Science and Technology, Engineering and Mathematics. It refers to teaching and learning that calls for greater emphasis on the above fields [3, 4] in order to decrease the mathematics and science achievement gaps among students of various backgrounds. Researchers noted some advantages of STEM education. It gives the students' opportunities to understand the scientific and technological knowledge [5, 6] or become STEM literate, who are capable of dealing complex problems [5]. Through STEM education, this country hopes to produce researchers, mathematicians, engineers, scientific leaders, and other STEM-related graduates [7] because STEM literacy plays a vital role in a competitive global market [8].

Relative to the implementation of K to 12 in the Philippines, qualifications for the entrants to a certain program in higher institutions were also changed. For Bachelor of Science in Mathematics Education (BS MathEd) program in this institution, the curriculum makers argued that only STEM graduates will be accepted in the program for alignment purposes. They believed that STEM graduates are more capable in mathematics than non-STEM graduates as observed in other countries. In Texas, for example, STEM academies performed higher in mathematics compared to non-STEM academies [6, 9].

Nonetheless, in the pilot implementation of STEM in SHS, several problems have surfaced like scarcity of learning materials, lack of classrooms, lack of teacher-training programs, lack of qualified teachers, exemptions of some students to undergo student admission policy and nonexistence of student retention policy [10,11]. Thus, the BS MathEd program owner reviewed the qualifications for the entrants to the program. Finally, STEM and non-STEM graduates were accepted in the program.

With this end in view, it is interesting to investigate the BS MathEd entrants' achievement in terms of problem solving. Specifically, to determine if there is a significant difference between the mathematics problem solving ability of STEM and Non-STEM graduates.

Mathematics problem solving is classified into two major categories: routine and non-routine problems. Routine problems place emphasis on the procedures rather than the process of learning and do not contribute to the development of students' cognitive growth. Non-routine problems, on the other hand, do not have direct solution to a given task and thus require heuristic strategies, thinking processes and creative thinking[12]. In this study, non-routine problems were used.

## 2. METHODOLOGY

### 2.1 Instrument

This is a quantitative study, aiming to investigate the difference between the mathematics problem- solving ability of STEM and non-STEM entrants to Bachelor of Science in Mathematics Education Program. In order to answer the research questions of this study, the researchers constructed a 27-item problem-solving ability test. The problem-solving ability test was reviewed by a panel of 5 mathematics educators, who determined that the items were appropriate. After which, the test was administered to the 71 third year BS Math Education students of USTP-CDO during the second semester of the school year 2017-2018. Item analysis was then conducted, and only 10 items were acceptable, the discrimination index ranges from 0.35 to 0.65. This 10-item test is reliable, the Cronbach alpha = 0.80 which is highly reliable [13].

Student's response to each item on the 10-item mathematics problem-solving ability test was scored using the holistic scoring rubrics below.

1 if the student writes nothing or obtains a wrong answer with no solution or with an inappropriate solution.
2 if the student obtains a wrong answer but the solution is appropriate and complete or the solution is appropriate but incomplete.
3 if the student obtains a partly correct solution but were not able to obtain a final correct answer.
4 if the student obtains a correct answer with appropriate and complete solution.

The total score in the test was obtained by dividing the tallied score by the total number of items. The highest possible score is 4 and the lowest possible score is 1. Below are the range of scores and description prepared by the teacher–researcher.

| Range | Description |
|---|---|
| 1.00 – 1.49 | Novice Problem Solver |
| 1.50 – 2.49 | Apprentice Problem Solver |
| 2.50 – 3.49 | Practitioner Problem Solver |
| 3.50 – 4.00 | Expert Problem Solver |

## 2.2 Participants

This study employed all entrants to Bachelor of Science in Mathematics Education Program in SY:2018-2019. The participants were separated into 2 groups; STEM graduates and non-STEM graduates. STEM group consists of 37 (36%) participants while non-STEM consist of 67 (64%).

## 2.3 Data analysis

The data analysis was done through descriptive statistics; mean and standard deviation were used to describe the problem solving ability of the participants, and t-test was used to determine the extent of the difference between the problem solving ability of STEM and non-STEM groups.

# 3. RESULTS AND DISCUSSION

After gathering the data, the researchers conducted the preliminary assumption testing; One-Sample Kolmogorov-Smirnov test for normality and a Leven's test for equality of variance. Normality for STEM and non-STEM strands on the dependent variable was found tenable at the .05 alpha level, $p < .82$ and $p < .81$, respectively. Also, the result of Leven's test provided evidence that the assumption of homogeneity of variance across groups was tenable, $F(2,102) = .002$, $p < .97$. Consequently, the analysis of the data proceeded using the parametric test. The descriptive statistics by STEM (N=37) and non-STEM (N=67) are shown in table 1.

**Table 1. Descriptive Statistics of Problem Solving Ability by Strands.**

| Strands | STEM (N=37) | non-STEM (N=67) |
|---|---|---|
| Mean (M) | 2.01 | 2.08 |
| Standard Deviation (SD) | 0.47 | 0.48 |
| Descriptive Level | Apprentice | Apprentice |

Perfect score: 4

Table 1 shows the mean and standard deviations of the scores of the participants on problem solving test. It can be observed that the mean scores of the STEM group and non-STEM groups are almost the same, 2.08 and 2.0, respectively. The same observation is also true to the standard deviations (0.47 and 0.48) which means that the problem solving ability of the participants from the two groups were likely the same. Based on their mean scores, they were classified as apprentice problem solvers, able to obtain a partly correct solution but were not able to give the final correct answers.

Students' inability to solve the given test might be due to the fact that the problems given were non-routine but the participants might be exposed only with routine problems. In mathematics class, most teachers teach mathematics with more practice, demonstrate each step and require students to follow the same procedure [14]. These routine problems do not contribute to the development of cognitive growth because it emphasizes a fixed method of solving that require students to memorize steps [15]. Thus, the participants may lack conceptual understanding and problem solving strategies. The reasons for these deficiencies in problem solving were students' lack of specific domain knowledge of concepts, formulas, and algorithms and the lack of spontaneity in applying heuristic strategies such as finding pattern, working backward, making a table, etc [16].

Non-routine problems require heuristic strategies, thinking processes and creative thinking [12]. In solving non-routine problems, students must possess both conceptual and procedural understanding of mathematical facts [17]. In addition, students' anxiety might affect their problem solving performance. Students were apprehensive and extremely uncomfortable because they are not able to recall and apply learned procedures in a straightforward way [18].

Furthermore, the extent of the difference between STEM and Non-STEM was performed using an independent t-test. The summary of the independent t-test is shown in table 2.

**Table 2. Summary of Independent t-test Result of the Students' Problem Solving Score**

| | Mean Difference (d) | Degrees of Freedom (df) | t | p |
|---|---|---|---|---|
| STEM-Non-STEM | -.068 | 102 | -.698 | .486 |

Independent t-test demonstrated that the effect of strands was not significant, $t(104)=-.698$, $p = .486$, $d = -.068$ . STEM (M=2.01, SD=0.47, N=37) on average do not statistically significantly differ from Non-STEM ((M=2.08, SD=0.48, N=67) in terms of Mathematics problem solving. This result contradicts to the findings of other researchers that students in STEM academies have higher mathematics achievement than students in non-STEM schools [6, 9]. This phenomenon might due to the fact that the Kto12 program in the country is at its early stage and several problems had surfaced in its implementation. In the pilot implementation of STEM in SHS, several problems have surfaced like scarcity of learning materials, lack of classrooms, lack of teacher-training programs, lack of qualified teachers, exemptions of some students to undergo student admission policy and nonexistence of student retention policy [10, 11].

## 4 CONCLUSION AND RECOMMENDATION

From the above result, it is possible to deduce that the problem solving abilities of STEM and non-STEM entrants to BS Mathematics Education Program do not differ, they were an apprentice problem solver. They may able to give a partly correct answer to the non-routine problems but were unable to arrive at the final correct answer. Thus, the researchers recommended that basic education program may be enhanced for the successful implementation of K to 12. Administrators and supervisors may provide quality instructional materials to teachers and students, a various teacher-training program, and considers teachers' qualifications in hiring. Moreover, BS Mathematics Education Program will not be exclusive for STEM strands graduates only, and mathematics education faculty may provide remedial activities to improve the problem solving abilities of the pre-service mathematics teachers.

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