



TECHNOLOGY: EFFECTS ON PRE-SERVICE MATHEMATICS TEACHERS' PROBLEM-SOLVING SKILLS

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Abstract: *This study investigates the effects of the use of appropriate technology in math problem solving skills and as motivating factor to learning in mathematics of pre-service Mathematics teachers. A total of thirty seven pre-service teachers are instructed to solve problem-solving tests in the form of a questionnaire. The respondents in the control group are instructed to use mental or paper-and-pencil skills in solving math problems while the experimental group was then assigned a technology (calculator, computer spreadsheet and graphing calculator) to use for the duration of the test. The major results of the study showed that there is a positive effect of the use of appropriate technology in the pre-service teacher's problem solving skills and as an essential, beneficial and motivating factor to enhance pre-service teacher's problem solving skills in mathematics learning. There are no statistically significant differences between the average scores of the two groups. Both groups are equally likely to have the same problem solving skills acquired with or without technology in solving mathematical problems.*

Keywords: *Technology, pre-service teacher, mathematics, problem solving*

I. INTRODUCTION

Today, we are continually moving to the age of technological, scientific and computer specialization, which has infiltrated every aspects of modern lives. Classrooms are of no exceptions. Mathematics classroom of today is rapidly moved in the direction of technology that has rendered obsolete some of the techniques and methods of teaching and learning previously used. The use of technology when learning mathematics is not a new issue, since time memorial humankind always has been looking for solutions to avoid time consuming routine work. The use of technology has a long history in mathematics education. Technology such as calculators, graphing calculators, computer and computer software, Apple I pad, converter, Abacus, and microcomputers can be powerful tools in the study of mathematics, particularly in the area of problem solving. Each year a new generation of such technology builds on the previous one with heighten speed and more advanced capabilities.



Technology in Mathematics problem solving embraces possible means wherein information can be presented, computations can become easy and fluent, solutions can be accurate. It is concerned with the gadgetry' use in computations. Its capabilities could be used to make possible mathematical exploration, experimentation, enhance learning mathematical concepts and increase mathematical problem solving skills. Thus, the principal role of technology in problem solving is to help improve the overall efficiency of the learning and solving process in (a) increasing the quality of solution or the degree of mastery; (b) decreasing the time taken for solvers to attain desired solutions/goals; (c) increasing the efficiency of learners process in solving without reducing the quality of learning (d) reducing costs without affecting quality.

In search to the effects of technology to the students' learning and problem solving skills, the National Council of Teachers of Mathematics has identified the "Technology Principle" as one of six principles of high quality mathematics education (NCTM, 2000). This principle states: "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (p. 24). Thus, NCTM supports the advancement of technology in the classroom, and asserts that the use of technology often allows for problem solving to occur in greater depth. It also acknowledges that the overarching principle of learning requires students to actively learn with understanding and build new knowledge from experience and prior knowledge.

In educational management, the relevance of technological equipment has been highly recognized especially in the teaching of mathematical problem solving. As cited by Robova (2001) in his paper "Graphing calculators as a tool for enhancing the efficacy of mathematics teaching" that the rapid progress of technology is one of the aspects that have affected mathematics teaching at all levels. In the traditional teaching of mathematics the teacher passes complete information to the students and the students are passive recipients, while the integration of technology encourages and enables new approaches and procedures in mathematics teaching and learning - in particular a deeper investigation of problems and discovery of connections between phenomena.

Additionally, in the research study of Cabanilla-Pedro (2006) "Using Calculators in Primary Mathematics" presents various possibilities on how the calculators can be incorporated in the teaching and learning in primary mathematics which is quite an effective tool for



problem solving, reinforcement of computational skills, pattern recognition, and number sense. She stated that the use of technology, students now have more opportunities to work enough problems to discover, observe patterns and be able to focus on useful, practical applications for the theories and concepts they learn in class.

There are some studies that show a positive benefit from graphing instruction than there are studies that show 'no significant difference' especially in the areas of problem solving, spatial visualization, pre-calculus achievement, and calculus readiness. If paper and pencil skills are taught in conjunctions with graphing methods, studies shows no loss of skills even when students are tested without technology (Questions and Answers About Using Hand-held technology to Teach Mathematics, 1997).

Furthermore, the National Research Council (2001) explained that visual and numeric supports offered by computers and graphing calculators are helpful for students to create meaning for expressions and equations and the use of such technology does not threaten the development of basic skills and that it can enhance conceptual understanding, strategic competence, and disposition toward mathematics. Likewise, the National Research Council C (2005) further explained that confronted with a complex arithmetic problem, students can use calculators and computers to see beyond tedious calculations to the strategies needed to solve the problem. "Technology can relieve the computational burden and free working memory for higher-level thinking so that there can be a sharper focus on an important idea." Skillfully planned calculator investigations may reveal subtle or interesting mathematical ideas, such as the rules for order of operations."

According to Ball (2005) technology can have a useful role even in the lower grades, but they must be used carefully, so as not to impede the acquisition of fluency with basic facts and computational procedures.

In the research study of Barkatsas et. al. (2009) on the complex relationship between students' mathematics confidence, confidence with technology, attitude to learning mathematics with technology, affective engagement and behavioral engagement, achievement, gender and year level. The participants were secondary students from state co-educational schools in Metropolitan Athens, Greece. It was found that high achievement in mathematics was associated with high levels of mathematics confidence, strongly positive levels of affective engagement and behavioral engagement, high confidence in using



technology and a strongly positive attitude to learning mathematics with technology. Low levels of mathematics achievement was associated with low levels of mathematics confidence, strongly negative levels of affective engagement and behavioral engagement, low confidence in using technology, and a negative attitude to learning mathematics with technology.

Jurdak (2004) investigated the impact of technological apparatus, particularly computers, as facilitators in problem solving in mathematics education, and opined that technology can serve as a tool for building bridges between abstract mathematics and problem solving in real life. Both calculators and computers were found to be reshaping the mathematical scenery, allowing students to work at higher levels of generalization and abstraction, thus resulting in a deeper mathematical understanding (Mathematical Association of America, 1991).

Abdul Raman et al (2003) identified an approach for novice mathematics problem solvers to be encouraged and also an attempt to encourage future teachers of mathematics to integrate ICT in the teaching and learning of mathematics. Their findings reveal that the student teachers' perception about problem solving in mathematics actually changed with the use of information and communication technology. Although they were quite apprehensive at first but they enjoyed the course and most importantly, they experienced a new perspective on mathematical problem solving. The role of information and communication technology is seen as supporting and enhancing the ability of the student teachers to solve mathematics problems. Most importantly, it changed the way the teachers see the problems and devise ways of teaching mathematical problem solving using technology in order to offer new and powerful learning environment for our future generations.

Adiguzel and Akpınar (2004) in their study on designed computer software, Labour Scale, which begins with the concrete representations and reaching the symbolic representations by using visual components supported by audio, to improve seventh grade students' word problem solving skills through computer-based multiple representations including graphic, symbolic, and audio representations. Students from both public and private elementary schools which had computer laboratories were administered pre-test and post-tests while studying work and pool problems in their classes. It was found that seventh grade students'



performance on work and pool problems increased significantly through the application of this computer representation which assisted students with the transition from concrete experiences to abstract mathematical ideas, with the practice of skills, and with the process of problem solving.

This study is in recognition of the significant roles, technology plays by providing a way to teach pre-service teachers how to solve different kind of tasking analytical and arithmetical problems and using this technology they will appreciate the nature of mathematics highly composed of problems.

In light of the findings, it is evident that our country's educational setting, calculators and computers are considered as tools to be used together with other available teaching devices to increase appreciation in mathematics and improve pre-service teachers' problems solving skills. Truly, the influx of technology in education should not be an issue but a treasure to be nourished.

In this context, it is highly relevant to ask question about how problem solving skills of pre-service teachers may be affected when modern technology is available. When it comes to technology support, its role is an agent of change. Thus, our main focus is helping the pre-service teachers become better problem solvers in all aspects of life, develop the higher order of critical thinking skills, analysis and scientific inquiry. Being exposed to the modern technologies will equip them with necessary knowledge and skills for them to become competent to enter the workforce and navigate a complex world.

Statement of the Problem

This study attempted to determine the performance level of pre-service mathematics teachers in secondary education in selected mathematics topics using appropriate technology. It focused on answering the following questions:

- 1) What are the effects of the use of appropriate technology in their math problem solving skills?
- 2) Do pre-service teachers perceive the use of technology as essential and beneficial factor to enhance their problem solving skills?
- 3) Is there a significant difference on the average performance level of pre-service teachers in the control and experimental group in the different areas of mathematics?



II. METHODS

Instrument and Procedure

This investigation used two approaches: the qualitative and experimental approach. The qualitative approach uses a 10- question survey to the respondents which was meant to gather data about respondents' assertiveness towards the use of appropriate technology in solving problems in mathematics, along with some other significant information. The questionnaire contained some multiple choice and few open-ended ones. The questionnaires were administered to the respondents during one of their classes.

The experimental approach uses a problem –solving type of test administered to two groups (experimental and control group) of pre-service teachers simultaneously to determine if there is a significant differences in the achievement scores of the respondents between groups. The control group answered the test mentally or using pen-and-paper skills while the experimental group made use of more advanced technology such as calculators and computers to answer mathematical test. The problem-solving type of test was given toward the end of the five-month course in Math during their class. Pre-service teachers were given an allotted time solving within 60 minutes.

Participants of the Study

The subjects of this study were the pre-service Mathematics teachers randomly selected from Cagayan State University- Andrews Campus. The pre-service teachers were enrolled in the 5-month course, Math 69 Seminar on Technology in Mathematics which offers a first-hand experienced in the use of technology such as graphics calculators and other calculators, geometric software, computer algebra system, and computer spreadsheets in solving problems in mathematics. They had already acquired the necessary skills on how to use such technology to solve mathematical problems.

The control group composed of 21 pre-service teachers using mental or paper-and-pencil skills in solving math problems while the experimental group composed of 16pre-service teachers with each was then assigned a calculator, computer spreadsheet and graphing calculator to use for the duration of the test. Over the course of the investigation, pre-service teachers completed 13 problem-solving tests.

Procedures for Collecting Data

Two methods of data collection were used: questionnaires and problem-solving type of test. The questionnaires were collected and studied for patterns and changes in pre-service



teachers' assertiveness towards appropriate technology and problem solving. Data also came from the test answered by the pre-service teachers. These tests were analyzed to see how effectively the pre-service teachers used calculators, computers, and other appropriate technologies to solve problems and how correctly they solved the problem.

Data Analysis

After the investigation was completed, the two kinds of data were analyzed for similarities and differences across individuals and groups. Data on questionnaire and experimental test were treated separately with the use of descriptive and correlational statistics in the analysis and interpretation of data. The results in the survey instruments were gathered and analyzed through the use of simple frequency and percentage and were displayed through tables and graphs. The same was done on the open ended responses. The scores gathered in the problem type of test were subjected to statistical analyses to assess the significant differences on the matched-pair groups. Specifically, the following statistical measures and procedures were employed in this research.

Statistical Package for Social Sciences (SPSS) program version 18.0 was used in testing the significant differences that were collected among the two groups.

After analyzing the pre-service teachers' surveys and test answers, and comparing the results, conclusions were drawn regarding pre-service teachers' assertiveness towards the use of appropriate technology in solving problems and its effects in problem solving.

Based on the results, and conclusions drawn from research, a discussion of suggestions for further research was provided.

III. RESULTS AND ANALYSIS

This study aimed to survey the effect of appropriate technology in the pre-service teachers' problem solving skills. Further, it also examined if there is significant difference between the experimental group using technology and the control group using pen-and-paper computation in solving problems in mathematics in terms of their achievement scores in problem-solving type of test.

Figure 1 showed that sixty two percent(62%) of the pre-service teachers always have the calculators and appropriate technology, 38% sometimes have and 0% never has the calculator. A 100% of the pre-service teachers said at least technology is available to them. This implies that technology is available to almost all the pre-service teachers.

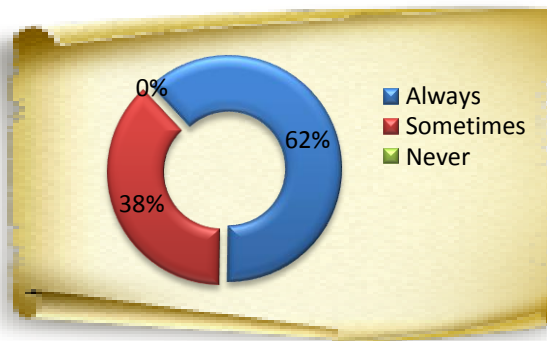


Figure 1 Availability and Use of Technology

The figure below showed that technology (46%) is the preferred used medium of the pre-service teachers in solving mathematics worksheets and practice exercises.

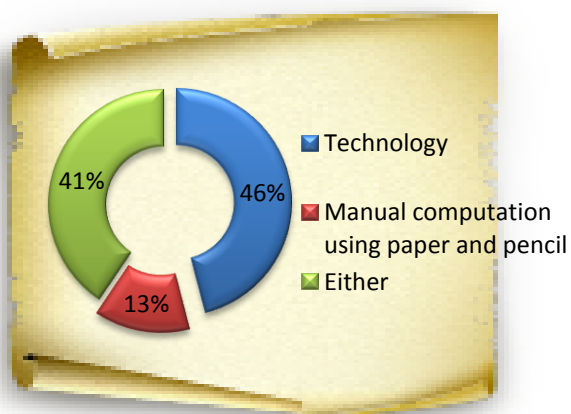


Figure 2 Preferred Medium in Mathematics Exercise and Problems

The table below showed that the use of technology is useful and appropriate most in tedious computation. Easier to get the answer comes the second while getting an accurate/confident solution is the third. Looking at these three primary reasons help students become a problem solver and develop a positive attitude towards mathematics.

Table 1 Use of technology in Mathematics problem solving skills Positive

Categories	Responses
Easier to get the answer	6
Improve or speed-up computation	4
Get accurate/confident solution	5
Useful in tedious computation	12
Easy to get logically formula	3
Subtotal	35



Negative

Categories	Responses
Tech is just a tool that will lessen computational abilities	1
Not comfortable	1
Subtotal	2
GRAND TOTAL	37

The chart below described the pre-service teacher's perception based on the given options. The pre-service teachers' responses in this question further strengthen the assumption that appropriate technology served as motivating factor for pre-service teachers' problem solving. The largest percentage claims that solving mathematics problems with technology helps learning and solving easier (95%) and it makes learning and solving more fun with (68%). The technology has formulas and fun game and it is important for us to learn to use the technology with 41%.

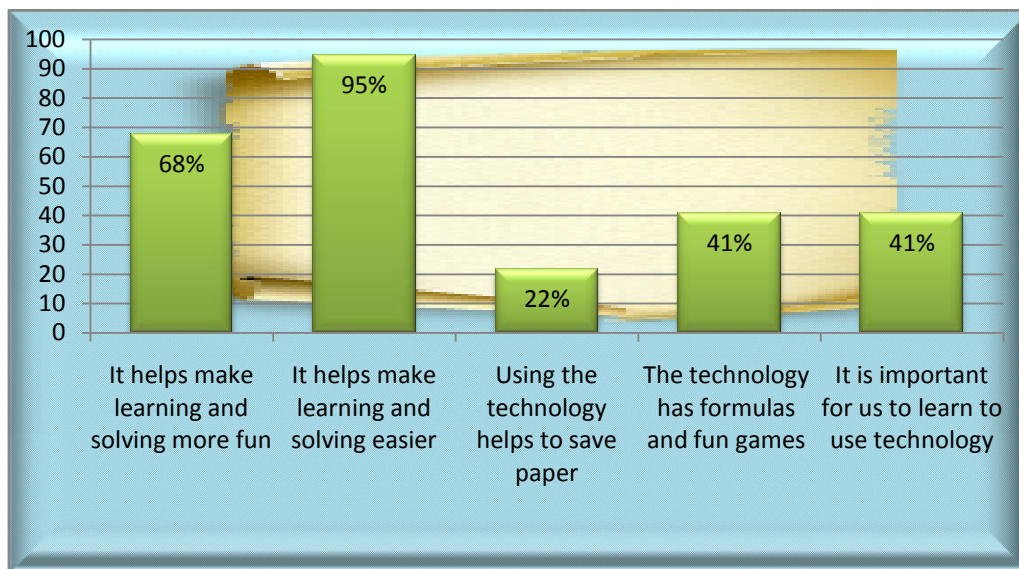


Figure 3 Significance of Technology in Mathematics Problem Solving

As shown in the chart below, Technology can sometimes be distractive in learning and computing (73%). This implies that technology is distractive to pre-service teachers' learning and computing performance.

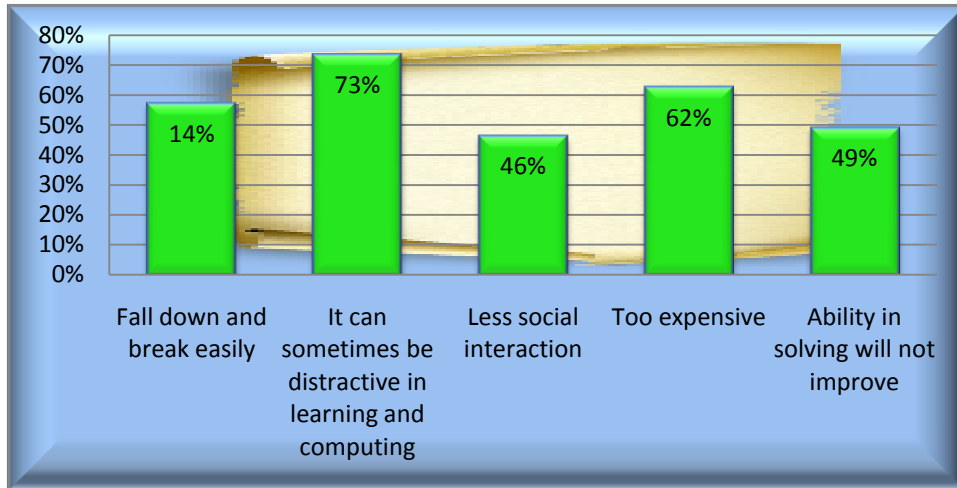


Figure 4 Disadvantages of the use of Technology in the classroom

Figure 5 reflected that technology usage is highly beneficial in enhancing pre-service teachers' skills in problem solving skills with an average score of 3.54.

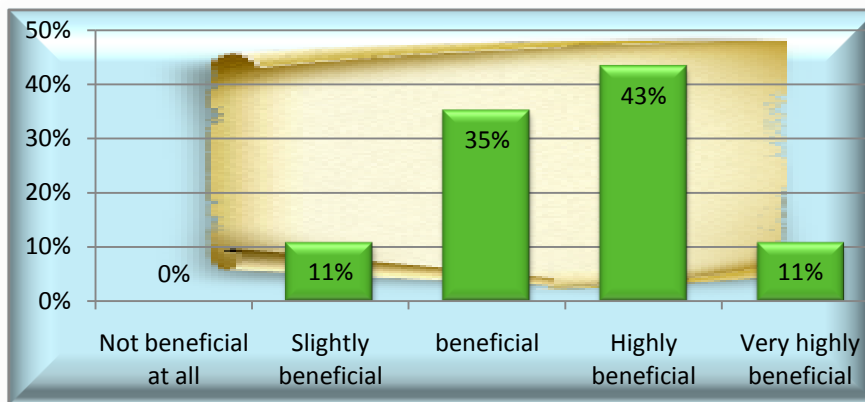


Figure 5 Provided Benefits of Technology in Problem Solving Skills in Mathematics

Table 2 showed that most pre-service teacher's response on the benefits of technology as able and easy to calculate/solve difficult problems in mathematics, 18 out of 37 (49%).

Table 2 Beneficial Use of Technology in Problem Solving Skills in Mathematics

Categories	Responses	Percentage
Able and easy to solve/calculate difficult problems	18	49
Accuracy	3	8
Comfortable	2	5
Enjoy solving	2	5
Improve solving skills	3	8
Lesser time/faster computation	4	12
Solve more problems	3	8
Understand more concepts	2	5
Total	37	100%



Table 3 clearly showed that among all the technology or software to be used in problem solving, calculator is found to be the most beneficial and helpful to the pre-service teachers, followed by computer software (spreadsheet).

Table 3 Most Beneficial Technology/Software to the Pre-Service Teachers' Learning and Improving Problem Solving Skills in Mathematics

Technology	Responses
Calculator	17
Scientific and graphing calculator	3
Computer software(spreadsheets)	10
Equation editors	4
Graphing calculators	3
TOTAL	37

Figure 6 showed the aspects where technology is most helpful in learning and problem solving is on homework (100%), followed by independent and group learning activities(83%). It is even helpful to practice or drill (74%) and lesson presentation (71%). The least result which is quizzes and examinations showed that technology is not helpful in performing it.

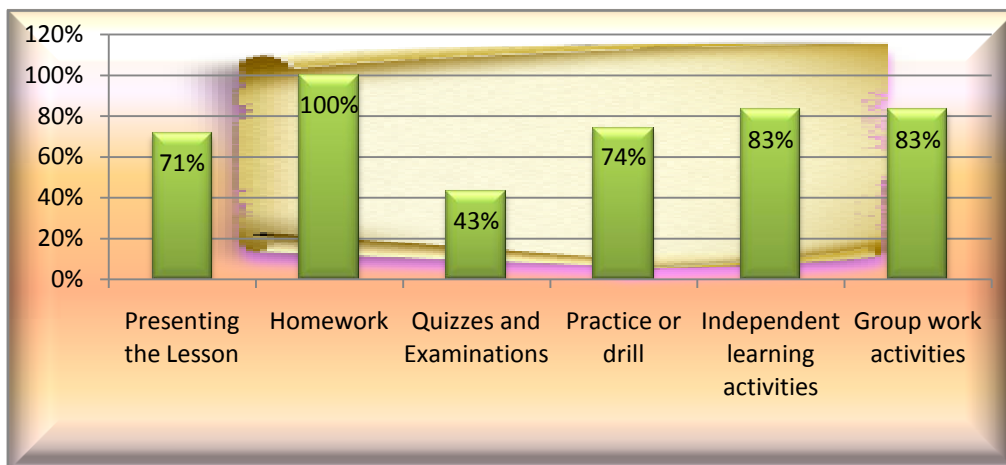


Figure 6 Aspect of Learning and Problem Solving Where Computer/Technology is Most Helpful

As identified from the participants' answers to the sixteen-item problem solving type of test in the form of activity sheets, the mean achievement or correct scores of the control group is 9.90 with the standard deviation of 1.21 while the experimental group has a mean correct



scores of 9.81 with a standard deviation of 2.11 presented on Table 4. Using the t-test on SPSS comparing two independent samples in terms of their means and variance scores, the results show that there are no statistically significant differences between the two groups with $p > 0.874$ and to further prove using the Levene's test for equality of variance there is no significant difference between the mean scores with $p > 0.061$ found in Table 5. Both groups are equally likely to have an approximate 10 correct scores with or without technology in solving problems in mathematics.

Table 4 Average Scores of Two Groups in the Problem-Solving Type of Test

Group	Number of students	Mean Scores	Std. Deviation	Std. Error Mean
Control Group Without Technology	21	9.90	1.411	.308
Experimental Group With Technology	16	9.81	2.105	.526

Table 5 Independent Samples Test for Two Groups According to their Achievement Scores

	Levene's Test for Equality of Variances		Student t-test for Equality of Means				
	F	Significance	t	Df	Significance (2-tailed)	Mean Difference	Std. Error Difference
Equal variances assumed	3.752	.061	.160	35	.874	.092	.578
Equal variances not assumed			.151	24.85	.881	.092	.610

IV. DISCUSSION

Calculators, computer software and other technologies can be powerful tools in the study of mathematics, particularly in the area of problem solving. This study was conducted to examine the effects of appropriate technology in the development of problem-solving skills in a class of Pre-Service Mathematics Teachers. It was intended to support the research already available on the topic of technology use and problem solving and in an attempt to answer the following questions: 1) What are the effects of the use of appropriate technology in pre-service teacher's mathematics problem solving skills? 2) Do pre-service teachers perceive the use of technology as essential and beneficial factor to enhance their



problem solving skills? 3) Is there a significant difference on the average scores or performance level of pre-service teachers in the control and experimental group in the different areas of mathematics?

The first question focuses on the effects of the use of appropriate technology in their mathematics problem solving skills and as motivating factor to their learning in mathematics.

The results presented earlier appear to have a positive effect of the use of appropriate technology in their mathematics problem solving skills and as motivating factors towards mathematics learning. As clearly shown in Table 1, 95% are in the affirmative side that appropriate technology are “useful in tedious computations”, “easier to get the answers”, “getting an accurate solution”, “speed up computations” and “easy to get logically formula”. Furthermore, in Figure 1, 100% the pre-service teachers said at least technology is available to them. Further results revealed that 46% of the pre-service teachers prefer the use of technology for doing their worksheets and examinations as evidenced shown in Figure 2. Almost half of the pre-service teachers do really prefer any of the two mediums either the use of technology or manual computations for doing their worksheets and practice exercises (41%). This implies that the technology is an essential tool and should be availed to the pre-service teachers all the time and technology complements pre-service teacher’s ability to solve problems as indicated by the responses of the pre-service teachers when they were asked whether they prefer to use technology when solving problems. This agrees with research conducted by Pomerantz (1997) that the technology is essential in learning and teaching mathematics and can be quite effective aid when it comes to problem solving.

Similarly, Figure 3 further strengthen the assumption that appropriate technology serves as motivating factor for pre-service teachers’ perception and problem solving because 95% of the respondents claim that solving mathematics problems with technology “helps learning and solving easier”, and “it makes learning and solving more fun” (68%).

It is even demonstrated [in Figure 5] that technology motivates highly the students in learning mathematics. Thus, indicating that appropriate use of technology has its positive effects toward mathematics and problem solving. This clearly shows their attitude is favorable to the possible positive effect of technology in mathematics and problem solving. Based on these foregoing results, the initial hypothesis is strongly supported.



The second question investigates the pre-service teacher's perception on the use of technology as essential and beneficial factor to enhance their problem solving skills. All the results unite to support the hypothesis that pre-service teachers perceive that the use of technology as essential and beneficial factor to enhance their mathematical problem solving skills. It is demonstrated [in Figure 3] that 95% of the pre-service teacher responded that "it makes solving and learning easier", and "it makes solving and learning more fun" (68%).

It is strongly supported in [Figure 6] that technology is of help to the pre-service teachers on their learning and problem solving. As such, homework (100%), independent and group learning activities (83%) as well as in drills and lesson demonstrations.

Additionally, the results show to support the hypothesis that technology is beneficial in their problem solving. Figure 5 attests that 11% agreed that the use of technology is very highly beneficial to enhance their problem solving skills, 43% and 35% highly beneficial and beneficial respectively. The responses have an average of 3.54, indicating that they feel that the use of appropriate technology is highly beneficial to them in enhancing their math problem solving skills. Furthermore, Table 2 further attests that the use of technology is highly beneficial to the respondents' problem solving skills because 18 out of 37 or 49% of the respondents agreed that "it is easy to calculate/solve difficult problems" when using appropriate technology. They see it as very beneficial because using such technology have "lesser time for computation", "solving more problems", "getting accurate answers", "improving problem solving skills", "understanding more concepts" and "comfortable and enjoy solving". Doing so these results support the assertion that appropriate use of technology in the classroom especially in mathematical problem solving does not hinder pre-service teachers' performance on problem-solving activities. Appropriate use of technology use may even improve pre-service teachers' performance in problem-solving activities.

Besides, when they were asked about the technology which they thought are very beneficial and important for their problem solving skills, Calculator is the foremost technology that they see useful and beneficial for the enhancement of their skills with 46%, 17 out of 37 respondents, followed by computer software (spreadsheet) with 27% or 10 out of 37 responses.



The second hypothesis has been strongly established with the aforementioned results based on the data collected.

The third question focuses on the significant difference on the average performance level of pre-service teachers in the control and experimental group in the different areas of mathematics. As a result indicated/attested in Table 5, showed that there are no statistically significant differences between the average scores of the two groups, which might be attributed to the varying difficulties of the problems and prior knowledge of the respondents. Both groups are equally likely to have the same problem solving skills acquired with or without technology in solving problems in mathematics.

V. CONCLUSION AND RECOMMENDATION

In this information age where technology is ever present, ever changing and advances at high speed, keeping up with the latest innovations and inventions that technology can offer is essential in order to be relevant now and in the future. As suggested by the result of the study, calculators and other technologies, in conjunction with mental or paper-and-pencil when appropriately used, comprise the tools to help pre-service teachers work through the computations and manipulations necessary for solving problems.

In mathematics education, technology found to be reshaping the mathematical scenery, allowing students to work at higher levels of generalization and abstraction, thus resulting in a deeper mathematical understanding and increase proficiency in problem solving (Jurdak, 2004). The findings of the study, suggest that the use of appropriate technology has a substantial effect on the problem solving of the pre-service teachers. Pre-service teachers perform better in mathematics, work out more problems, finish their work faster, it makes mathematics easy and enjoyable, motivates them in doing and learning mathematics, and more inspired to explore the richness of mathematics. In general, use of technology resulted in better pre-service teachers' increase their motivation to learn. Pre-service teachers are actively engaged in mathematics using technologies as problem-solving and decision-making tools. Thus, there is an extensive benefit of appropriate technology use in the classroom.

Technology serves as facilitators for child's problem solving skills. The use of appropriate technology plays a vital role in the development of child's mathematical problem solving proficiency and enables students to focus on the "whys" of mathematics rather than on the



“hows”. Mathematical investigations which were not possible in the past are now explored more easily by students enabling them to make more complex and insightful discoveries. However, technologies will never replace the human mind when it comes to reading, understanding a problem situation, choosing a solution, solving a problem and interpreting the answer. Technology do not “solve and understand” mathematics. Technologies do not solve mathematical problems but they do considerably facilitate the understanding of mathematics and enhancing of mathematical skills. It is then incumbent upon teachers to make decision on when and how to use technology in their mathematical classrooms especially in problem solving.

Hence, the question is no longer whether teachers should use technology or not, but rather how best to incorporate various technology applications into classroom settings especially in problem solving. However, new and better tools are needed to harness the power of technology to enhance mathematics achievement for all pre-service teachers/students. Mathematics teachers at all levels should promote the appropriate use of technology to enhance problem solving skills, by integrating technology use in assessment and education, by remaining current with state of the art of technology and by considering new application of technology to enhance the study and learning of mathematics. Educators should be prepared to deal with enormous challenges in mathematics education. Thus, as more and more teachers teach mathematics with technology as a tool, the shift must be towards the evolving issues more directly focused on student learning of mathematics – evaluating the results of the decision and its impact on the mathematics curriculum and instructional strategies needed so that all students are able to learn Mathematics. Ultimately if technology is used to improve the learning of mathematics at all levels, students will be better prepared to use technology appropriately, fluently, and efficiently to do mathematics in techno-rich environments in which they will study and work in the future. All educators should consider how to integrate them into their classrooms to best enhance mathematics instruction and benefit our students, particularly in the area of problem solving.

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