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# Portfolio as an Alternative Assessment: Effects on Problem-Solving Performance, Critical Thinking, and Attitude in Mathematics

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## Introduction

Assessment has long been the “missing link” in the effective curriculum program. According to Burke (1997) teachers who introduce exciting educational strategies like cooperative learning, higher-order thinking skills, multiple intelligences, and integrated curricula challenge students to expand their *critical thinking*, let alone stretch their creativity. Their teaching signals a new order of challenge and change, but when they end the unit with a multiple-choice test, their assessment signals a return to tradition. It does not take long for students to figure out how to study and what to value. If teachers teach what they think is important, they need to test what they think is important.

Traditionally, assessment in mathematics courses consists mainly of tests, quizzes, and textbook exercises. Webb (1992) explained that tests are important quantitative assessment tools, but in and of themselves do not constitute the totality of assessment. Traditional assessment techniques make it difficult to develop inferences about students’ learning, and consequently new ideas about how to improve students’ learning are less likely to take place.

Thus, even preservice mathematics teachers enter their mathematics courses with expectations for similar assessment.

The current reform movement in mathematics education recommends that student assessment be integral to instruction and that multiple assessment be used (NCTM, 1989).

The Professional Standards for Teaching Mathematics (NCTM, 1991) highlights the need for teachers to reflect on their practices and to use alternative assessment methods. Mathematics teacher-educators must model these practices in methods and content courses. In the words of the Curriculum and Evaluation Standards (NCTM, 1990), merely adding scores on written tests will not give a full picture of what students know. The challenge for teachers is to try different ways of grading, scoring, and reporting to determine the best ways to describe students' knowledge of mathematics, as indicated in these standards.

It is not enough to preach about alternative assessment. If preservice teachers are expected to adopt multiple assessment methods, then they must experience these. By using multiple methods of assessment, the teacher educator not only models behavior for the preservice teachers but also assesses their learning and understanding.

The present study was anchored on how alternative assessment practices can improve the problem solving performance of preservice teachers in mathematics and thereby enhance the critical thinking, as well as their attitude toward mathematics. Many studies have been done about alternative assessment but no study has focused on the effects of alternative assessment on the problem-solving performance of the students, specifically of preservice teachers of mathematics.

### **Statement of the Problem**

Mainly this study sought to find out the effects of alternative assessment on problem-solving performance, critical thinking, and attitude toward mathematics.

Specifically, the study attempted to answer the following questions:

1. To what extent does portfolio assessment affect preservice mathematics teachers?
  - 1.1. problem-solving performance;
  - 1.2. critical thinking; and
  - 1.3. attitude toward mathematics?
2. Is the effect of using alternative assessment moderated by the level of mathematical abilities of the students?
3. What is the nature of the relationship between these pairs of variables?
  - 3.1. problem-solving performance and critical thinking
  - 3.2. problem-solving performance and attitude toward mathematics
4. What are the students' perceptions of the use of alternative assessment?

### **Theoretical Basis of the Study**

The present study is based on the constructivist theory of learning. In the constructivist's view, learning is a constructive process in which the learner is building an internal representation of knowledge, a personal interpretation of experience that is constantly open to change. Learning is an active process in which meaning is developed on the basis of experience (Bednar, et.al., 1993).

#### ***Constructivist Theory of Learning***

Constructivists suggest that learning is not linear in that it does not occur on timeline of basic skills. Instead, learning occurs at a very uneven pace and proceeds in many different directions at once.

Meaningful learning does not just happen when people are able to receive information through direct instruction. In

order for meaningful learning to take place, people have to interpret information and relate it to their own prior knowledge. They need to know not only how to perform, but also when to and how to change the performance to fit new and different situations.

Bellanca (1992) argues that traditional forms of assessment like multiple-choice tests can also assess lower-order recall of factual information and one or two of the multiple intelligences. These tests are rarely able to assess whether or not students can organize complex problems. The new cognitive perspective stresses that meaningful learning is constructive. Learners should be able to construct meaning for themselves, reflect on the significance of the meaning, and self-assess to determine their own strengths and weaknesses.

New assessments, therefore, should focus not on whether or not students can acquire knowledge, but whether or not they can acquire disposition to use skills and strategies and apply them appropriately. Recent studies suggest that poor thinkers and problem-solvers may possess the skills they need, but may fail to use them in certain tasks. Integration of learning, motivation, collaboration, the affective domain, and metacognitive skills all contribute to lifelong learning. Assessment practices must stop measuring knowledge skills and start measuring the disposition to use the skills (Burke, 1997).

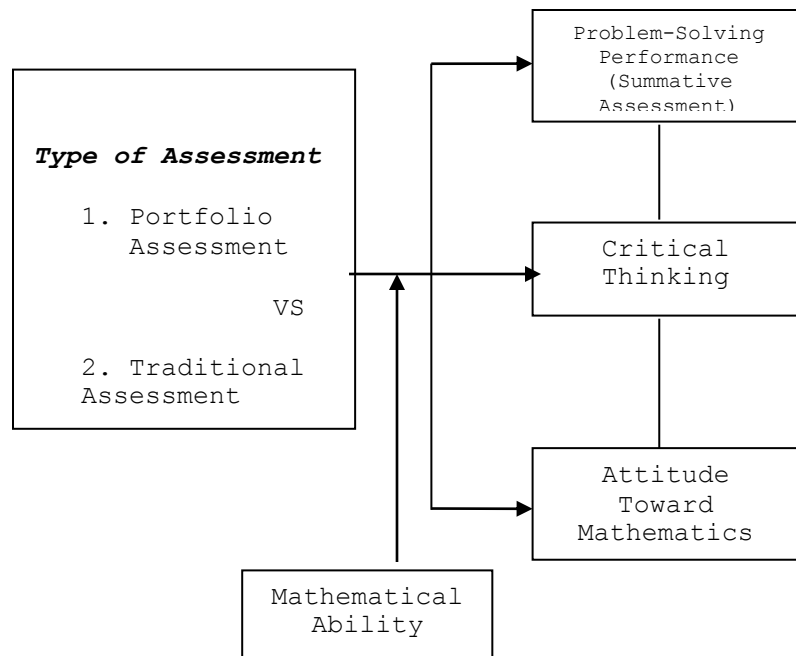
### **Conceptual Framework**

Since problem solving is a complex process, which cannot be evaluated using a single assessment method such as the traditional method, alternative forms of assessment should be tried.

This study investigated the effects of using an alternative form of assessment, specifically, portfolio assessment on problem-solving performance of the students in

mathematics. It also attempted to look into the effects of this assessment process on their critical thinking, and attitude. More specifically, the main purpose of this study was to link an alternative assessment approach to problem-solving performance.

The conceptual model of this study shown in Figure 1 stresses that the main objective of this study was to find out the effect of alternative assessment approach on a) problem solving performance, b) critical thinking, and c) attitude of students towards mathematics. It also points out that the study also determined for which group of students, alternative assessment is appropriate when they are classified according to ability. Finally, this study tried to find out the extent of relationship among problem-solving performance, critical thinking, and attitude toward mathematics.



**Figure 1.** Conceptual Framework

## **Research Design**

Using the pretest-posttest quasi-experimental research design, the objective of the experiment was to find out the effect of using alternative assessment on the problem-solving performance, critical thinking, and attitude of the students in mathematics.

Focus group discussion was used to find out the perceptions of the students toward the use of alternative assessment.

## **The Participants of the Study**

The Ss participants of this study comprised of second year mathematics majors of the Philippine Normal University enrolled in Math 7S (Solid Geometry) during the first semester of SY 2004-2005.

Two intact sections of students were used because randomization was impossible, as the students were already assigned to their respective sections. These sections were randomly assigned as experimental and control groups by using the fish-bowl technique.

The experimental group (BSMT II-A) was taught using the alternative assessment method, while the control group (BSMT II-B) the traditional assessment method. In other words, the two groups of students were taught the same lessons and topics using the same teaching strategy, but were formatively assessed using different methods of assessment.

The 19 students in each section were initially classified into three ability groups, based on their average grades in all mathematics courses that they had taken.

## **The Research Instruments**

Three research instruments were used in this study: a problem solving performance test, a critical thinking test, and an attitude inventory.

### ***The Problem-Solving Performance Test***

This was a 30- item test consisting of 20 multiple-choice items and 10 open-ended items. Each multiple-choice item was rated or scored 6 points for every correct answer. By contrast, the open-ended problems were scored using the ***scoring rubrics for problem-solving performance test***. The perfect score for this test is 180 points.

While the Cronbach Alpha Reliability Coefficient of the test was 0.85, which means that the test was reliable, the validity coefficient was 0.702 which means that the test was valid.

### ***The Critical Thinking Test***

This was a 10-item test consisting of typical word problems with supplementary questions designed to encourage communication of critical thinking.

The items in the test took on any of the following forms:

1. A problem wherein the question or a fact was withheld. The students examine the problem's facts and conditions and write their own questions and solutions.
2. Students create a similar or related problem after they have solved a problem.
3. Students are asked to examine the solution to a problem that contains a conceptual or procedural error and they answer a series of questions

focused to reveal the extent of their critical thinking.

4. Students are asked to create a problem for which they must communicate an explanation without actually solving the problem.

The reliability coefficient of the test was found to be 0.84 and the validity coefficient 0.87 meant that the critical thinking test proved reliable and valid.

### ***The Attitude Scale***

To assess the attitude of the participants toward mathematics, the attitude scale developed by Sillorequez (1997) was used. This instrument was designed to measure attitude towards mathematics as a school subject and towards its applications in life.

Of a Likert-scale type, it consists of 30 items, 15 of which are positively oriented and the other 15, negatively oriented. Its reliability coefficient is high (0.91), which means that the instrument has high internal consistency reliability.

Scoring was based on the respondent's agreement or disagreement with each statement using the 5-point scale as follows:

### ***Questions for the Focus Group Discussion***

Focus group discussion was done to determine the students's perceptions towards the use of portfolio assessment.

The responses of the students during the focus-group discussions were further validated by asking them to write their answers to the above questions. This was done at the end of the course when the students were required to submit their final portfolio including their written answers to these questions.



## **Data Collection Procedure**

As stated earlier, this study utilized the experimental design in which one group of students was taught using the alternative assessment method; and the other group the traditional assessment method.

The data gathering procedure went through three stages: preparation, experimental, and evaluation.

## **Planning and Preparation Stage**

On the first day of the semester, the problem solving performance test, the critical thinking skills test, and the attitude scale were administered to both the control and experimental groups.

The next meeting was spent for the course orientation. The students in the experimental group were given the orientation on portfolio assessment. The whole session was spent on introducing the concept of mathematics portfolio and portfolio assessment. They were asked to give their comment about portfolio. It was found that they had been doing portfolio in other courses, but the mathematics portfolio that they would be doing this time was very much different. A handout about portfolio assessment (Appendix BB) was given for them to grasp its concept better.

The use of portfolio assessment as an alternative assessment in the course was also explained to them. At this point, they were asked to write their perceptions on pencil and paper test. They mentioned some problems like being anxious during test.

Four lesson units were covered during the experimental period. Each unit on prisms, pyramids, cylinders, and cones covered approximately two weeks each.

For this study, different models and designs of portfolio were examined. An eclectic model was used; processes and procedures were selected from different designs to suit the needs of the study. In addition, common steps and techniques in the different models were selected for the present design of the portfolio.

### **Experimental Stage**

The actual experiment started in the second unit of the syllabus and lasted for almost ten weeks because of some university activities and suspension of classes. However, respective assessment methods were used entirely for the whole semester in the experimental and control groups.

The control group was taught and assessed using quizzes, chapter exams, and other paper-pencil tests. Lecture-discussion, assignments, and seat work were also part of the usual activities in the control group. Short quizzes were given weekly, while chapter exams were given four times during the experimental period.

The teacher introduced the topic using lecture discussion method or deductive method. Students were asked to solve exercises taken from the textbook individually. At the end of the session, the teacher summarized the lesson. Assignments were also given to the students based on the textbook.

The experimental group was taught using the alternative assessment method mentioned above. Students were asked to answer open-ended problems and free-response, inquiry-based activity sheets weekly. This was done either individually or by group. At the end of each session, the students were asked to write their reactions, opinions and reflections in a reflective journal. Moreover, they were asked to write what they have learned in the lesson using a learning log. The purpose of this was to have an idea of what the students'

think they have learned or have not learned in every session. Assignments given to the students required them to make any of the evidences entered in their portfolio. They were constantly reminded of their duty to collect the entries in their portfolio. Portfolio conferences were held between the students and the teacher as the need arose.

All students's outputs were rated by the instructor using the appropriate scoring rubrics. The results were given immediately the following meeting to provide them immediate feedback of their work and make some corrections for any misconceptions.

Portfolio conferences between teacher and students and among students were held regularly. These were done to observe the students' perceptions and attitudes in the process of organizing their portfolio.

The final portfolios of the students in this study were graded using the holistic-scoring rubric although some of its contents have been graded previously (Appendix G). This was purposely given to the students at the start of the semester for them to know how their portfolios would be rated and to enable them to assess their own learning, monitor their own behavior, work habits, and thinking skills for self-improvement.

The students were asked to evaluate their own portfolio using the scoring rubrics presented to them at the start of the experiment before submitting them. The teacher-researcher made a separate evaluation of the portfolios using the same set of scoring rubrics.

The final portfolios of the students were rated based on the six learning objectives (Appendix G). Each learning objective was rated 0, 1, 2, or 3 based on the degree to which the evidences or artifacts in the portfolio demonstrated the competence with respect to the objective. Each item in the

portfolio should have clearly indicated which of the six learning objectives it demonstrated.

The final portfolios of the students were rated by the researcher and the two other mathematics instructors of the Philippine Normal University to make the scoring more reliable. The average of the ratings given by the three raters was the final score of the student's portfolio.

### **Data Analysis Procedure**

The following statistical analyses were used to analyze the data gathered:

The *mean and standard deviation* were used to describe the scores of the students in the problem-solving performance test, critical thinking test, and attitude scale. The *t-test for dependent samples* was used to determine the presence of a significant difference between the pretest and posttest scores of the students in the problem-solving performance test, critical thinking test, and attitude scale. To determine if there is a significant difference between the students who were taught using alternative assessment and those who taught the traditional assessment in terms of problem-solving performance, critical thinking, and attitude toward mathematics, the *t-test for independent samples* was used. To find out if the effect of alternative assessment is moderated by the level of mathematical abilities of the students, *the two-way analysis of variance (Two-way ANOVA)* was employed. To determine if there are significant relationships among problem solving performance, critical thinking, and attitude towards mathematics, *Pearson Product-Moment Correlation* was used. All statistical computations were processed using SPSS (Statistical Packages for Social Sciences).

## Results and Discussion

### *Comparison of the Posttest Mean Scores of the Experimental and Control Groups*

Table 1 shows the comparison of the posttest mean scores of the control and experimental groups in the problem solving performance test, critical thinking test, and attitude scale.

**Table 1.** Comparison of the Posttest Mean Scores of the Control and Experimental Groups in the Problem Solving Performance Test, Critical Thinking Test, and Attitude Scale

		<i>Mean</i>	<i>Std. Dev.</i>	<i>Mean Difference</i>	<i>df</i>	<i>t-value</i>	<i>p-value</i>
<i>Problem Solving Performance (Multiple-Choice Type)</i>	<i>Control</i>	78.63	14.95	10.74	36	2.416	0.021
	<i>Experimental</i>	89.37	12.31				
<i>Problem Solving Performance (Open-ended Type)</i>	<i>Control</i>	36.47	6.86	0.95	36	0.347	0.947
	<i>Experimental</i>	37.42	9.74				
<i>Problem Solving Performance (Over-all)</i>	<i>Control</i>	115.11	18.80	12.21	36	2.080	0.045
	<i>Experimental</i>	127.32	17.36				
<i>Critical Thinking</i>	<i>Control</i>	21.26	3.66	4.58	36	3.39	0.002
	<i>Experimental</i>	25.84	4.61				
<i>Attitude Scale</i>	<i>Control</i>	4.19	0.35	0.03	36	0.211	0.834
	<i>Experimental</i>	4.16	0.44				

There is a significant difference between the posttest mean scores of the control and experimental groups both in the problem solving performance test and critical thinking test. Evidently, the experimental group performed significantly higher than the control group in the problem solving performance test and critical thinking test.

From this result it can be inferred that alternative assessment is better than the traditional assessment in developing the problem solving performance and critical thinking of the students. The result confirms the findings of Milo (1999) that portfolio assessment developed higher order thinking skills. However, this contradicts the findings of Century (2002) that traditional method of assessment yielded more concrete cognitive content learning than did the alternative assessment.

The result further implies that method assessment significantly affects the problem solving performance and critical thinking of the students. This result suggests that there must be a paradigm shift in the role of assessment in learning. Assessment and instruction are not independent processes. For too long, assessment and instruction have been adversaries. But, the findings of this study show how assessment complements instruction. Linking assessment and instruction enhances teaching and improves student learning.

However, no significant difference was found between the posttest mean scores of the control and experimental groups in the attitude scale. This means that method of assessment did not significantly affect the attitude of the students. This result contradicts the findings of Milo (1999) that portfolio assessment has a significant effect on the attitude of the students. This can be explained by the fact that both groups consist of mathematics majors; thus, they more or less have the same level of attitudes towards mathematics.

### ***Interaction Effect of Assessment Method and Mathematical Ability***

The mean scores on the problem solving performance test of the students in the control and experimental groups, when grouped according to their mathematical abilities, are shown below.

	<i>Below Average</i>	<i>Average</i>	<i>Above Average</i>
<i>Control</i>	104.67	119.56	113.86
<i>Experimental</i>	123.63	123.63	147.00

The data above shows that the effect of the method of assessment did not remain constant across below average, average, and above average ability students. In the control group, average ability students performed better than above average ability students. While in the experimental group, above average ability students performed better than the average ability students. Thus, it can be inferred that there was an interaction effect.

The configuration of these data in Figure 2 concretizes the presence or absence of interaction effect.

**Figure 2.** Graph of the Interaction Effect of Assessment Method and Mathematical Ability on the Problem Solving Performance

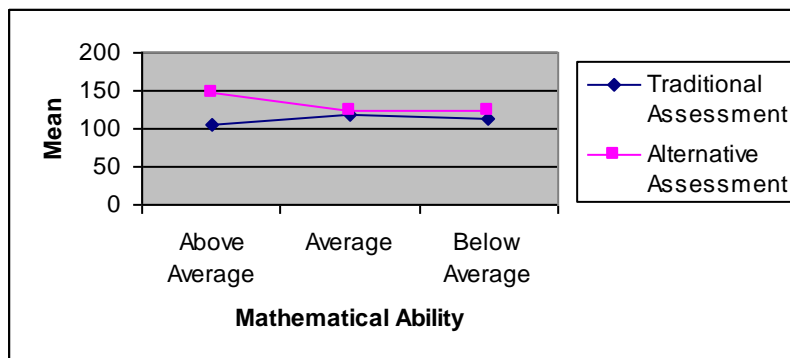


Figure 2 above shows that the lines are not parallel; hence, indicating the presence of interaction effects of the method of assessment and mathematical ability on the problem solving performance of the students. However, whether these effects are statistically significant or not can only be determined by testing them and not by just visually inspecting them. Thus, a Two-Way Analysis of Variance (ANOVA) was used.

Table 2 summarizes the Two-Way Analysis of Variance (Two-Way ANOVA) showing the interaction between method of assessment and mathematical ability wherein the dependent variable was problem-solving performance.

The table shows that method of assessment significantly affects the problem solving performance of the students. This finding is congruent to the previous result that there was a significant difference between the problem solving performance of the students who were taught using traditional assessment and those in the alternative assessment. However, mathematical ability did not significantly affect the problem solving performance of the students. In other words, mathematical ability is not a factor on the problem solving performance of the students.

Further analysis of the table reveals that method of assessment and mathematical ability had no significant interaction effects on the problem solving performance of the students. This implies that the effect of the method of assessment is not moderated by the level of mathematical abilities of the students. In other words, regardless of mathematical ability of the students, portfolio assessment can enhance problem solving performance.

**Table 2.** Two-Way ANOVA for the Interaction Effect of Method of Assessment and Mathematical Ability on Problem Solving Performance

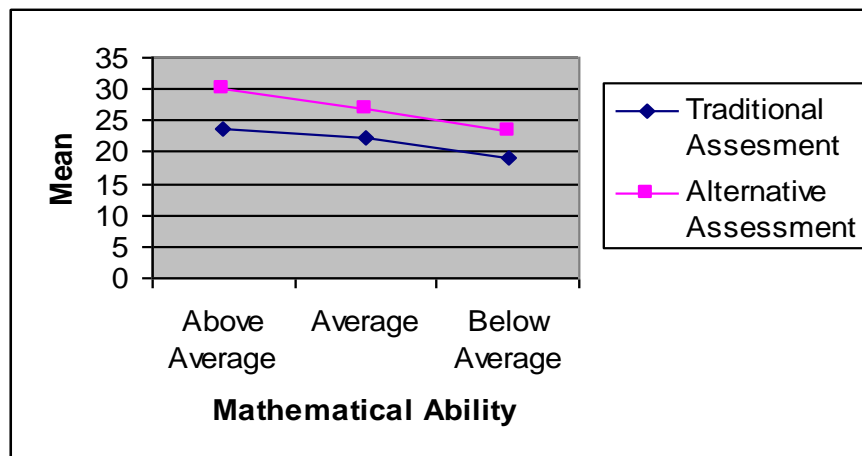
Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value	Interpretation
Method of Assessment	2695.24	1	2695.24	8.73	0.006	Significant
Mathematical Ability	221.54	2	110.77	0.36	0.701	Not significant
Interaction	1663.79	2	831.89	2.69	0.083	Not significant
Error	9885.50	32	308.92			
Total	13198.32	37				



The next data show the posttest mean scores in the critical thinking test of the students in the control and experimental groups when grouped according to their mathematical ability. The effect of the method of assessment remains constant across three different levels of mathematical ability. This result signifies that there was an absence of interaction effects of method of assessment and mathematical ability on the critical thinking of the students.

	<i>Below Average</i>	<i>Average</i>	<i>Above Average</i>
<i>Control</i>	19.00	22.22	23.67
<i>Experimental</i>	23.25	26.88	30.00

To effect better visualization of the absence of interaction effect, the configuration of the above data is shown in Figure 3. The lines are parallel, indicating the absence of interaction effects of the method of assessment and level of mathematical ability on the critical thinking of the students.



**Figure 3.** Graph of the Interaction Effect of Assessment Method and Mathematical Ability on Critical Thinking

To find out if the interaction effect was statistically significant or not, Two-Way Analysis of Variance was used. Table 2 presents the summary of the Two-Way ANOVA for the

interaction effect of the method of assessment and mathematical ability on the critical thinking.

There is no significant interaction effect of the method of assessment and level mathematical ability on the critical thinking of the students. This implies that the effect of the method of assessment was not moderated by the level of mathematical ability of the students; moreover, regardless of mathematical ability, portfolio assessment can enhance critical thinking of the students.

**Table 2.** Two-Way ANOVA for the Interaction Effect of Method of Assessment and Mathematical Ability on Critical Thinking

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value	Interpretation
Method of Assessment	198.30	1	198.30	14.15	0.001	Significant
Mathematical Ability	169.39	2	84.69	6.04	0.006	Significant
Interaction	4.77	2	2.37	0.169	0.845	Not Significant
Error	448.60	32	14.02			
Total	823.40	37				

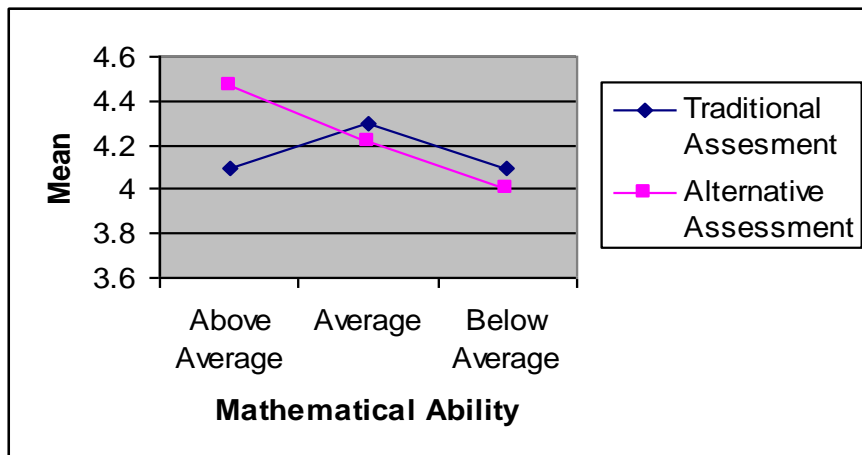
Also, the table shows that the main effects were significant. In other words, method of assessment as well as level mathematical ability significantly affects the critical thinking. This validates the previous analysis in Problem 1.

The data given below show the mean scores of the students in the control and experimental groups on the attitude scale when grouped according to mathematical ability. There seems to be an interaction effect of the method of assessment and level of mathematical ability on the attitude towards mathematics, because the effect of the method of assessment did not remain constant across the different levels of mathematical ability. Notably, in the control group, average

ability students had a higher mean score than the above average ability students.

	<i>Below Average</i>	<i>Average</i>	<i>Above Average</i>
<i>Control</i>	4.09	4.30	4.09
<i>Experimental</i>	4.00	4.22	4.47

As shown in Figure 4, the graph of the data above reveals that while there seems to be an interaction effect of the methods of assessment and level of mathematical ability on the attitudes of the students because the lines in the graph intersect each other, this is not borne out by the two-way analysis of variance.



**Figure 4.** Graph of the Interaction Effect of Assessment Method and Mathematical Ability on the Attitude Toward Mathematics

The Two-way ANOVA was used to verify if there was really a significant interaction effect. Table 3 summarizes the results of the Two-Way ANOVA showing the interaction between method of assessment and mathematical ability.

Mathematical ability and method of assessment had no significant interaction effect on the attitude towards

mathematics. This means that the simultaneous effect of mathematical ability and method of assessment did not significantly affect the attitude of students. Hence, the effect of the method of assessment was not moderated by the level of mathematical abilities of the students in terms of their attitudes. Restated, regardless of mathematical ability of the students, any method of assessment can be used.

**Table 3.** Two-Way ANOVA for the Interaction Effect of Method of Assessment and Mathematical Ability on Attitude in Mathematics

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value	Interpretation
Method of Assessment	0.036	1	0.036	0.231	0.634	Not significant
Mathematical Ability	0.447	2	0.224	1.145	0.249	Not significant
Interaction	0.289	2	0.145	0.939	0.402	Not significant
Error	4.93	32	0.154			
Total	5.69	37				

The main effects were not significant either, a validation of the previous analysis that method of assessment did not significantly affect the attitudes of the students. Similarly, mathematical ability did not significantly affect the attitudes of the students. Hence, it appears from this result that mathematical ability is not a factor in the attitude of the students.

Table 4 shows the matrix of correlation among the variables taken pairwise. A significant relationship was found between problem-solving performance and critical thinking ( $r = 0.334, p < .05$ ).

**Table 4.** Matrix of Correlation Coefficients among Variables

Variables	Problem-solving	Critical Thinking	Attitude
<b>Problem-solving (p-value)</b>	1.00	0.334 (0.040)	0.225 (0.175)
<b>Critical Thinking (p-value)</b>		1.00	0.226 (0.173)
<b>Attitude</b>			1.00

This means that if problem-solving performance score of a student rates high, his critical thinking score would be high also. In this regard, Szetela (1991) explains that problem solving involves a great amount of critical thinking; successful problem solvers are those with high level of critical thinking.

However, no significant relationship was found between problem-solving performance and attitude towards mathematics. This means that attitude towards mathematics is not a factor on the problem-solving performance of the students.

### ***Correlation of Portfolio Scores to Problem Solving Performance, Critical Thinking, and Attitude Scores***

Students' scores in their final portfolio were correlated to their scores in the problem solving performance test, critical thinking test, and attitude scale. It was found out that portfolio scores were significantly correlated to problem solving performance ( $r = 0.72$ ,  $p < 0.05$ ), critical thinking ( $r = 0.56$ ,  $p < 0.05$ ), and attitude toward mathematics ( $r = 0.65$ ,  $p < 0.05$ ). This shows the validity and reliability of portfolio assessment. Furthermore, this result supports the findings of Milo (1999) that portfolio assessment proves valid and reliable; and that problem solving is a construct highly evident in portfolio assessment.

### ***Students' Perceptions of Portfolio Assessment***

To find out the perception of the students on the use of alternative assessment, focus group discussion was conducted. Four major themes emerged from the focus-group discussion:

1. Portfolio assessment lessens the students test anxiety.
2. It makes the students learn differently.
3. It equally allows students to learn with greater retention.
4. Finally, portfolios require students to work and learn independently.

When the participants were asked about their perceptions on alternative assessment, 95% had positive attitude towards the use of portfolio in the classroom assessment. The following were some of their responses:

*“For me the use of alternative assessment in our class has a positive impact because in using and making portfolio, our creativeness and all our learning in Solid Geometry were included.”*

Their creativeness was evident in the problems which they created especially those with conceptual errors.

Another student explains her feelings in doing her portfolio:

*“When I first heard of the Portfolio Assessment, I just thought that it would be about the experiences in Solid Geometry class. I didn't figure out then that there would be a lot of discussions inside the portfolio.”*

Cheong (1993) found in her study that portfolio gives an avenue for students to show that they do know something. The documentation contained in the portfolio was both validating

and educational. Cheong added that the students' learning is more visible in that teachers can see how students think, make decisions, and draw conclusions.

One student commented that portfolio assessment makes the learning more lasting and reflective:

*"It is something that requires a lot of effort as if every portion of the mind has to function but the retention of the lessons and geometric concepts are longer since I was able to reflect on them."*

Even though results in using alternative assessment were positive, some students expressed their negative feelings about it. Some mentioned that alternative assessment imposes substantial burdens on them, as time demands in preparing and organizing the portfolio. Moreover, they said that it is harder to score students' performance through portfolio.

*"It took too much of my time. I have to do lot of reflection on journals and learning logs."*

*"Students who are not ready for this approach has [sic] this mental shock."*

In the study conducted by Cheong (1993) teacher respondents expressed concerns about the amount of time required to carry out portfolios over the course of a school year, and the degree to which time needed to construct portfolios would intrude on their central focus, instruction.

One student commented:

*"The disadvantage of this kind of assessment is that I can't find my real ability in it."*

In Koretz's (1994) study, teachers indicated some concerns about the use of alternative assessment especially portfolios. Most of them mentioned that portfolio assessment is

more subjective than traditional testing and reliability and validity can be questionable.

When the students were asked whether portfolio assessment is a good assessment tool, the majority replied that it was.

*“With the use of alternative assessment, I get to think more comprehensively and critically. I really have to study every bit of information in solving a single problem because it is not only the answer that matters; the process in solving is also counted.”*

When the students were asked to give the benefits that they derived from the use of alternative assessment, they gave the following positive answers:

*“I learned to be honest to myself because through journals, I can say what I didn’t understand in the lessons. Portfolio also helped me to be creative and diligent enough in the class.”*

Basically, the amount of time that a student devotes to his/her studies varies considerably among students. However, with portfolio assessment, the students were required to have a sustained effort to study hard. They were required to reflect on the salient points of a class lecture or discussion. This process seems to encourage the students’ grasp of the concept. Admittedly, they have to spend more time going over the textbook and references to make sure they comprehended the depth of each learning objective than they would have had, if they had been assessed traditionally.

When the students were asked if they would use this alternative assessment in their own classes when they become teachers, they gave the following responses:



*“I would definitely make use of alternative assessment. Maybe it will be an additional work for me, but knowing the effects of it, I know it will offset all the hardships and hassles of scoring each and every single problem. One more thing is that by using portfolio, I can make sure that the student really understood the lesson very well because it will be shown in his explanation, solution, and reflection.”*

One student wrote the following comment in her portfolio:

*“After doing this portfolio, I still want to try and apply it to my other courses to understand more clearly my lesson in the subjects. In the future, as a teacher, I will assign my students to do this alternative assessment because it will really serve as a tool to measure my future students’ performance in my class. And I know that it will also help them to understand, know, and improve their strengths and weaknesses in their courses.”*

Thus, the use of alternative assessment in this study seems to have given preservice mathematics teachers a chance to experience a process that they want to use in their future classrooms.

## **Conclusions**

Based on the findings of this study, the following conclusions were formulated:

1. The use of alternative assessment produced better problem solving performance and critical thinking among the students than the traditional assessment. It is an effective tool in enhancing and improving the problem solving performance and critical thinking of the students. It provides a better motivation and mechanism for learners to organize their knowledge.

2. Alternative assessment can be used for any ability group of students.
3. Portfolio assessment is an effective method of evaluating students formatively. It can be used as a diagnostic tool to discover students' difficulties, weaknesses, misconceptions, as well as strengths.
4. The use of scoring rubrics to monitor skill development is one promising feature of alternative assessment. Scoring rubrics can clarify for both students and teachers how valued skills are being measured.
5. Alternative assessment can develop students' ability to be more reflective and metacognitive especially in assessing their own work, collecting the evidences in their portfolio, or in setting their goals. Putting their portfolios together required them to review the concepts that they have studied, thereby giving them another opportunity for learning.
6. Alternative assessments that ask students to demonstrate both declarative and procedural knowledge are valid in assessing their growth. Hence, portfolio assessment is a valid and reliable method of assessment.

### **Recommendations**

In light of the conclusions drawn from this study, it is recommended that:

1. Teachers should start using portfolio assessment in their classes gradually. It can be used either in just one unit only for a specific purpose or tried to a particular class only. It may also be used, as a start, with the traditional assessment. The idea, therefore, is to start

small and not to attempt so many things at the same time.

2. Mathematics teacher educators should model the use of alternative assessment in the methods and content courses. If preservice mathematics teachers are exposed to alternative assessments as students, they are more likely to adopt these when they are already teachers.
3. Like any other change, the use of portfolio assessment should be implemented by teachers with great care and commitment so that its effectiveness, reliability, and validity as an assessment method could be assured. It is important, therefore, that teachers be given proper and formal training on how to use portfolio assessment in the class.
4. To increase the reliability and validity of portfolio assessment, its content and artifacts must be selected judiciously. Only those evidences that reflect students' performance must be included.
5. A study should be conducted in other content and method courses of preservice mathematics teachers to investigate other forms of alternative assessment and their effects on students' conceptual understanding.

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