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MATHEMATICS PRE-SERVICE TEACHERS' CLASSIFICATION OF TEST ITEMS USING THE REVISED BLOOM'S TAXONOMY

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Abstract:

This study identified the pre-service Mathematics teachers' interpretations of each thinking skills in the revised version of Bloom's Taxonomy (BT). It used a group of twenty two pre-service Mathematics teachers who were were asked about their views on Lower-Order Thinking (LOT) and Higher-Order Thinking (HOT) and to classify each of the six thinking skills in BT as to LOT or HOT. Furthermore, they were asked to create test items falling under each category for about two weeks. Descriptive statistics was used to determine the range of views of the teachers about LOT and HOT and which among the six thinking skills in BT was correctly classified. Also, percentage was used to identify which among the test items developed by the pre-service teachers were correctly classified according to the hierarchy in BT. Results revealed that most of the pre-service teachers have viewed LOT and HOT based on the level of difficulty of the given problem. They also found it moderately easy to create test items falling under the first four thinking skills – remembering, understanding, applying, and analyzing. However, they found it too difficult to create test items falling under evaluating and creating.

Key Words: Revised Bloom's Taxonomy, Higher-Order Thinking Skills (HOTS), Lower-Order Thinking Skills (LOTS), Test Items & Pre-Service Mathematics Teachers

1. Introduction:

Mathematics contributes directly to effective, intelligent living. Competencies with number relations are essential to every individual beginning at an early age and continuing through old age. Hence, numeracy and problem solving skills have been the focus of the present Mathematics instruction. However, Mathematics teaching has traditionally relied on factual recall and a focus on the use of standardized algorithms with little effort to teach or assess for higher-order thinking skills(Kulm, 1990; Battista, 1994) as cited by Thompson (2008). As a result, students generally learn Mathematics without being able to use their knowledge to solve problems in diverse or non-familiar situations.Furthermore, the result of the Trends in International Math and Science Study (TIMSS) with 46 participating countries is a dismal scenario where the Philippines emerged as third from the last both in Math and Science after South Africa and Morocco. Educational analysts believe that the performance of the Filipino students in the TIMSS indicates danger signal which do not auger well for the country's attainment of its goals towards industrialization and economic development.

Unfortunately, the blame for the said disappointing scenario is always on the part of the teachers as ineffectiveness in instructional efforts results to the underachievement of students in Mathematics; and that ineffective instruction is a result of being an incompetent teacher. Thus, teachers of Mathematics have been spending more time and effort to find the best possible teaching strategy that could make their students learn. However, evaluation of Mathematics achievement yields the same poor results, if not worse.

According to the National Center for Education Statistics (1996), teaching for higher order thinking (HOT) along with professional development in HOT were found to be two of the top five variables positively associated with improved student achievement. Students of teachers who teach for both lower-order-thinking (LOT) and higher-order-thinking outperform students whose teachers only teach for LOT. Thus, Mathematics teachers should have a strong conception of higher-order thinking and sustain it as an integral part of classroom instruction and assessment. With this, students will be able to meaningfully apply methods and concepts to situations previously unfamiliar to them. And because Bloom's Taxonomy is a well-known model for teaching critical thinking skills in any subject area, it is used as a guide in creating test items.

Also, based on the K – 12 Mathematics Curriculum Guide (2013), the twin goals of mathematics in the basic education levelsare critical thinking and problem solving. Critical thinking, according to Scriven and Paul (1987) is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or 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 (1945 & 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 the different contexts of Filipino learners.

Critical thinking skills have become a generic phase used to encompass many processes involved in learning and problem solving. Several reasons are often given for teaching thinking skills. One reason given by Gough in 1997, which was affirmed by Nisbet and Schucksmith (2000), is that the world is changing rapidly and critical thinking skill is the most important element in today's information age.

Most countries like the Philippines are concerned with raising the educational standards throughout the compulsory school years. The Department of Education (DepEd Order No. 33, s. 2004) has set minimum desired learning competencies and mastery of the "basics" are exposed such as reading, writing, Mathematics and Science. These basics maybe excellently taught, but these are not sufficient to meet the demands of the labor market and active citizenship. It is now recognized that a broader range of competencies, redefined as higher-order thinking skills (HOTS), are required because:

- ✓ The "banking theory" of knowledge based upon rote learning has been discredited as it is recognized that individuals cannot "store" sufficient knowledge in their memories for future use.
- ✓ Information is expanding at such a rate that individuals require transferable skills to allow them to address different problems in different contexts at different times through their lives.
- ✓ The complexity of modern jobs requires staff who demonstrates comprehension and judgment as participants in the generation of knowledge or processes.
- ✓ Modern society assumes active citizenship which requires individuals to assimilate information from multiple sources, determine its veracity and make judgments.

The cognitive skills developed by people in a society are profoundly influenced by the ways knowledge and literacy are taught and used. Thinking skills are viewed as crucial for educated persons to cope with a rapidly changing world. Many educators believed that specific knowledge will not be as important to tomorrow's workers and citizens as to the ability to learn and make sense of new information.

According to Robinson (1997), if students are to function successfully in a highly technical society, then they must be equipped with life-long learning and thinking skills necessary to acquire and process in an ever-changing world. Moreover, Pascua (1991) mentioned that it is the higher-order thinking skills that enable an individual to learn more, to apply Mathematics in other disciplines and to solve problems throughout life.

Bloom's research as cited by Mergel in 1998, emphasized that in skill mastery, the teacher needs to focus and develop the higher thinking of students. There is substantial evidence that directed and controlled intervention programs can improve students' abilities to give more original and unusual solutions to Mathematical problems of higher level.

According to Balmaceda as cited by Laviña (2000), in the knowledge-based and technology-driven society of the next millennium, creativity, analytical skills, logical reasoning and critical thinking will be of paramount importance. These skills will be crucial in coping with the explosion of information and adapting to new and changing demands and challenges. The development of higher-order thinking skills (HOTS) and strategies to improve such has been the focus of educators in recent years, partly in response to the challenges of the emerging world. Higher-order thinking skills or what others refer to as critical thinking has emerged as a priority for secondary and college curricula in most subject areas.

Since pre-service teachers were being developed to become successful in-service teachers, they were the focus of this study. Thus, Mathematics pre-service teachers must have a strong conception of critical thinking (higher-order thinking) and sustain it as an integral part of classroom instruction and assessment. With this, students will be able to meaningfully apply methods and concepts to situations previously unfamiliar to them. And because Bloom's Taxonomy is a well-known model for teaching critical thinking skills in any subject area, it is used as a guide in creating test items.

1.1 Research Questions:

This study attempted to determine the Mathematics pre-service teachers' interpretation of higher-order thinking in the revised Bloom's Taxonomy. Specifically, it aimed to answer the following questions:

- ✓ How do Mathematics pre-service teachers describe lower- and higher-order thinking skills?
- ✓ How do Mathematics pre-service teachers classify the six thinking skills in the revised Bloom's Taxonomy using higher-order and lower-order thinking?
- ✓ How do Mathematics pre-service teachers develop and classify test items using the revised Bloom's Taxonomy?

2. Methodology:

The participants of the study were composed of 22 high school mathematics pre-service teachers from selected public high schools in the CALABARZON region of the Philippines. Purposive sampling was used to identify the participants as pre-service teachers of mathematics, assigned to teach Geometry, were only the ones selected.

The high school mathematics pre-service teachers were asked to write their interpretations about lower- and higher-order thinking. When testing for levels of thinking, it is important that teachers should note the

familiarity to the problem situation (Thompson, 2008). It is considered as HOT if the problem situation is new, unfamiliar, or in some way different from those used in the instruction. Otherwise, it is deemed LOT.

Pre-service teachers were then asked to classify each thinking skill in Bloom's Taxonomy as either LOT or HOT. Lastly, they were asked to construct a Geometry examination item for each thinking skill. The researcher classified each item as to whether it fits with a thinking skill in BT. Three consultants were asked to classify each test item independent of the researcher.

Each item was classified into one of four categories: Items classified as LOT by both the teacher and the researcher (LOT – LOT); Items classified as HOT by both the teacher and the researcher (HOT – HOT); Items classified as LOT by the teacher and HOT by the researcher (LOT – HOT); and Items classified as HOT by the teacher and LOT by the researcher (HOT – LOT).

3. Results:

Of the twenty 22 participating Mathematics pre-service teachers, seventy three percent of them indicated that they were either very familiar (14%) or somewhat familiar (59%) with Bloom's Taxonomy (BT). Some of these pre-service teachers also indicated that they had learned BT during their undergraduate courses as part of their curricular program. Others have learned it also through researches and seminars they had attended.

3.1 Research Question Number 1:

How do Mathematics pre-service teachers describe lower- and higher-order thinking skills?

Some pre-service teachers included as part of their characterizations of LOT or HOT the level of difficulty of the given problem – as to simple or complex processes involved. Several pre-service teachers wrote that LOT problems are easier than HOT problems – they involve logical and critical thinking as well as careful analysis of the given problem.

Furthermore, a few pre-service teachers had mentioned that LOT requires simple recall of information and that these information are too basic and based only on rote memory, whereas, HOT as mentioned is a challenging tool in teaching and learning Mathematics because it enhances the creativity of the students in solving given problems.

However, they fail to characterize LOT or HOT problems based on students' familiarity to the given problem.

3.2 Research Question Number 2:

How do Mathematics pre-service teachers classify the six thinking skills in the revised Bloom's Taxonomy using higher-order and lower-order thinking?

Pre-service teachers were asked to classify each thinking skill in the Bloom's Taxonomy as either LOT or HOT. The results are presented in table 1.

Table 1: Teachers' Classification of Thinking Skills

Thinking Skills in Bloom's Taxonomy	LOT		HOT	
	Frequency	Percentage	Frequency	Percentage
Remembering	22	100.00		
Understanding	17	77.27	5	22.73
Applying	10	45.45	12	54.55
Analyzing			22	100.00
Evaluating	8	36.36	14	63.64
Creating			22	100.00

Teachers' classification of thinking skills indicated that 100% of the teachers classified remembering, analyzing and creating correctly as to LOT or HOT. Over 75% of the teachers classified understanding correctly as LOT. Applying is considered LOT or HOT in Bloom's Taxonomy. About 55% of the teachers classified application as HOT and the rest as LOT. It is interesting to note that most of the teachers identified applying items correctly. Evaluating is the second highest level of thinking skill in BT and should be considered as HOT. However, there are more than 35% of the teachers who classified it as LOT.

3.3Research Question Number 3: How do Mathematics pre-service teachers develop and classify test items using the revised Bloom's Taxonomy?

Classification Made by Pre-Service Teachers	Actual Classification in Bloom's Taxonomy					
	R	U	Ap	An	E	C
R	13	2	1		2	
U	1	12	2	1	3	1
Ap	5	5	14	2	4	
An	1	1	1	13	3	7
E			3	1	8	7
C				4	2	4
Total	20	20	21	21	20	19

R – Remembering; U – Understanding; Ap – Applying; An – Analyzing; E – Evaluating; C - Creating

Out of 121 test items, only 53% were correctly classified according to Bllom's Taxonomy. The application and analysis categories both received the highest percentage of correct classifications (65%) followed by remembering skills (60%). Test items under creating skills had the lowest percentage (35%). These three levels had the highest percentage of correct classification under HOT.

4. Discussion:

In the analysis of test items created, it is noticeable that common HOT items were those that will require students to construct and/or criticize proofs given some conditions of the problems, without really establishing their familiarity with the problem. Another is that teachers were likely to categorize as HOT those items that will require students to solve complex procedures where in fact, the procedure has been taught to the students before but is not implied on the problem the solution to be used. Some teachers had interpreted evaluating items as "finding the value of" where in fact; test items within this category must be considered application items. Several pre-service teachers commented that although the test items were familiar to the students, there is still a need to analyze the problems, identify and combine theorems and postulates and their relations to the condition stated in order to arrive at the conclusion. Hence, despite the pre-service teachers' familiarity with the Bloom's Taxonomy, this did not help much in the construction of the test items that are appropriate to their classifications of thinking skills.

5. Conclusions:

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

- ✓ In teaching for HOT in Mathematics, pre-service teachers disregarded the concept of familiarity of the student to the situation presented to them. What they thought of was that LOT items were easier to answer and/or solve than HOT items.
- ✓ Pre-service teachers' classification of thinking skills indicated that all of them correctly classified remembering as to LOT; analyzing and creating as to HOT. Some teachers committed errors in classifying understanding and evaluating items as to LOT or HOT. Hence, even if the sequence of the thinking skills in BT is very obvious to the pre-service teachers, some of them misclassified some thinking skills as to LOT or HOT and these misclassifications were brought into teaching for HOT in Mathematics.
- ✓ Most of the pre-service teachers found it difficult to construct test items that fit in the thinking skill described in Bloom's Taxonomy, especially those at the evaluating and creating levels. Teachers also overestimate those "complex problems" and regarded them as HOT where in fact, they are considered as LOT. Also, they tend to underestimate those LOT items which require student to recall theorems and concepts without anticipating that the problems need to be analyzed in order to come up with such theorems.

6. Recommendations:

Based on the conclusions derived, the following are hereby recommended:

- ✓ Use this study in order to attend to the needs of the pre-service teachers in improving their professional preparation and teaching practices. They may use the concepts presented in the texts as they may want to teach for HOT. Others may improve their instructional materials, lesson plans and techniques of test construction, conforming to the teaching for higher-order thinking.
- ✓ The findings of the study may be used as a basis for planning pre-service training on test construction and evaluation of educational outcomes. Teachers may seek improvement, study and learn more and strive for greater competency in test construction and in teaching Mathematics.
- ✓ Use this study as a take-off point in the conduct of another study considering College Instructors as the respondents since the tertiary level really requires the use of higher-order thinking, especially those courses like engineering, accounting, and the likes.

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