

Mathematics Content Knowledge of Pre-service Elementary Teachers

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Abstract — This study determined the level of mathematics content knowledge of the 172 pre-service elementary teachers in higher education institutions in Sorsogon. The 40-item researcher made test in an open-ended form was used in this descriptive analysis method of research. The test result was analyzed and interpreted using frequency count, mean and percentage to determine the performance level and difficulties of pre-service elementary teachers along numbers and number sense, measurement, patterns and algebra, geometry, and probability and statistics content areas of mathematics. Content analysis of incorrect responses was done to find out the reasons why pre-service teachers meet difficulty in the identified areas of mathematics. It revealed that most of the pre-service teachers met difficulties due to limited skills in translating mathematical statements into mathematical equations, confusion in the use of inverses and the rules of operations of integers, poor reading comprehension that results to incorrect application of formula, and unmastered skills in unit conversion. Trial and error method and guessing are applied in solving problems due to lack of mastery of the basic mathematical concepts. The Mathematics Training Course for Pre-service Elementary Teachers (MTC4PET) is proposed to address the identified difficulties along five content areas of mathematics.

Keywords — *Mathematics content knowledge, mathematics difficulties, Pre-service elementary teachers, higher education institutions*

I. Introduction

Content Knowledge is one of the most important tools in the teaching profession. Teachers as front liners must be equipped with content knowledge in the field of specialization. Being a chain of reform, pre-service elementary teachers must have a strong and solid foundation of knowledge. Teachers of elementary pupils need to understand the big ideas which are involved in mathematics they are expected to teach. This understanding leads to a major paradigm shift in what mathematics teachers teach in their classrooms and the manner in which they enable students to learn (Cluck 2006). Hence this may be started at elementary mathematics pre-service teachers who take general mathematics courses. As future teachers they must have enough content knowledge in all subjects, since they will be the source of fundamental knowledge of the students. It should be in accordance with the Commission on Higher Education Memorandum Order (CMO) No. 30 S. of 2004, Article 1, Section 1, which states:

The Revised Policy and Standard for Undergraduate Teacher Education Curriculum” states that all efforts to improve the quality of education in the Philippines are dependent on the service of the teachers who are properly prepared to undertake the various important roles and functions

of teachers. As such, it is of utmost importance that the highest standards are set in defining the objectives, components, and processes of the pre-service teachers' education curriculum.

Under section 15 of the BEED content courses there should be 57 units of the content courses that correspond to the various learning areas in the elementary curriculum. Mathematics is only 12 units and composed only of four subjects; the general mathematics, advance algebra, probability and statistics and pre-calculus which should be taken up during first year college. It shows that there are limited content areas taken up in mathematics during college compared to the content areas of the present K-12 spiral curriculum.

There are five content areas of mathematics under the K to 12 curriculum, as adopted from the framework prepared by Mathematics Teachers Educators (MATHTED 2010); these are the numbers and number sense, measurement, geometry, patterns and algebra, and probability and statistics. To teach all students according to today's standards, teachers indeed need to understand the subject matter deeply so they can help students map their own ideas, relate one idea to another, and re-direct their thinking to create powerful learning. Teachers also need to see how ideas connect across fields and to everyday life.

According to Philippine Council of MATHED, the Framework for Philippine Mathematics Teacher Education contains resources that could guide higher education institutions, professional organizations of mathematics teachers and school administrators in assessing and improving the performance and career development of mathematics teachers based on a set of standards. The qualities of effective mathematics teachers in terms of what they should know (content knowledge), what they are expected to do to achieve quality learning outcomes (pedagogical knowledge) and what they should possess to be able to manage the different aspects of the teaching and learning process (management skills) upon which the indicators are based are also included. All these are anchored on the objective of raising the quality of mathematics education.

Ornstein (1992) states that a number of educators maintain the undergraduate teachers' preparation are the gate-keeping process for the teaching professions. Prospective teachers must be able to demonstrate a specified level of competence by the end of the pre-service stage in order to be allowed entry into the profession. Lardizabal (1995) expressed that being effective and efficient teachers, they must have the knowledge of subject matter. This means that teachers must be totally equipped with the needed content knowledge to enable them to share and impart the target competencies to the learners.

Brown, Cooney & Jones (1990) also mention that pre-service elementary teachers do not possess the level of mathematical understanding necessary to teach elementary school mathematics as recommended in various proclamations from professional organizations such as National Council of Teachers of Mathematics (NCTM)"

There are five content areas of mathematics in the present spiral curriculum, these are numbers and number sense, measurement, geometry, patterns and algebra and probability and

statistics under K to 12 programs (2013). Algebra is an important part of school mathematics but is challenging for students to learn (Blume & Heckman, 1997; NCTM, 2000).

Cunningham and Roberts (2010) mentioned that careful attention to challenging geometry concepts is needed so that pre-service teachers will be able to provide their students with improved conceptual understanding. Begg and Edward (1999) cite that only about two-thirds of the in-service and pre-service primary school teachers understood equally likely events and very few understood the concept of independence in statistics. Content area teaching experts similarly seek the best knowledge on how to prepare teachers of adolescents to meet the demands unique to their specialization.

Huang (2016) also cites that content knowledge is crucially important to the improvement of teaching and learning. With these premises teacher's content knowledge makes a difference in their instructional practice and their students' achievement.

Many government-initiated school reform programs in the United States focus substantially on the professional learning of teachers (Hassel, 1999). Similarly, Pasley (2002) posits the idea that deeper knowledge will help teachers guide student learning; thus he states that professional development engage teachers with content that is more sophisticated than the level they will be teaching. Relative to this, Solis (2005) also asserts that professional development and teacher preparation research also support the importance of teaching quality and further identify content specific pedagogy as a key ingredient in quality teaching.

These literatures find relevance to the present study since they all focus on the professional development of teachers. These are significant to the present study in providing the idea that future teachers need to develop certain skills, concepts and knowledge needed in the teaching profession in order to attain quality education.

The comparative study of Matthews, Rech, and Grandgenett (2010) on mathematical deficiencies of pre-service elementary teachers revealed that many teacher preparations require mathematical content courses specifically focusing on mathematics taught in the elementary level. The study considered the impact of two courses focusing on arithmetic and the other focusing on geometry and measurement. There is a comparison between pre-service elementary teachers who took only more general mathematics courses such as college algebra. Result indicates that those pre-service teachers who took the specialized course had significantly higher mathematical content knowledge compared to those pre-service elementary teachers who took general mathematics.

The aforementioned studies found relevant to the present study and have some degree of similarity since they dealt both content knowledge and the difficulties of pre-service teachers. The present study dealt the five content areas which are included in the K-12 spiral curriculum.

Purposes of the Research

The main purpose of this study determine the level of mathematics content knowledge of pre-service elementary teachers in mathematics along the five content areas numbers and number sense, measurement, geometry, patterns and algebra, probability and statistics. Determine the difficulties of pre-service elementary teachers along five content areas and find the reasons why they met the difficulties.

II. Methodology**Research Design**

The study used the descriptive-analysis research design, the raw data are rearranged, ordered, and organized to generate descriptive information that will be easy to understand and interpret.

Frequency count, percentage and mean were utilized as statistical tools. The researcher-made test was used as an instrument in gathering data from the respondents who were chosen conveniently. The respondents were the pre-service elementary teachers in the different Higher Education Institutions (HEIs) in Sorsogon.

Participants

The samples are the 172 pre-service elementary teachers from six HEIs in Sorsogon. The samples were taken from a population of 303 pre-service elementary teachers. Slovin's formula was used in determining the sample size with 0.05 margin of error. The samples were chosen conveniently because they were the only present during the conduct of test, since they undergone pre-service teaching already.

There are nine pre-service elementary teachers from Annunciation College of Bacon as respondents of the study, 20 from Aemillianum College Institute, 30 from Bicol University Gubat Campus, 18 from St. Louise Technological Foundation of Pilar INC., 40 from The Lewis College of Sorsogon and 55 pre-service teachers from Veritas College of Irosin.

The Instrument

The research instrument used in this study was the researcher-made test. This test was given with an open-ended form in order to find out the difficulty of pre-service elementary teachers along the five content areas of mathematics. These include eight items in every content area from numbers and number sense, measurement, geometry, patterns and probability and statistics, with a total of 40 items. The Table of Specification was based on the K-12 curriculum and National Competency-based Teacher Standards (NCBTS) which was critiqued by the panel of evaluators prior to the conduct of dry-run on January 27, 2017.

To validate the researcher-made test a dry-run conducted to sample respondents in 22 pre-service elementary teachers in Sorsogon State College main campus to improve its quality. Test

questions were analyzed in order to come up with a reliable question. The easiest and most difficult questions were discarded and other were improved. The test questions were finalized and reduce to 40 items out of the original 60 items which is good for one hour.

Data Collection Procedures

To facilitate the conduct of the study, permission was secured from the deans of the HEIs where the study was conducted to ensure the full cooperation of the respondents as well as the faculty members. Having been granted the permission, the researcher personally administered the test on March 11, 2017. The final conduct of the test was on March 25, 2017.

Test papers were retrieved on the same day of the assessment. Respondents were not allow the use of calculators in order to determine the level of mathematics content knowledge of pre-service teacher in mathematics.

Procedures

The data gathered were analyzed and tabulated using statistical measures like frequency count, mean and Percentage. Item analysis was done in every competency along five content areas.

Frequency count was used to find the number of respondents' correct answers, unanswered and incorrect answers. Percentage was used to find the respondents' correct answer and difficulties while mean was used in finding the average level of content knowledge of the respondents which was transmuted using the guidelines in Dep.Ed Order no.8 s. 2015. The scale below was utilized to interpret the level of content knowledge. It is adapted from the policy guidelines in the implementation of K to 12 Basic Education Curriculum (DepEd Order number 8, series of 2015).

III. Results and Discussion

The data were consecutively arranged as follows: (1) the level of mathematics content knowledge of pre-service elementary teacher in the province of Sorsogon along five content areas, namely, numbers and number sense, measurement, geometry, patterns and algebra, and probability and statistics (2) the difficulties along the five content areas in mathematics, (3) the reasons why the respondents met the difficulties, and (4) a proposed Mathematics Training Course for Pre-service elementary teachers (MTC for PET) as the result of the study.

Table 2.a presents the level of mathematics content knowledge of pre-service elementary teachers along numbers and number sense. The table shows the over-all level of content knowledge of 77 percent is fairly satisfactory.

TABLE 2.a
Level of Mathematics Content Knowledge of Pre-Service Elementary Teachers in Numbers and Number Sense

Topics	PL	Description
Properties of operation	74	Did not meet the expectation
Operation with whole nos. fractions, decimals, ratio & proportion and Integers	77	Fairly Satisfactory
Principal, Interest rate and base	82	Satisfactory
Divisibility Rule	75	Fairly Satisfactory
LCM and GCF	78	Fairly Satisfactory
Mean	77	Fairly Satisfactory

This revealed that pre-service elementary teachers in the HEIs in the province of Sorsogon do not have an acceptable level of content knowledge along numbers and number sense. This result can be greatly attributed to the respondents' difficulty in properties and operation.

Table 2.b presents the level of mathematics content knowledge of pre-service elementary teachers in measurement. The over-all content knowledge is 77 percent categorized as fairly satisfactory.

TABLE 2.b
Level of Mathematics Content Knowledge of Pre-service Elementary Teachers in Measurement

Topics	PL	Description
Conversion	73	Did not meet the expectation
Volume	80	Satisfactory
Perimeter	77	Fairly Satisfactory
Weight	73	Did not meet the expectation
Distance	73	Did not meet the expectation
Area	74	Did not meet the expectation
Mean	75	Fairly Satisfactory

The result may affirm that the respondents have difficulty along measurement under the competencies of conversion, weight, distance and area. This also signifies that pre-service elementary teacher do not have sufficient knowledge in measurement.

Table 2.c presents the level of mathematics content knowledge of pre-service elementary teacher in Geometry. The content knowledge of pre-service teachers which is 73 percent shows that they did not meet the expectation level. The competencies on Polygon, circle and solid figures problem involving angle, triangle congruence and inequalities, are all described as *did not meet the expectation* having PL ranging from 72 to 73 percent.

TABLE 2.c

Level of Mathematics Content Knowledge of Pre-service Elementary Teachers in Geometry

Topics	PL	Description
Polygon	72	Did not meet the expectation
Circles and solid figures	73	Did not meet the expectation
Angles	73	Did not meet the expectation
Triangles(congruence, inequalities & similarity)	72	Did not meet the expectation
Mean	73	Did not meet the expectation

The result may be ascribed to the respondents' difficulty in all the topics in Geometry. This implies that pre-service elementary teachers' performance level in geometry is very low since they did not meet the acceptable performance level in geometry. There is a necessity to deepen the knowledge in geometry to attain at least satisfactory level.

Table 2.d presents the level of mathematics content knowledge of pre-service elementary teacher in patterns and algebra. The over-all result is 73 percent *did not meet the expectation*. Their content knowledge under the competency of sequence and series 73 percent, in polynomial equations and inequalities 72 percent were all described as did not meet the expectation. However they have satisfactory PL in algebraic expressions.

TABLE 2.d
Level of Mathematics Content Knowledge of Pre-service Teachers in Patterns and Algebra

Topics	PL	Description
Sequence and Series	73	Did not meet the expectation
Polynomial Equations (linear, Quadratic, others)	72	Did not meet the expectation
Inequalities (Linear, Quadratic, others)	72	Did not meet the expectation
Algebraic Expressions	80	Satisfactory
Mean	74	Did not meet the expectation

The effect may be attributed to the difficulty in patterns and algebra along the competencies of sequence and series, polynomial equation and inequalities. In the problem involving algebraic expressions, although they are satisfactory, still some of them have difficulty in this competency.

Table 2.e presents the level of content knowledge of pre-service elementary teachers in probability and statistics. The average level of content knowledge of pre-service elementary teachers is 74 percent *did not meet the expectation*.

TABLE 2.e
Level of Content Knowledge of Pre-service Elementary Teachers in Probability and Statistics

Topics	PL	Description
Measure of Central Tendency	80	Satisfactory
Measures of Position	74	Did not meet the expectation
Measure of Dispersion	71	Did not meet the expectation
Counting Techniques	73	Did not meet the expectation
Probability of the event	74	Did not meet the expectation
Mean	74	Did not meet the expectation

This implies that in measure of central tendency, respondents had previous knowledge about the topic while the succeeding topics attributed to the difficulty in probability and statistics. Findings revealed that the pre-service elementary teachers lack content knowledge in probability and statistics.

2. Difficulties of Pre-service Elementary Teachers along Five Content Areas of Mathematics.

Along numbers and number sense, the pre-service elementary teachers had difficulties in properties of operation 73 percent where 110 did not attempt to answer and 37 had incorrect solutions. Along measurement, pre-service elementary teachers had difficulty on the problems involving conversions 72 percent, 120 of the respondents did not try to solve the problem in which 48 has incorrect answer. Topic involves weight 73 percent wherein 112 had no answer while had 41 incorrect answer. Problem involving area 73 percent, 105 of the respondents had no answer while 53 had wrong answers.

In geometry, the respondents had difficulty on problem involving polygon 72 percent, 140 had no answer and 31 had wrong solution, circles and solid figures 73 percent, 137 had no answer and 33 with wrong solution. In angles 73 percent, 150 had no answer and 14 with incorrect solution and triangle congruence 72 percent, 156 had no answer, 14 had wrong solution. In patterns and algebra the respondents find difficulty in sequence and series with 165 having no answer, five had wrong solutions, polynomial equation 147 had no answer, 21 had wrong answers, and polynomial inequalities, 155 had no answer 15 with wrong solutions. Along probability and statistics the respondents' encountered difficulty in measure of central tendency 74 percent 115 had no answer and 14 had wrong solution. In measure of position 71 percent 145 had no answer and 23 had wrong solutions and measure dispersion 71 percent 132 no answer and 36 has wrong solution. In counting techniques 73 percent 133 had no answer and 22 had wrong solution and probability of the events 73 percent 132 had no answer and 17 had wrong solution.

3. The Reasons Why the Pre-service Elementary Teachers Meet the Difficulty

Findings reveal that there are a number of difficulties encountered by the respondents in answering the test questions based on the analysis of the respondents' answer.

In summary, the reasons why pre-service elementary teachers met the difficulty are due to the lack of knowledge in transforming mathematics statements into equations. Respondents have not easily recalled the operation of signed numbers or operation on integers. They also found difficulty in conversion due to lack of mastery in converting one unit to another; they forgot the rules in solving inequalities and quadratic equations, and lack knowledge in factoring. They also found difficulty in extracting the roots of quadratic equation. Respondents applied the trial and error method or guessing in answering the test questions due to lack of mastery of the basic concepts.

This implies that pre-service elementary teachers need to enhance their understanding in different content areas of mathematics for them to be able to master the basic concepts, develop the skills and have a deeper understanding of competencies. The results of this study finds support

from the study of Dio, Carretero, Caturla, Digo, and Romero (2013) that the proficiency level of pre-service teacher needs to be enhanced further in all competencies.

4. A Proposed General Mathematics Training Course for Pre-service Elementary Teachers (MTC4PET).

Based on the result of the study on content knowledge of pre-service elementary teachers in mathematics, there is a need to enhance their content knowledge in five content areas of mathematics and deepen their knowledge in all competencies. This Mathematics Training Course for Pre-service Elementary Teachers (MTC4PET) hopes to address the difficulties of pre-service elementary teachers and this may insure its alignment of the objectives to the present K to 12 curriculum.

REFERENCES

A. BOOKS

- [1] Amid, D.M. 2005. Fundamental of statistics. Quezon City: Lopimar Publishing Inc.
- [2] Lardizabal, A.G. 1995. Principles and methods of teaching Third Edition. 927 Phoenix Publishing House Inc. Quezon Avenue, Quezon City
- [3] Ornstein, A.C. 1992. Strategies for effective teaching Harper Publishing Inc, Philippines.
- [4] Pascua, L.B. 1997. Mathematics IV Textbook for Fourth Year High School. Developed Instructional Materials. Philippines : Book Media Press.
- [5] Pascua, L.B. 1998. Mathematics concept and operation. Third Edition. Diwa Learning System Inc. Gil Puyat Avenue, Makati City Philippines.
- [6] Patacsil, L. Q. 2006. Exploration and application in geometry. Vicarish Publication and Trading INC.
- [7] Department of Education Learners Materials for Mathematics 9.

B. PUBLISHED MATERIALS

- [8] Capate, R.A., & Lapinid, M.C. (2015). Assessing the mathematics performance of grade students as basis for enhancing instruction and aligning with the K to 12 Curriculum. DLSU Research Congress De La Salle University Manila, Philippines.
- [9] Rubin, R.J., Mortel, J., Lapinid, M. C. (2014). Activity based teaching of integers concept and its operation. DLSU Research Congress. De La Salle University Manila.

C. UNPUBLISHED MATERIALS

- [10] Despuig, M.D. 2014. Perceived problem of grade I mathematics teacher of K to 12 basic education Curriculum. Unpublished master's thesis. Sorsogon State College, Sorsogon City.
- [11] Gamazon, H. M. 2014. Effect of computer aided instruction in mathematics. Unpublished master's thesis. Sorsogon State College, Sorsogon City.
- [12] Hular, M. 1999. In service raining and their relation to teaching effectiveness of mathematics teacher. Unpublished master's thesis. Sorsogon State College. Sorsogon City

D. JOURNALS

- [14] Chesler, J. (2015) Statistical Preparation of Pre-service Secondary Mathematics Teacher. The Journal of Content Knowledge, 1 (5), 1-5.
- [15] Cunningham, R. F. and Robert, A. (2010). Reducing Mismatch of Geometry Concept Definitions and Concept Images Held by Pre-service teachers. The Journal of Content Knowledge. 1 (4) 1-2.

- [16] Dio, R.V., Romero, F.S., Caturla, J.R., Digo G.S., and Carretero, G.A. (2013). Development of Mathematics Proficiency Course (MPC) for Pre-service Teachers. ADLE Research Journal. International Research Conference. 1(2) 89-92.
- [17] Girvan, C., Conneely, and Claire T.B. (2016).
- [18] Extending Experiential Learning in Teacher Development. The Journal for Teaching and Teachers Education, 58(3), 129-139.
- [19] Isik, C. and Kar, T. (2012) The Analysis of Problem Pose by the Pre-service Teachers About Equations. Australian Journal of Teacher Education, 37(6), 92-100.
- [20] Pickreign, J. (2007) Rectangle and Rhombi: How well the pre-services Teacher know them? The Journal, 1(3), 1-7.

E. E-SOURCES

- [21] Almeda, D., Cruz E., and Dy, A. (2013). Conceptual understanding and procedural skills on fractions using manipulative materials. Retrieved at www.dlsu.edu.ph on October 24, 2017.
- [22] Ball, D.C., Thames, M.H., and Phelps, G. (2008). Content knowledge for teaching what makes special? Journal for Teacher Education Vol. 59 No. 5. <https://jtesagepub.com>.
- [23] Boggan, M., Harper, S., and Whitmire A. (2010). Using manipulative to teach K-12. Retrieved from prep.math.ttu.edu/https://cse.google.com/ on September 23, 2016.
- [24] Blume and Heckman (1997); NCTM (2000); MAP (2008). Teacher knowledge of algebra for teaching. Retrieved from <https://www.eric.ed.gov> on June 12, 2017.
- [25] Chesler, J. (2015) Reading the News: The Statistical -reparation of pre-service secondary mathematics teachers. Retrieved at <https://www.K-12prep.ath.ttu.edu/> on September 23, 2016.
- [26] Cluck, K. Guided textbook Solution. Retrieved at <https://www.chegg.com/homework> on October 30, 2016.
- [27] Egodawatte, G. (2011). Secondary school students' misconceptions in algebra. Retrieved at <https://tspace.library.utoronto> on October 15, 2016.
- [28] Guimaraes, R., Sitaram, A., Jardon, L., Taguchi, S., (2013). The Effect of Teacher Content knowledge on student achievement: A Quantitative Case Analysis of Six Brazilian States. Retrieved at <https://www.edu.on> on September 30, 2016.
- [29] Hill, H., Rowan, B., and Ball, D. (2006) Effects of teachers' mathematical knowledge for teaching student achievement. Retrieved from https://www._Rowan_Ball_pdf on June 12, 2017.
- [30] Huang, H.M.E. (2005). Investigating of teachers' mathematical conceptions and pedagogical content knowledge in mathematics. Department of Elementary Education, Taipei Municipal Teachers College, Taiwan. Retrieved at www.mat_con. On October 21, 2016.
- [31] Huang, W. (2016). Standard content knowledge. Retrieved at <https://www.google.com> on October 21, 2016.
- [32] Knapp, A. (2007). Basic algebra and advanced algebra. Retrieved at www.Springer.com/gp on November 25, 2016.
- [33] Matthews, M., Rech, J., and Grandgenett, N. (2010). The Impact of content courses on pre-service elementary teachers' Mathematical Content Knowledge. Retrieved at <http://www.K-12prep./Math.ttu.edu> on November 03, 2017.
- [34] Lee, S. (1986). Research paper topics pedagogical content knowledge studies on teacher. Retrieved at <http://www.enotes.com> on September 25, 2016.
- [35] Olanoff, D., Lo, J., and Tobias, J. (2014). Mathematical content knowledge for teaching elementary mathematics: A Focus on Fraction. Retrieved November 05, 2017. <http://scholarworks.umt.edu/tme>.

- [36] Pasley, J. (2004) Mathematics and science. Retrieved at <http://www.horizon.research.com> on November 30, 2017.
- [37] Solis, A. Pedagogical content knowledge. Retrieved at <http://www.IDRA> Newsletter on October 30, 2016.
- [38] Southwell, B. and Penglase M. (2005). Mathematical knowledge of pre-service mathematics teachers. Retrieved at <http://www.emis.de/> on November 20, 2016.
- [39] Strawhecker, J. (2004). Preparing Elementary teachers to teach mathematics.
- [40] Stylianides, A., Stylianides, G. (2006) Content knowledge for mathematics teaching of the case of reasoning and proving. Retrieved at <http://www.google.com> on June 10, 2017.
- [41] Tutak, F. and Adams, T. (2015) A study of geometry content knowledge of elementary pre-service teachers. Retrieved at <https://www.google.com> on September 13, 2017.
- [42] Walshaw, M., Anthony, G. (2007). Effective Pedagogy in Academy of Education International Bureau of Education. Educational Practices Series–19 Retrieved at <https://www.google.com.ph/> on October 5, 2016.
- [43] Zikmund, W. (2003) Research method, descriptive analysis Retrieved at [www. LRMO2](http://www.LRMO2). on September 13, 2017.
- [44] Commission on Higher Education Order No. 30-series of 2004. Retrieved at <https://www.CMO2004/> on June 17, 2017.
- [45] Department of Education 2016. K to 10 curriculum guide. Retrieved at <https://www.google.com>. 2016 on November 25, 2016.
- [46] Philippine Council of Mathematics Teacher Educators (MATHTED), Inc., Mathematics Department, Ateneo de Manila University, Katipunan Avenue Loyola Heights, Quezon City 1108 Philippines Retrieved at <http://MATHEDphil.com> on September 25, 2016.
- [47] The Glossary of education Reform (2016). Content Knowledge Definition. Retrieved at <http://www.edglossary.org> on September 20, 2017.
- [48] Trends for Mathematics and Science Study (TIMMS) 2015. Retrieved at <http://nces.ed.gov/TIMSS>. March 15, 2017.