RESEARCH ARTICLE

DEVELOPMENT OF MICRO-SCALE MATHEMATICS KITS

Erminda C. Fortes
Olive Buzon, Aurora Gonzales, Antonio Ferrer, Rosemarivic Diaz, Robert Diaz, Myla Esperanza, Blesilda Infante, Wilmer Marquez, Gladys Nivera, Reymond Quan, & Allan Reyes

Abstract

The use of manipulative devices in classrooms has been studied for years, and results have yielded a better understanding of mathematics concepts and principles. However, despite positive results regarding teaching mathematics with manipulative devices, many mathematics teachers still hesitate to use them in teaching, primarily because they do not know how to, and when to use them. This drove the researchers to design and construct thirty prototype manipulative devices and write accompanying lesson plans that would guide Kindergarten to Grade 10 teachers when using them in mathematics classes. Both these instructional support systems received "outstanding" evaluations for their content/face validity. Having established the content/face validity of the manipulative devices in each MATHEMATICS KIT, cum accompanying lesson plans, it seemed that: (1) the former devices may be used to develop different concepts in Kindergarten to Grade 10 Mathematics, and (2) the latter to guide mathematics teachers in using the manipulative devices in classrooms.

Keywords: *manipulative devices, micro-scale mathematics kits*

INTRODUCTION

Learners often struggle to grasp the abstract mathematics concepts taught in elementary and high school. During this period, learners are still developing the psychological ability to think abstractly, even if they are expected to demonstrate mastery of academic goals and objectives that require critical thinking. According to Sharma (1997), learners tend to easily forget their lessons when they are taught only at the abstract level, and they become frustrated because mastery is never fully attained. Experiences of frustration or failure create an aversion towards mathematics among learners. This is where students' difficulty in learning mathematics begins.

Research suggests that learners' negative experiences in mathematics may be avoided by allowing them to use concrete, tangible objects, known as "manipulative devices" to apply abstract concepts to real-life situations. Seefeldt and Wasik (2006) advocated that learning opportunities in mathematics require that: (1) children have firsthand experiences related to mathematics, (2) they interact with other children and adults concerning these experiences, and (3) they have time to reflect on their experiences. Educational research indicated that the most valuable learning opportunities occur when students actively construct their own mathematics understanding, which is often accomplished through the use of manipulative devices (Boggan, Harper, & Whitmire, n.d.).

Manipulative devices, as defined by Smith (2009), are physical objects used as teaching tools to engage learners in the hands-on learning of mathematics. For example, when figuring out the number of candies left, if a pupil has 15 candies, then gives 2 to one friend, and 5 to another, may be difficult for children. However, once the pupil holds counters that he can pretend are candies, he can then act out the problem concretely and arrive at an understanding of the mathematics concept. Similarly, as Fortes (1992) noted, students in Algebra would be able to concretize the square of a binomial $(a + b)^2$ if they were exposed to algebra tiles in order to discover the formula by themselves based on their knowledge of areas of plane figures that they learned in Geometry during previous years. Eventually, in most cases, the learners will no longer need the manipulative devices because the concepts will have been internalized once understanding is achieved.

This idea was substantiated by Sharma (1997), who stressed that manipulative devices will teach concrete understanding of the abstract mathematics process. This is especially useful when a learner may not understand the concept behind the skill. By using manipulative devices to model and represent abstract ideas, the stage is set for learners to understand the abstractions they represent (Spikell, 1993).

The use of manipulative devices in the classroom has been studied for years. Post (1981) pointed out that the major theoretical rationale for such research on the use of manipulative materials in a laboratory-type setting has been attributed to the works of Piaget, Bruner, and Dienes. Each proponent represents the cognitive viewpoint of learning wherein learning is an active process in which learners attempt to make sense of what they study. Research from both learning theory and classroom studies on manipulative devices confirm that using them to help teach mathematics can positively affect student learning.

However, despite positive reports of teaching mathematics with manipulative devices, many mathematics teachers are still reluctant to use them in teaching, partly because such publicly available devices are usually expensive. Likewise, many teachers feel as though they do not know how to, and when to, use manipulative devices and therefore, hesitate to use them in the classroom. As Kelly (2006) stated, teachers need to know when, why, and how to use manipulative devices effectively in the classroom. Teachers also need opportunities to observe, first-hand, situations of, and the impact of learning through exploration with concrete objects.

In light of the foregoing, the researchers conceptualized the development of three (3) different Mathematics Kits for use by pre-service and in-service teachers of K – Grade 3, Grades 4 – 6 and Grades 7 – 10. Each Mathematics Kit contains a set of manipulative devices for use in teaching various levels and a manual describing each device, its pedagogical use, accompanied by a set of lesson plans with worksheets/activity sheets to guide teachers on their use for teaching certain mathematics concepts. Hopefully, the developed Mathematics Kits will encourage mathematics teachers to use manipulative devices and be more learner-centered in their approach to teaching mathematics. Equally, these learning tools may encourage learners to be more actively engaged in their learning of mathematics, give them a better understanding of mathematics concepts, and lead to higher academic achievements.

The micro-scale manipulative devices that the researchers constructed are founded on the cognitive view of learning, as discussed earlier, while the lesson plans developed are anchored on the Constructivist Learning Theory. The principle of constructivism allows learners to play an active role in the discovery of new information. Rakes, Flowers, Casey, and Santana (1999) determined that constructivism creates a sense of ownership within the learner because learning occurs from hands-on experience and exploration; rather than by being given new information by someone else. Thus, according to Brooks and Brooks (1999), a constructivist teacher should see how children/students are learning and not what the students are recalling.

The paradigm in Figure 1 illustrates how the previously-mentioned principles guided the researchers in developing the Mathematics Kits.

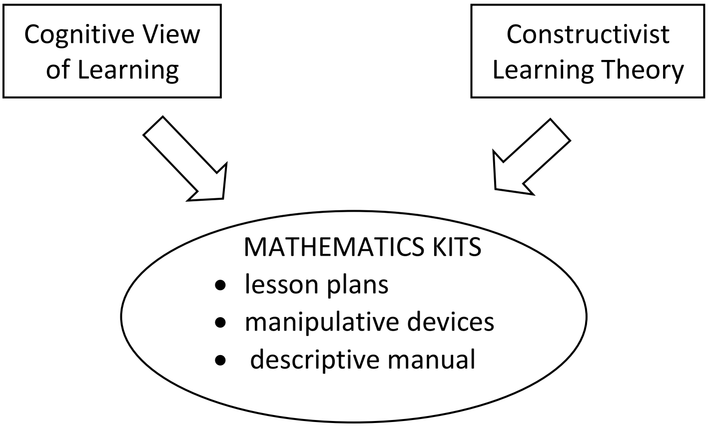


Figure 1. Conceptual paradigm of the study.

STATEMENT OF PURPOSE

This project aims to develop and validate micro-scale mathematics kits for pupils/students, and pre-service and in-service teachers.

Specifically, it seeks to: (1) design and write manuals and exemplar lesson plans for 3 different micro-scale MATHEMATICS KITS for K-Grade 3, Grades 4-6 and Grades 7-10 based on the needs of the teachers and learners of each group; (2) produce prototype manipulative devices for three MATHEMATICS KITS; and (3) establish the content and face validity of the manipulative devices and lesson plans in each MATHEMATICS KIT.

METHODOLOGY

Research Procedure

Making use of the descriptive developmental design, the research project describes and explains in detail the procedural developmental stages of the instructional material as follows:

Stage 1 – Designing and constructing the manipulative devices

The researchers interviewed Mathematics teachers and students on the topics they found very difficult to teach or learn. This needs analysis was used to identify topics/content for inclusion in the Mathematics Kits. The researchers also conducted a meta-analysis of books, journals, other references, and online resources in order to conceptualize the manipulative devices for development. After conceptualizing the different manipulative devices, proto-types were designed and constructed based on the findings of the analysis.

Stage 2 – Designing and writing the lesson plans

As Kelly (2006) pointed out, teachers need to know when, why, and how to use manipulative devices effectively in the classroom. To this end, thirty (30) lesson plans were written to provide teachers with a clear flow of the lessons and to guide them on how to use the developed teaching materials in class. They utilized the Constructivist Learning Theory for each lesson plan composed of the following parts: (1) topic and suggested references, (2) materials, (3) strategies, (4) procedures, and (5) evaluation. The researchers ensured that the objectives for each lesson conformed to the competencies in the K-12 Mathematics Curriculum. Strategies were carefully chosen to ensure that the problem solving and critical thinking skills of students would be enhanced, as this was the main goal of the aforesaid curriculum. With carefully designed motivation, each lesson sought to capture the students' attention when the teacher started the discussion. In presenting the lesson, the teacher's activities were presented in detailed form. Activity sheets and worksheets were provided and guide questions written. The researchers ensured that the activities would give students an avenue to construct their own understanding of the concepts presented to reinforce Post's (1981) contention that children be allowed to develop their concepts in a global intuitive manner emanating from their own experiences. These experiences, when carefully selected by the teacher, formed the cornerstone upon which all mathematics learning is based. At some future time, attention will be directed toward the analysis of what has been constructed; however, Post pointed out that it is impossible to analyze what is not yet there in some concrete form.

To synthesize the lesson, activities for the summary/generalization were also written. Guide questions were formulated for the teachers to help the students to recall the major points in the lesson and allow them to highlight those main points. As Jack and Lockhart (1994) stressed, to teach effectively is to teach reflectively. By giving students time to reflect and process what transpired in the discussion, teaching becomes more effective and meaningful to students.

Stage 3- Evaluating the Manipulative Devices and Lesson Plans

Upon completion of the manipulative devices and the accompanying lesson plans, at least five experts from different public and private pre-schools, elementary schools, and high schools were gathered to evaluate the materials. The researchers presented the manipulative devices by doing a micro-teaching with the experts posing as learners.

During the micro-teaching, the experts who served as learners were given the lesson plans and asked to evaluate them based on the following criteria: (1) learning objectives, (2) learning activities, (3) concluding activity, and (4) assessment. The experts were also asked to rate the manipulative devices after the micro-teaching. Later on, their responses were summarized and interpreted.

The manipulative devices were improved and lesson plans revised, based on the experts' comments and suggestions.

Instruments and Statistical Tests Used

Two instruments were used in the research project – one was the checklist for the lesson plans, and the other one for the manipulative devices.

The checklist for the lesson plans included the following criteria: (1) learning objectives (measureable, attainable, appropriateness to the intended learner and clarity of the statements on the use of the device), (2) learning activities (alignment with the objectives, feasibility to complete within allotted time, development of the lesson, and encouraging students to be creative and think critically), (3) concluding activity (alignment with the objective and providing opportunity for integration of concepts learned), and (4) assessment (providing evidence for integration of concepts learned). These criteria followed the format of the developed lesson plan.

By contrast, the checklist for the manipulative devices had the following criteria: (1) usefulness of the device, (2) appropriateness of the device to the intended user, and (3) design and materials used in making the device (size, color, kind of material used, and durability).

Both instruments were first adapted and slightly modified by the coordinators and project leader, then by experts to validate and give feedback on the lesson plans and manipulative devices.

Responses were based on the Likert's scale, as follows:

5 – Excellent
4 – Very satisfactory
3 – Satisfactory
2 – Fair
1 – Needs improvement

The mean ratings obtained were interpreted as follows:

Table 1. Mean Ratings and their Interpretation.

Mean Rating	Interpretation
4.51 – 5.00	Outstanding
3.51 – 4.50	Very Satisfactory
2.51 – 3.50	Satisfactory
1.51 – 2.50	Fair
1.00 – 1.50	Needs Improvement

The descriptive rating was adapted from the rating scale used by Abante (2006) in his study. The researchers agreed to include the lesson plans and manipulative devices if the mean rating was within the range of 3.51 – 5.00

RESULTS AND DISCUSSION

Thirty manipulative devices, ten (10) each for Kindergarten to Grade 3, Grades 4 to 6 and Grades 7 to 10, were constructed by the researchers.

Table 2. Manipulative Devices Developed with the Corresponding Grade Level.

Name of Manipulative Device	Grade Level
For Kindergarten – Grade 3	
Pattern Blocks	Kindergarten
Tangrams	Grade 1
Division Pin Board	
Centi-strip	
Symmetry Blocks	Grade 2
Money Gram	
Multibers	Grade 3
Deci-tiles	
Square Tiles	
Wonder Spinner	

For Grades 4 - 6	
Fraction Kit	Grade 4
Peg Board	
Square-rec Tiles	
Unit Cubes	
Fraction Discs	Grade 5
Circle Pie	
Congruent Blocks	
EQ Board	
Pos Neg Counters	Grade 6
In-line con Uni-tiles	
For Grades 7 - 10	
Spatial Nets	Grade 7
Binomial Cube	
Quadri Tangrams	
SIAP	
Cy-Sphe-Con	
An-Pade	
Pythagorean Tiles	Grade 8
Par-su-se	
Trig Trainer	Grade 9
Angle-Arc Device	Grade 10

DESCRIPTION:

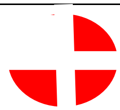
A basic set of fraction discs is a manipulative device made up of 1 whole circle, 2 halves, 3 thirds, 4 fourths, 6 sixths, and 8 eighths. Each fraction comes in different colors. The set may be expanded to include 9 ninths, 10 tenths and 12 twelfths.

Figure 2. Fraction Discs

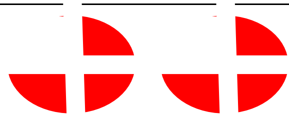
The following discussion focuses on an example of a manipulative designed and constructed. The manipulative illustrated in Figure 2 is a set of fraction discs with its description and pedagogical uses. The cited device was included in the Mathematics Kit for Grades 4 - 7.

B. *Lesson Proper*

1. *Ask the pupils to place the fraction discs and whole-part on their desk.*
2. *Each pack of ready-to bake cookie mix needs $\frac{3}{4}$ cup of butter. Show $\frac{3}{4}$ on the chart using fraction discs.*

Whole-Part Chart	
WHOLE	***PART***
	

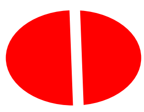
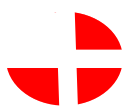
3. *Since I would be using 2 packs of the ready-to-bake cookie mix, how many $\frac{3}{4}$s cup of butter do I need? Show them on the whole-part chart.*

Whole-Part Chart	
WHOLE	***PART***
	

This can be written as $\frac{3}{4} + \frac{3}{4}$.

Since repeated addition is multiplication, then we write $\frac{3}{4} + \frac{3}{4} = 2 \times \frac{3}{4}$.

4. *To find out the product of 2 and $\frac{3}{4}$ (or the sum of two $\frac{3}{4}$s), form wholes using the fraction discs on the whole part chart. What mixed number do you get?*

Whole-Part Chart	
WHOLE	***PART***
	

As seen in the example above, the manipulative device is described and its pedagogical uses are enumerated to guide the teachers, as pointed out by Kelly (2006), as to when, and how, to use such devices effectively in the classroom. For this reason, the researchers wrote thirty (30) lesson plans, with their content validated by experts.

Presented below is a portion of the lesson plan that accompanies the fraction discs discussed earlier.

Notably, the lesson proper discusses the details on how the manipulative device "*Fraction Discs*" is used to concretize the addition of fractions, so that teachers will be guided on the use of the "*Fraction Discs*" device in a classroom. As Kelly (2006) stated, teachers need to know when, why, and how to use manipulative devices effectively in the classroom, and should be given opportunities to observe, first-hand, the impact of allowing learning through exploration with concrete objects.

Establishing the Face Validity of the Manipulative Devices and Corresponding Lesson Plans

The face validity of each of the thirty (30) manipulative devices and corresponding lesson plans were established using the mean of the experts' evaluations with the corresponding verbal interpretation. The following discussions focus on the summary of the aforecited evaluation.

Table 3 shows the results of the experts' evaluation for the manipulative devices and lesson plans for Kindergarten to Grade 3.

Table 3. Experts' Responses on the Evaluation of the Manipulative Devices and Lesson Plans for K to Grade 3.

Name of the Manipulative Device	Mean for the Device	Interpretation	Mean for the Lesson Plan	Interpretation
Pattern Blocks	4.53	Outstanding	4.75	Outstanding
Tangrams	4.73	Outstanding	4.67	Outstanding
Division Pinboard	4.60	Outstanding	4.50	Very Satisfactory
Centi-strip	4.43	Very Satisfactory	4.70	Outstanding
Symmetry Blocks	4.83	Outstanding	4.56	Outstanding
Money Gram	4.97	Outstanding	4.94	Outstanding
Multibers	4.73	Outstanding	4.64	Outstanding
Deci-tiles	4.40	Very Satisfactory	4.59	Outstanding
Square Tiles	4.57	Outstanding	4.70	Outstanding
Wonder Spinner	4.30	Very Satisfactory	4.59	Outstanding
Grand Mean	**4.61**	**Outstanding**	**4.66**	**Outstanding**

It may be gleaned from Table 3 that both manipulative devices and lesson plans were rated "Outstanding" by the experts.

Thirty percent (30%) of the manipulative devices got an average rating of above 4.50 with a verbal interpretation of "Very Satisfactory". The remaining seventy percent (70%) got a mean rating of above 4.50 with a verbal interpretation of "Outstanding". Furthermore, the Money Gram that develops the concept of money got the highest mean rating, while the Wonder Spinner that develops the concept of simple probability got the lowest mean rating. Despite this latter setback, the results seem to imply that based on the evaluation of the experts, the ten manipulative devices developed by the researchers were all acceptable.

Moreover, Table 3 showed that one (1) of the ten lesson plans written by the researchers got an average rating 4.50 with a verbal interpretation of "Very Satisfactory". In addition, the remaining nine (9) lesson plans had a mean rating of above 4.51 with a verbal interpretation of "Outstanding". Consequently, all lesson plans seemed to be acceptable to the experts. With this result, it may be inferred that the lesson plans developed may guide the K - 3 teachers to know when, why, and how to use manipulative devices effectively in the classroom (Kelly, 2006).

The detailed mean ratings show that the lesson plans' strong point was in the "Learning Objectives". All lesson plans were rated "Outstanding" in that criterion. This confirmed the fact that the researchers had ensured that the learning objectives of the lessons clearly stated the use of the device and were measurable, attainable, and within the scope of the Kindergarten to Grade 3 competencies.

Table 4 presents the results of the experts' evaluation of the manipulative devices and the corresponding lesson plans developed and written for Grades 4 to 6.

As seen in Table 4, the grand mean for the manipulative devices was 4.48 with a verbal interpretation of "Very Satisfactory". Presumably, one hundred percent (100%) of the manipulative devices were acceptable to the experts, of which 70% got a mean rating with verbal interpretation of "Outstanding" and the remaining 30% got an average or "Very Satisfactory". Notably, the Unit Cubes intended for Grade 4 got the highest rating.

Table 4. Experts' Responses on the Evaluation of Manipulative Devices and Lesson Plans for Grades 4 to 6.

Name of the Manipulative Device	Mean for the Device	Interpretation	Mean for the Lesson Plan	Interpretation
Fraction Kit	4.23	Very Satisfactory	4.91	Outstanding
Peg Board	4.70	Outstanding	4.61	Outstanding
Square-rec Tiles	4.33	Very Satisfactory	4.91	Outstanding
Unit Cubes	4.77	Outstanding	4.61	Outstanding
Fraction Discs	4.53	Outstanding	4.86	Outstanding
Circle Pie	4.47	Very Satisfactory	4.58	Outstanding
Congruent Blocks	4.43	Outstanding	4.53	Outstanding
EQ Board	4.57	Outstanding	4.53	Outstanding
Pos Neg Counters	4.53	Outstanding	4.58	Outstanding
In-line Con Unit tiles	4.23	Outstanding	4.54	Outstanding
Grand Mean	**4.48**	**Very Satisfactory**	**4.67**	**Outstanding**

Moreover, seventy percent (70%) of the manipulative devices got a perfect score (5.00) in the item "appropriateness". This result seemed to imply that experts found the seven manipulative devices very much suited to the intended learners. As cited by Boggan, Harper, and Whitmire (n.d.), Smith (2009) stressed that the mathematics manipulatives should be appropriate for the students and chosen to meet the specific goals and objectives of the mathematics program.

In contrast, two (2) devices, namely the fraction kit and the square-rec tiles, got the lowest mean rating of 3.60 in terms of "kind of materials used", although manipulative devices constructed by the researchers were just prototypes. It was assured, however, that the materials used in the final version of the Mathematics Kit will be much improved versions of the prototypes.

Besides, with the grand mean of 4.67 for the lesson plans, it could be said that the experts rated one hundred percent (100%) of all the lesson plans as "Outstanding" to indicate that all the ten lesson plans written were acceptable to the experts.

The highest mean rating was given to the lesson plans for the Fraction Kit and the Square-rec Tiles. The lesson plan for the former developed the concept of fractions, one of the difficulties of students, while that for the latter developed the derivation of the formulae for the areas of quadrilaterals.

The "concluding activity" and "assessment" were the strong points of the lesson plans for both the Fraction Kit and Square-rec Tiles. This result indicated that the experts seemed to believe that the "concluding activities" were aligned with the objectives of the lesson and provided an opportunity for the integration of fractions/areas of quadrilaterals with other concepts or real-life situations. Also, the experts seemed to believe that the "assessment" of the lessons gave clear evidence that students would have achieved the lesson objectives using both the Fraction Kit and Square-rec Tiles. Interestingly, students who have appropriate manipulatives to help them learn fractions outperform students who rely on textbooks when tested on these concepts (Jordan, Miller & Mercer, 1998; Sebesta & Martin, 2004)

In contrast, the "assessment" was the weakest point of the lesson plans for the Congruent Blocks, the EQ Board, and the In-line con Unit Tiles. This is because the aforesaid lesson plans got the lowest mean rating in that criterion. But it is noteworthy that given this, it still falls well within the "acceptable" range.

Table 5 summarizes the evaluation of experts for the ten (10) manipulative devices that the researchers constructed for Grades 7 – 10.

Table 5. Experts' Responses on the Evaluation of Manipulative Devices and Lesson Plans for Grades 7 to 10.

Name of the Manipulative Device	Mean for the Device	Interpretation	Mean for the Lesson Plan	Interpretation
Spatial Nets	4.90	Outstanding	4.67	Outstanding
Angle-Arc Device	4.80	Outstanding	4.67	Outstanding
Binomial Cube	4.73	Outstanding	4.61	Outstanding
Quadri Tangrams	4.87	Outstanding	4.79	Outstanding
SIAP	4.90	Outstanding	4.94	Outstanding
Cysphecon	4.97	Outstanding	4.78	Outstanding
An-Pade	4.83	Outstanding	4.89	Outstanding
Pythagorean Tiles	4.90	Outstanding	4.66	Outstanding
Parsuse	4.90	Outstanding	4.56	Outstanding
Trig Trainer	4.67	Outstanding	4.67	Outstanding
Grand Mean	**4.85**	**Outstanding**	**4.72**	**Outstanding**

As shown in Table 5, all eleven manipulative devices got a mean rating of above 4.50 with a verbal interpretation of "Outstanding" to imply that the manipulative devices designed and constructed for use of Grades 7 – 10 teachers and students all seemed highly acceptable to the experts, as supported by the grand mean of 4.85.

Notably, the Cysphecon, a device that may be used to derive the formula for the volumes of cylinders, spheres and cones, got the highest mean rating. It got an average rating of 5.00 in 5 of the 6 criteria and 4.80 in one of the criterion for "Design and Materials Used".

Also, the table revealed that the eleven (11) lesson plans written for Grades 7-10 teachers got a mean rating of 4.72 to indicate that based on the standards of the experts, all lesson plans were "Outstanding" and acceptable to them.

Moreover, the "learning objectives", "learning activities", and "concluding activity" were the strong points of the lesson plans written for Grades 7 – 10. It was worth mentioning that the lesson plans for SIAP (to derive the sum of the interior angles of a polygon) and Cysphecon (to derive the formulae for areas of some quadrilaterals) obtained an average rating of 5.00 in the "learning activities" category. This result showed that in those lesson plans in Geometry, the experts felt that the "learning activities" encouraged students to be creative, and when aligned with the learning objectives, were capable of being completed within allotted time, and developmentally appropriate, engaging, creative, and innovative. Incidentally, an action research conducted by Allen (2007) revealed that as a result of geometry instruction using manipulatives, students increased their skills and showed more interest and enjoyment when learning.

Revising the Manipulative Devices

Experts' suggestions for improving some of the manipulative devices focused on the design and materials used in constructing the device. Some experts suggested that the colour of some devices be improved. Consequently, this suggestion was followed by the researchers. Furthermore, despite the researchers' explanations that the manipulative devices were simply prototypes and that the materials used could still be improved, the experts still wrote in the evaluation forms that the kind of materials used should be upgraded when constructing the actual device.

SUMMARY AND IMPLICATIONS

Thirty (30) manipulative devices with accompanying lesson plans were conceptualized, carefully designed and constructed by the researchers. These learning tools underwent face and content validation by experts who have been teaching mathematics for at least 5 years. Results showed that the manipulative devices were acceptable to the experts in terms of usefulness of the device, appropriateness of the device to the intended user, and design and materials used in making the device (size, colour, kind of material used, and durability). Similarly, the lesson plans developed to guide teachers in using the manipulative devices effectively were rated "outstanding" by the experts. These results seem to reflect the researchers' consideration of learner-centeredness when constructing the manipulative devices and when developing the accompanying lesson plans.

Manipulative devices serve many purposes, all leading towards a better understanding of mathematics concepts. Although manipulative devices are not the be-all and end-all in teaching mathematics, the researchers believe that they can be very useful if they are wisely designed and implemented to build a firm, concrete model for abstract mathematics concepts. However, despite the success of manipulative devices as mathematics teaching tools, many mathematics teachers were still reluctant to use them in teaching due to their unavailability in the local market. Still many teachers felt that they did not know how and when to use manipulative devices, and therefore, hesitated to use them in the classroom. The researchers hoped to bridge this gap by introducing their developed lesson plans. Teachers need to know when, why, and how to use manipulative devices effectively in the classroom and should have opportunities to observe, first-hand, the impact of allowing learning through exploration with concrete objects (Kelly, 2006). Although the developed manipulative devices and lesson plans are still in their proto-type phase, the feedback from the experts indicates that they are a small, but important step in the right direction.

CONCLUSION AND RECOMMENDATIONS

Based on the results derived from data gathered in this research, it may be inferred that the manipulative devices designed and constructed by the researchers with the accompanying lesson plans may be used to develop different concepts in Kindergarten to Grade 10 Mathematics.

This conclusion yields the following recommendations:

1. The manipulative devices be tried-out with the intended users;
2. Each of the three Mathematics Kits be validated;
3. Mass production of the Mathematics Kits for distribution in various parts of the country;
4. Other researchers may want to develop manipulative devices and lesson plans for the mathematics concepts excluded in this study; and
5. Educators and researchers alike may want to pursue the development of manipulative devices and lesson plans using other media, such as computers and the internet, and other languages such as the mother-tongue.

REFERENCES

Abante, M. (2006). *Computer-aided instructional materials in teaching statistics in the tertiary level* (Unpublished Thesis). Eulogio Amang Rodriguez Institute of Science and Technology, Manila.

Allen, C. (2007). *An action based research study on how using manipulatives will increase students' achievement in mathematics.* Marygrove College. Retrieved from *files.eric.ed.gov/fulltext/ED499956.pdf*

Boggan, M, Harper, S. & Whitmire, A. (n.d.) *Using manipulatives to teach elementary mathematics*, Mississippi State University. Retrieved from *www.aabri.com/manuscripts/10451.pdf*

Brooks, J. & Brooks, M. G. (1999). *Educational research: an introduction (3rd Ed.)*. New York: Longman Inc.

Fortes, E. C. (1992). *The immediate and carry-over effects of the use of the innovative approach in teaching special products and factoring on mathematics achievement of sophomore high school students* (Unpublished Thesis). Philippine Normal University, Manila.

Jack, R. C. & Lockhart, C. (1994). *Reflective teaching in second language classroom*. New York: Cambridge University Press.

Kelly, C.A. (2006). Using manipulatives in mathematics problem solving: A performance Based analysis [Electronic version]. *The Montana Mathematics Enthusiast* 3(2), 184-193.

Post, T. (1981). The role of manipulative materials in the learning of mathematics concepts in selected issues in mathematics education (pp. 109-131). Berkeley, CA: *National Society for the Study of Education and National Council of Teachers of Mathematics*, McCutchan Publishing Corporation, Retrieved from http://www.cehd.umn.edu/ci/rationalnumberproject/default.htm

Rakes, G., Flowers, B., Casey, H. & Santana, R. (1999). An analysis of instructional technology used and constructivist behaviors in k-12 teachers. *International Journal of Educational Technology VI N2.*

Research on the benefits of manipulatives. Retrieved from*www.hand2mind.com/pdf/Benefits_of_Manipulatives.pdf*

Seefeldt, C., & Wasik, B.A. (2006). *Early education: three-, four-, and five-year-olds go to School* (2nd Ed.). Upper Saddle River: Pearson Education.

Sharma, M. (1997). Improving mathematics instruction for all. Fourth Lecture in Colloquium "Improving Schools from Within: Your Role”. pp. 2-12

Smith, S. S. (2009). Using manipulatives. *Early Childhood Mathematics* (4th Ed.) Boston: Pearson Education, Retrieved from http://www.teachervision.fen.com/pro-dev/teaching-Methods/48934.html

Spikell, M. (1993). *Teaching mathematics with manipulatives: a resource of activities for the K-12 teacher*. New York: Allyn and Bacon.