International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:6, No:6, 2012

Math Curriculum Adaptation for Disadvantaged Students in an Inclusive Classroom

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***Abstract*—**This study was a part of the three-year longitudinal research on setting up an math learning model for the disadvantaged students in Taiwan. A target 2nd grade class with 10 regular students and 6 disadvantaged students at a disadvantaged area in Taipei participated in this study. Two units of a market basal math textbook concerning fractions, three-dimensional figures, weight and capacity were adapted to enhance their math learning motivations, confidences and effects. The findings were (1) curriculum adaptation was effective on enhancing students' learning motivations, confidences and effects; (2) story-type problems and illustrations decreased difficulties on understanding math language for students from new immigrant families and students with special needs; (3) "concrete – semiconcrete – abstract" teaching strategies and hands-on activities were essential to raise students learning interests and effects; and (4) curriculum adaptation knowledge and skills needed to be included in the pre- and in-service teacher training programs.

***Keywords*—**curriculum adaptations, mathematics, disadvantaged students, inclusive classroom

I. Introduction

TAIWAN students' average math achievements ranked highly in the world. Educational reform raised in these two decades has constructed a new Grade 1-9 Curriculum which consisted of Language Arts, Health and Physical Education, Social Studies, Arts and Humanities, Mathematics, Science and Technology, and Integrative Activities for the elementary and junior high level students [1]. The Mathematics curriculum guidelines indicated every student had the right to receive good math training, to fully know the important math concepts, and to enhance well-math abilities [2]. Therefore, every student including the socially and economically disadvantaged and the disabled students as well should receive meaningful and effective curriculum to develop their potentials. According to the researcher's thirty-eight years experiences in teaching and counseling students with special needs, curriculum adaptation on adjusting the content, process, and product were indispensible to enhance their learning effects.

Inclusion now is an international trend for the placement of students with special needs. In Taiwan, main programs for the students with special needs are full or partial inclusion with needed special education and related services from resource room teachers, the whole school administrative and regular educators.

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In this study, we united researchers from mathematics education and special education together to assist an elementary school, which located at a disadvantaged area with approximately 30% disadvantaged students in Taipei city to set up a math counseling and guidance model for the disadvantaged students. All the class size was about 16 to 26 students and every student studied in their regular classrooms with some supports from the resource room programs or other in- and out-school resources. The whole research lasts for three years and we are doing the third year part at present. This presentation focused on a part of the methodologies and results of the second year. The main purpose of this study was to provide curriculum adaptation to a 2nd grade target class based on the first year's findings and math teacher's needs for enhancing the learning motivations, confidences, and effects of the disadvantaged students.

II. Literature Review

A. Curriculum Adaptation

The general curriculum is mainly designed to serve students in the normal range which excludes diverse learners such as the disadvantaged and students with disabilities. Adapting general education curriculum to meet each student's needs is necessary for successful inclusion [3], [4]. Curriculum adaptation is an ongoing process on modifying the general education curriculum to meet learners of all abilities and ensures that every student is challenged to learn. To reach this goal, curriculum content, instructional design, instructional settings, and student behaviors are needed to modify to fit the students' needs [5]. Differentiating instruction and providing multiple ways assess allows more flexibility for students to meet the standards and requirements of the class [6]. Cushing, Clark, Carter and Kennedy discussed the use of paraprofessionals to work with general educators to adapt the general curriculum and assessments to meet the needs of the learning disabled students and found it could assist the student in the overall comprehension of general curriculum as well as learn the other important skills that were intended with inclusive programs [7].

In Taiwan, elementary teachers needed to teach language arts, math, social studies, and arts altogether, some might be lack of math content knowledge and pedagogical content knowledge since their undergraduate majors were not in mathematics. However, math is the basis for learning other subjects and solving daily living problems. Besides, the Grade 1-9 math curriculum only provides competence ability indicators but no specific content which allows a lot of flexibilities for editing and adapting the teaching materials.

Based on the above, we chose to provide math curriculum adaptation for a specific teacher whose major was not in mathematics for convincing and assisting her to modify the curriculum according to the students needs in the future.

B. Math Teaching and Learning of Disadvantaged Students

Math is the basis for learning other subjects and solving daily living problems. Research findings showed that mathematics was the most difficult subjects for the elementary students [8], [9]. Many disadvantaged students' math learning problems were caused by teacher's unfamiliar with the new contents, over emphasizing on computation ability training, neglecting of inter- and intra-individual differences, and doing too many paper and pencil practices [10]. Bentley's study indicated that in-service training on learning strategies was needed and very useful for teachers of all subjects [11]. Research used concrete, semiconcrete, abstract instructional sequence to teach students with disabilities and found it was a successful approach for enhancing learning motivations and effects [12], [13]. In addition, positive self-concepts and confidences toward math learning had great impacts on students' learning performances [14], [15].

From first year study of the three-year longitudinal study, we also found (1) remedial teaching needs in mathematics for regular students were not so high in comparison with the disabled and disadvantaged students; (2) teachers teaching strategies of Direct Instruction, multi-level instruction, co-teaching and cooperative learning needed to strengthen; (3) learning interests, confidence, and effects towards mathematics were gradually dropped down according to their age and grades; (4) students loved hands-on activities more than just lecturing; (5) students math mistakes and learning difficulties as well as the number of math disadvantaged students were also increased gradually; (6) about 60% first grade students had some difficulties to connect the concepts of composition and decomposition to additions and subtractions, to find the mistakes and conflicts from plane and three-dimensional figures. Also, word problems were difficult to the low achievers and students from the new immigrant families; and (7) 60% second graders could not do two-step additions and abstractions in computation and real-life application problems. 50% would mix the two-dimensional and three-dimensional figures together. 30% had difficulties on doing division problems [16]. Therefore, math teaching and learning for the disadvantaged students were worthy of notice if Taiwan wants to keep world top rate and reach the goals of the Grade 1-9 math curriculum.

III. Methods

A. Participants

Subjects were six 2nd grade disadvantaged students found in one target class with a total of 16 students since the first year study. Among them, A1 was identified with intellectual disabilities in the first grade and then through our assistance to re-identified as with learning disabilities. He also had attention-deficit problem and often asked the teacher to repeat the illustrations. A2 and A3 were from single-parent families without enough learning confidence but with good learning attitudes. A2 was very impulsive whereas A3 was very introvert and passive. A4, A5 and A6 were from new-immigrant families with mothers from south-Asian countries. Their math learning motivations and confidences were lower and easy to be distracted in comparison with the regular students.

B. Instruments

Curriculum adaptation need forms, classroom observation records, and mid-term and final tests were used as instruments in this study. Curriculum adaptation forms were given to the teacher in advance with some of the difficulties found in the first year and asked the teacher to fill out the form unit by unit to see if it was necessary for us to do the adaptations beforehand after the mid-term test. Classroom observation were conducted during the curriculum adaptation intervention period with a full time assistant whose major was in mathematics during the undergraduate and master programs and a part time assistant whose major was in special education during the undergraduate, master, and doctoral studies. Mid-term and final test scores of four 2nd grade classes were collected through the academic affairs supervisor of the school.

C. Statistical Analysis

Data were analyzed by using descriptive analysis and content analysis. SPSS for windows 18.0 were used to analyze the quantitative data and QSR Nvivo 7.0 for the qualitative data.

IV. Results

A. Adaptations and Modifications of the Textbooks

According to the collected curriculum adaptation forms from the teacher and the findings of the first year study, two units of the 2nd grader basal math were modified. One unit was "concepts of fractions" and the other was "three-dimensional figures, capacities, and weight concepts". The modifications were followed math competence indicators for the 2nd graders in the Grade 1-9 curriculum and the textbook used in their regular classrooms. Since 2nd grade math is not too difficult on counting and calculation, we focused on modifying the concept illustrations and word problem statements into daily living situations and story-type problems for connecting with their experiences in the content part. The main adaptations were on the process and product parts through applying "concrete – semi-concrete – abstract" math teaching strategies, Direct Instruction, multi-level instruction, cooperative learning, and providing apple hands-on practices and activities. In additions, teaching aids (i.e., pancakes, cookies, cakes, juices, fruits, cups, pots, bottles, magic blocks) were used to cause their learning motivations and connect with the real-life situations. In addition, work sheets were redesigned to connect the concepts together and provide more actual practices according to students' needs.

In the "fractions concepts" unit, the textbook divided into fractions unit, fractions comparison, and word problem by implementing the above two concepts together. In the first part, round, oblong and lines were used to demonstrate the bisection, trisection and other sharing parts to the concepts from 1/2 to 1/6.

Then, it jumped quickly to the worksheet with rhombus, polygon, other two-dimensional shapes and much more complex equal division parts (e.g., 1/12, 1/8, and 1/7) which might cause students' confusion. So we modified them by using daily life story-type problems to connect with their neighborhood stores and by using round and square pancakes to actually compare the size of a whole equaling with two bisections and then to connect it with the concept of 1/2. Also, through cutting cookies and folding the papers, students could practice more about the concepts of 1/4 and so on to clarify and compare the size.

As to the fraction comparison, the original unit only used lines to compare the size from 1/2 to 1/10 and gave two similar guided practices (e.g., 1/2>1/3 and 1/5<1/4). Then, the independent worksheet dramatically shifted with square, oblong, and round shapes to compare each pairs from 1>1/2, 1/4 < 1/3, 1/9 < 1/3, 1/8< 1/4, and 1/6 >1/12, which were much more complicated and difficult in comparison with the teacher demonstration and guided practices and also put more emphasis on the less comparison. Therefore, we used honey cakes and plastic knifes to let them understand by sharing more people each person would get less. And also, we provided apple practices through manipulating cookies and papers for firming this concept.

The final word problem part of the original textbook unit only provided with six questions, one was asked to answer equal division to fraction, three were transferring fractions into equal divisions, and the other two were doing the fraction comparison problems. Each question was separately stated without any connections which made the problems more difficult to answer. Thus, we altered them into a series of story-type problems and provided more practices and connections with each other. After doing the adaptations, we let the teacher to see whether it was appropriate to the students. We altered some words based on the teacher's response. Then, we gave it to the teacher for teaching preparations and prepared all the teaching supplements for the teacher before teaching.

As to the "three-dimensional figures, capacities, and weight concepts" unit, the textbook divided it into five parts including understanding the vertical and horizontal concepts, knowing the vertex, side, and plane concepts, comparing the weight with real- life seen animals or goods, comparing the weight on the weighing scales, and comparing the capacities. In the first part, the unit stated the real-life figures to indicate the vertical phenomena, i.e., door curtain, wind bell, pendulum, and pendent lamp and then shifted to the horizontal phenomena through showing the pictures of still water in bottle, flower vase and fish bowl, which were less relevant to their living experiences and interests and rendered very little practices and hands-on activities as well. We modified it by using the swing they liked to play at this age to indicate when the swing was still it was in a vertical direction. And then, providing a string to tie the eraser up for each student and asking him/ her to hold the string lightly to actually feel the vertical phenomenon. After that, we demonstrated the bottles, glasses and various containers by pouring water or drinks inside and even put the containers slanting with a book on the bottom to let them realize the horizontal phenomena.

Also, apple practices were provided to firm this concept. On introducing the concepts of vertex, side and plane, the textbook drew a cube and a cuboid to demonstrate the concepts and through tracing the sides and planes to compare the length and size. We altered them by using real magic blocks and through watching its different colors and touching its surfaces to know the vertex, side and plane. After that, we provided boxes for cookies and cakes to firm the concepts. The third part of comparing the weight, the book drew a lion and a mouse to ask students comparing their weight. Then examples were shown on comparing a balloon with basketball, a full bucket of water with a half-filled bucket of water. The guided practices, however, shifted to the teeterboard, scales which were irrelevant to the illustrations but were the practices of the next concept. To the weighting on scales only one kind of scale picture shown with 1 to 4 poises were used to do the comparisons. But the guided practices were the concept shown in the last part by comparing various size animals and vehicles. We corrected the mistakes and added more daily life goods and hands-on activities, i.e., to compare the orange with a guava, a 900ml bottle of grape juice with a 300 ml bottle of black tea, a big pack of potato chips with a medium size can of fish for emphasizing size was not the decision indicator for weight. To the last part of capacity concept, still concrete and delicious drinks were used to replace the pictures and plane water for causing their learning motivations and doing the manipulations. We also asked the teacher to see the modifications beforehand. She agreed with and loved our revision of the materials.

B. Classroom observations

Nine sections of classroom observations were conducted for examining the learning effects on curriculum adaptations. The qualitative data analyses found that (1) All 16 students in the whole class liked the adapted materials and understood better. For example, they felt very interested through cutting various foods, lessoning real life story-type illustrations, and manipulating by small cooperative learning groups to know the concept of fractions. In addition, they were very concentrated on measuring actual goods weight to understand size was not the exact indicator for weight and using various containers to know they would not alter the capacity measure; (2) as to the disadvantaged students, A1 was attracted from the first unit adaptation and gladly assisted the teacher to manipulate the teaching aids on the platform. He was very concentrated on doing the vertical and horizontal measure and loved to manipulate the magic blocks. In all, A1 had much less distractive and passive behaviors which were frequently shown before the intervention; (3) during both two units' learning sessions, A2 and A3 maintained high interests not only during teacher demonstrations but also on the hands-on sessions. They even raised their hands actively and anxiously to answer teacher's questions; (4) A4's learning motivations and attitudes were highly enhanced. He knew better through hands-on activities but sometimes still needed teacher's oral corrections to keep on the pacing; and (5) A5 and A6 had great progress on learning attitudes and involvements. They both had good interactions with the teacher in comparison to pre-intervention stage.

C. Disadvantaged Students' Math Performances

There were four 2nd grade classes with a total of 68 students in this school. In each semester, same mid-term and final tests were administered to examine their learning outcomes. Since the two adapted units were intervened right after the mid-term test and before the final test, we used these test scores to indicate and compare their math learning effects. Table I was the means, standard deviations, and progress percentages of these four classes. From table I, we could see the mean of the mid-term math performances for the whole target class only ranked third before the curriculum adaptation. The final test score, however, was the highest among the four classes. Also, their standard deviation was much smaller than the other three classes, which indicated the whole class students' scores were much more centralized than those of the other classes. This finding indicated almost all students' math scores were between 90 and 100. As to the progress percentage between the mid-term and final scores was 2.88% which also was the highest progress rate among the four classes.

TABLE I
MID-TERM AND FINAL MATH SCORES OF THE FOUR 2ND GRADE CLASSES

class	n	mid-term		final		progress
		M	SD	M	SD	%
201[a]	16	94.37	7.34	97.25	3.15	2.88
202	17	94.58	7.68	94.29	5.30	- 0.29
203	18	95.16	4.24	95.83	5.21	0.67
204	17	91.05	9.67	92.94	8.26	1.89
total	68	93.80	7.46	95.05	5.89	1.25

[a] the target class receiving curriculum adaptation

As to the six disadvantaged students, table II analyzed their score, percentile rank, and progress percentage of the mid-term and final tests. In table II, we could find A1, A5, and A6 performed lower than PR 25 on the mid-term test but rose to PR33 and above on the final test. The progress percentages were from 2% to 23%. Although A4's progress rate is negative, he still got 98 which had only 2 point loss during the final test. The results indicated these disadvantaged students math performances were enhanced after the curriculum adaptation.

TABLE II
MID-TERM AND FINAL MATH SCORES OF THE SIX DISADVANTAGED STUDENTS

student	mid-term		final		progress %
	score	PR	score	PR	
A1	70	2	93	33	23
A2	98	73	100	99	2
A3	98	73	100	99	2
A4	100	99	98	64	-2
A5	92	20	98	64	6
A6	87	10	93	33	6

V. DISCUSSION

In this research, we found the learning motivations and effects of both disadvantaged and regular students were enhanced which were very consistent with the findings of previous research. From the first year study, we found some teachers lacked of the knowledge in the characteristics and needs and some specific math content knowledge while teaching students with special needs.

In addition, most teachers relied mainly on the pencil-paper tests, individual student oral response which limited the learning of those students with math learning difficulties. In this study, however, the disadvantaged students' learning difficulties were overcome through using the story-type illustrations, concrete – semiconcrete – abstract teaching strategies, multi-level instructions, small cooperative learning groups, and hands-on activities. Although some might still need more individualized instructions and practices than regular students, they gained confidences and interests in the inclusive classroom learning. For example, A1 was identified as a student with intellectual disabilities in the first grade. Through our intervention, the teacher noticed the label was incorrect because of A1's math performances sometimes even better than many regular students. Also, she admitted that the wrong label influenced her attitudes and expectations toward A1. We recommended her to call for a re-identification process and thus changed the label to language learning disabilities. Besides, this teacher's attitudes and expected standards towards other disadvantaged students were also changed after the curriculum adaptation. In all, the student with special needs like A1 gained most not only on the math performances but also on the learning motivations and confidences. Also, some disadvantaged students without enough confidences and resources gained teacher's notice and out-school assistances. In this study, we found market math textbooks had problems on lacking of enough illustrations, less connections with in- and cross-subject concepts and experiences, no sufficient guided and independent practices, and existing wrong editing order through curriculum adaptation process. Therefore, in-service and pre-service teacher training on evaluating market textbooks and adapting current used one are very important skills in the future. Since math will become more and more difficult and instructional time is not enough for some disadvantaged students, we are now providing remedial teachings and connecting the resource room program teaching and other in- and out- school resources together to some disadvantaged students for setting comprehensive math counseling and guidance model to these students and for the whole school. After that, we will disseminate the model to the similar schools and areas in Taiwan for future implementations.

VI. CONCLUSION

The study was just a part of the second year's math intervention program. The main findings of this study were (1) two units of the curriculum adaptation findings indicated they were effective on enhancing students' math learning motivations, confidences and effects; (2) modifications of story-type word problems and teacher illustrations decreased and minimized the difficulties on understanding the math language for students from new immigrant families and students with special needs; (3) "concrete – semiconcrete – abstract" teaching strategies and hands-on activities were essential to raise the disadvantaged students learning interests and effects; and (4) curriculum adaptation knowledge and skills needed to be included in the pre- and in-service teacher training programs. Based on the above results, we are now providing necessary provisions to the students and the school as well.

ACKNOWLEDGMENT

The author would like to thank Mr. Chi-Hsiang Liao, the full time research assistant, and Miss. Yi.-Zhen Ke, the part time research assistant, for their helps on data collecting and analyzing and classroom observations. In addition, the author would like to thank the principle, administrators, teachers, and students of the Taipei Municipal Hua Jiang Elementary School for their cooperation as the research partner in the three-year longitudinal research.

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