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An experimental study of the effect of a specialized teaching device on the arithmetic achievement of mentally handicapped children

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AN EXPERIMENTAL STUDY OF THE EFFECT OF A SPECIALIZED TEACHING DEVICE ON THE ARITHMETIC ACHIEVEMENT OF MENTALLY HANDICAPPED CHILDREN

by

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CHAPTER I

INTRODUCTION

The Problem

Arithmetic is necessary to all children, whether normal or retarded, but the goals and methods of teaching arithmetic to these children would differ somewhat. For the average child or gifted child arithmetic is a foundation for further study in the field of mathematics or a tool in the study of science. In dealing with the retarded child, who may not achieve beyond the third or fifth grade level, it is essential to teach the arithmetic that will be meaningful to him now and that he will be able to use in ordinary encounters of everyday life.

Little adjustment has been made in the instructional presentation of arithmetical concepts to meet the educational limitations of the mentally handicapped child. Kirk and Johnson certify:

> While there are few comprehensive studies comparing the arithmetic abilities of mentally handicapped children with normal children of the same mental age, we do have enough information to know that a curriculum designed for normal children is not applicable and will not meet the needs of the mentally handicapped.[1]

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[1] Samuel A. Kirk and G. Orville Johnson, Educating the Retarded Child (Cambridge, Massachusetts: Houghton Mifflin Company, 1951), p. 278.

During the past few years many major achievements have been accomplished in special education and particularly in curriculum planning for the mentally retarded. While an extensive amount of literature is available on the teaching of arithmetic, comparatively few studies have been undertaken and only minor articles have appeared pertaining to the teaching of arithmetic to mentally retarded children. There is a definite need for further research in this area of the special education curriculum. Thresher states:

> There are conflicting opinions in the literature in regard to the capabilities of retarded children, an appropriate arithmetic curriculum for them and the method and materials for teaching it. The opportunities for research in this area are limitless. Much work must be done in regard to how retarded children form arithmetical concepts, and to the best ways by which the teacher can foster this ability.[2]

In teaching arithmetic to the mentally retarded it is essential that the number concepts be made functional. Mentally retarded children are handicapped in the study of arithmetic because of their deficiency in transfer of learning, low abstract thinking ability, poor comprehension, slow absorption of facts, and their lack of ability to concentrate. In the teaching of arithmetic it is essential to keep in mind the child's present and future needs. While planning and structuring the curriculum, therefore, it is necessary to consider the concepts and experiences

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[2] Janice M. Thresher, "Problem for Education: Arithmetical Concept Formation in the Mentally Retarded Child," American Journal of Mental Deficiency, LVI (March, 1962), p. 772.

he will need to help him live the role of a citizen in the community.

The mentally retarded child, even more than the average child, must be taught to apply the arithmetic he learns to the specific situations in life in which he functions. He must be taught how to use numbers in the situations in which he is most likely to need them. Some of these include the use of money in purchasing articles, computing wages per week, payrole deductions, interest charges, etc. These skills must be taught in an effort to produce functionally successful citizens.

In teaching number concepts to normal children the material must be presented in an interesting, meaningful way. If this is true in the case of the normal child, how much more so when considering the instruction of retarded children! Bowers states that for retarded children:

> Arithmetic must be meaningful, practical and related to life situations. Many experiences will be required by some children in learning relationships between numbers. Hence, emphasis must be placed on concrete material and on teaching for understanding rather than for rote learning.[3]

Statement of the Problem

The purpose of this study is to determine the effect of a specialized teaching device on the arithmetic achievement of mentally retarded children. Mentally handicapped children need concrete learning experiences. Audio-

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[3]Joan E. Bowers, Exceptional Children in Home, School, and Community (Vancouver, Canada: J. M. Dent and Sons, 1957), p. 146.

visual materials not only aid learning but they also extend and enrich the child's education. The Math Builder was used to reinforce student skills after the basic concepts had been introduced.

The Math Builder is a modified 35 mm filmstrip projector which presents arithmetic numbers or story problems at controllable rates in either a left-to-right fashion or line-by-line. There is a special masking control which makes it possible to cover the answer, varying the type of drill. Each filmstrip contains exercises for both oral and written responses. There are six sets of filmstrips, ranging from first grade through high school, and with each filmstrip set is a teacher's manual.

According to a report submitted by the Lancaster, California, school district, the Math Builder was incorporated into their total arithmetic program during the 1959-1960 school year. The students accomplished twice as much as was expected, based on results from previous years. Since then, Math Builder has been considered a standard part of their arithmetic program. The Baldwin, New York, public schools enlisted Math Builder training into their 1961 one-month summer session. Most of the children in this experiment showed a six-month change in their final test scores.[4]

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[4]Jack W. McLaughlin, Educational Developmental Laboratories, Newsletter No. 12 (Huntington, N.Y.: Educational Developmental Laboratories, 1959).

The principal objectives considered in the development of this study were:

1. To provide training in developing accurate responses to the basic number facts.
2. To afford practice with the basic number facts as met by the child in everyday experiences of his life.
3. To ascertain the effect of this training and practice with the Math Builder on the arithmetic achievement of mentally retarded children.

Arithmetic is like a jigsaw puzzle. When all of the pieces or steps are in proper places the picture can be seen, but if two or three pieces or steps are missing, there is no logical relationship. It is the purpose of the present research to help the retarded child find the missing pieces, and thus be able to achieve in arithmetic.

Justification of the Problem

Many retarded children are able to attain success in learning activities that are suited to their limited abilities. Cruickshank states:

> The group of experiences provided [retarded] children must be within their ability to understand, be of such a nature that they enable them to live as effectively as possible within the limitations of their abilities and disabilities, have meaning in terms of their present living experiences, and provide them with necessary background to grow and live effectively in their potential physical, social, and economic environment

as adults.[5]

If attention is given to these considerations, most retarded children can profit from learning experiences.

The teaching of arithmetic to the retarded is just as important as teaching it to the normal child. Effective arithmetic teaching will include more than the textbook direction of pencil and paper, of examples and problems. It will direct the child's attention to the fact that he is living in a world in which situations involving numbers are so numerous that ability to solve these arithmetic problems is an everyday necessity. In dealing with the retarded child, a little essential arithmetic well learned is better than superficial exposure to a variety of things that he cannot learn nor will actually ever use.

Audio-visual education has specific applications in special classes for retarded children. These aids increase learning possibilities while they broaden and expand children's general education. Garton says that:

> The mentally retarded child will learn more readily from audio-visual and sensory materials than he will from lectures or explanations.[6]

If education is to keep pace with a rapidly chang-

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[5]William M. Cruickshank and Orville G. Johnson, Education of Exceptional Children and Youth (New Jersey: Prentice Hall Inc., 1958), p. 200.

[6]Malinda Dean Garton, Teaching the Educable Mentally Retarded (Springfield, Illinois: Charles C. Thomas, Publisher, 1962), p. 127.

ing and expanding world, there must be a major breakthrough in school education. Much has been done to expand the educational system, and presently there is a move to provide teachers with better equipment, and with new learning and teaching aids. The Math Builder is merely one of many mechanical aids to learning, but is the only machine that is specifically designed for the teaching of arithmetic.

An important aspect in teaching arithmetic to retarded children is motivation. Audio-visual materials offer a great opportunity for motivating the child. Statements from public school teachers of retarded children varify the value of audio-visual methods and materials.

> Audio-visual materials and methods are a wonderfully effective substitute for first-hand experience...They have important reinforcement applications...They provide motivation for the improvement of arithmetic... They increase powers of concentration...They help explain difficult facts...They focus all the children's attention in one direction...They make learning come alive...They open the door to areas formerly inaccessible to the children.[7]

In the present research the writer has assumed the following premises:

1. Mentally handicapped children, despite their limited experiences, nevertheless meet situations in daily life which call for skill in the basic number facts.

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[7]Katherine C. Cotter, "Audio-Visual Education for the Retarded," Elementary School Journal, LIII (May, 1963), p. 441.

2. Though much research has been done on the effect of mechanical devices on the arithmetic achievement of normal children, little has been reported on the advantage of their use with the mentally handicapped.
3. Arithmetic achievement of the retarded child plays an important role in the overall adjustment of the individual if he is to become a useful member of his community.

Techniques Employed

Both the experimental and control groups were taught by the writer during the period of the experiment. The two groups were presented the arithmetic facts in the same manner. The specialized teaching device, namely the Math Builder, was utilized in the drill process for the experimental group. The method of drill for the control group included flash cards and the use of the abacus.

Population

The experimental and control groups consisted of thirteen pupils each from a private day school for mentally handicapped children.

Children included in this experiment presented four types of disabilities, namely: cerebral palsy, brain injury, epilepsy and mental retardation.

Although the number of subjects in this experi-

ment is very small, it is hoped that the study will encourage further investigation on a larger scale.

Testing Program

In order to formulate the experimental and control groups, an intelligence test and an arithmetic achievement test were administered. The groups were matched according to M.A., I.Q. and arithmetic achievement level.

The Stanford Binet Intelligence Test, Form LM, was used for determining the mental ability of the children.

To ascertain the arithmetic level of the children the Stanford Achievement Arithmetic Test, Form J, was utilized.

In the final testing the Stanford Achievement Arithmetic Test, Form K, was given.

CHAPTER II

REVIEW OF LITERATURE

Math Teaching

Studies on the teaching of arithmetic to mentally retarded children have been relatively few. The available literature on the teaching of arithmetic is confined primarily to courses of study and descriptions of suggested programs. Comparatively little experimental research has been reported of statistical evaluations of methods and procedures used in teaching arithmetical concepts to the retarded.

The education of retarded children should consist of learning activities that are within the scope of their abilities. A curriculum designed for normal children is not applicable to and will not meet the needs of the mentally retarded. A program for the retarded must be of value to them now and in later life. According to Kirk and Johnson:

> In planning the curriculum for the mentally handicapped the major consideration is to plan it so that by the time they leave school they will have the type of knowledge, the concepts, and the experiences they will need to help them live as better citizens in their community. Most of the adult usages of arithmetic which are encountered in their everyday life are the fundamental concepts and addition, subtraction, multiplication, and division skills rather than the skills

included in a typical secondary or college program.[1]

The objective in the education of any retardate should be to prepare him to live what is for him a good life--a life lived as happily, actively, and purposively as his potentialities permit. The curriculum should consider his interests and his mental and social capacities as related to the activities which may be expected of him.

There is no set formula that will assure success with all mentally retarded children. Each teacher must devise his own ways of making arithmetic meaningful, for only thus will it be functional. Brueckner and Grossnickle state that "meaning and understanding are prime requisites." They also claim that "one learns a thing by meeting it in many meaningful situations."[2] For the mentally retarded, arithmetic must involve numbers, and quantitative concepts. Complex activities which may cause the child to become lost in them should not be included.

Arithmetic concepts have to be developed gradually and through concrete means. Baker says that from the very beginning the meaning of numbers should be the first consideration. The rote phases of learning number combinations have become less important than a well-defined num-

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[1]Samuel A. Kirk and G. Orville Johnson, Educating the Retarded Child (Cambridge, Massachusetts: Houghton Mifflin Company, 1951), p. 278.

[2]Leo J. Brueckner and Foster F. Grossnickle, Making Arithmetic Meaningful (Philadelphia: Winston Publishing Company, 1953), p. 232.

ber sense which is fundamental to arithmetic. What adding really means is probably more significant than the fact that two plus three equals five. When its value is understood, there is more interest in finding out the sum is five, rather than four. This meaning needs to be specific and concrete in the early stages and it is hoped that this may be a firm basis for abstract and generalized concepts.[3]

The mentally retarded child is slow to see relationships between things. He is slow in learning to transfer knowledge acquired in one situation to others where they might apply. Cruickshank observed that mentally retarded subjects are not as adept as normal subjects in differentiating unneeded from needed facts in solving arithmetic problems. He also concluded that the experimental and control groups showed similar abilities to solve concrete rather than abstract problems.[4]

Learning is facilitated and quickened by the utilization of all sensory avenues that naturally apply to a situation. If a mentally retarded child can hear, touch and smell as well as see something, that something will have more meaning for him. The mentally retarded child

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[3]Harry J. Baker, Introduction to Exceptional Children (New York: The Macmillan Company, 1959), p. 273.

[4]William M. Cruickshank, "Arithmetic Ability of Mentally Retarded Children," Chapter I, Journal of Edutional Research, XLII, 1948, p. 168.

thinks more concretely than he does abstractly. He needs to be taught as concretely and specifically as possible.

A good teacher should have an interest in each and every student entrusted to her care. She should utilize every effort possible for the child's advancement. The teacher of the mentally retarded child must have the same interest in her students, but must furnish the child with additional helps in the areas needed. It is necessary to keep a close watch for work habits that cause errors. Cruickshank explains in one of his experiments that the work habits which cause error and difficulty are of four general types. These are counting on fingers or making marks on paper, processes involving zero, carelessness in work habits, and errors in reading.[5]

In another research article Cruickshank states that tests in arithmetic show that the inability to understand is characteristic of the responses of the retarded group and may be due to poor work habits and lack of technical understanding of arithmetic processes.[6] It takes a teacher with a sincere interest in the child to watch that these errors do not occur, and to instill correct ideas of numbers, which will develop into a real under-

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[5]William M. Cruickshank, "Arithmetic Work Habits of Mentally Retarded Boys," American Journal of Mental Deficiency, LII (June, 1945), p. 328.

[6]William M. Cruickshank, "Arithmetic Ability of Mentally Retarded Children," Chapter II, Journal of Educational Research, XLII, (April, 1948), p. 287.

standing of arithmetic.

In teaching the number facts to retarded children it is necessary to allow sufficient time for the mastery of each step. To proceed to the next fact before there is understanding of the previous fact, means that the child will not be confident in responding. Ingram reports the necessary steps for the child to experience:

1. Having readiness and motivation for learning the number concept, fact or drill.
2. Taking ample time to observe and use the concept or fact in many different concrete situations.
3. Understanding the meaning of the number concept, or fact, when he hears it and expressing it orally and meaningfully.
4. Translating the meaning of the written symbol which stands for the concept or fact.
5. Associating the written symbol many times with the meaningful concept or fact that it stands for.
6. Using the written symbols many times to convey meaningful ideas and facts.
7. Having opportunity for sufficient meaningful oral and written repetition to gain confidence and independence in using numbers.[7]

If these steps are followed in teaching arithmetic to the child, the facts will be meaningful to him and he will retain them longer. He will also be better able to transfer this learning to new situations. By learning these concepts in a meaningful way the retarded child will develop good work habits, have a feeling of success in doing arithmetic, and will be initiated into the social aspect of living.

It is important to remember that retarded children do have needs just as normal children do. An arithmetic program that does not recognize such needs would undoubtedly

fail or fall far short of its goals. Barbe claims:

> The difference which exceptional children possess are primarily differences of degree. They are, first of all, children of their age. The most important thing to remember is that exceptional children need love, security, success, and acceptance as all other children.[8]

The school must provide opportunities for the progress of all its pupils. In order to profit from the opportunities the teacher must have a thorough understanding of the child. It is recognized that the goals of education for the retarded child must be in keeping with his capacities, limitations and interests. Education seeks the all-round development of the individual in helping him to become an integrated personality and a good citizen, aware of his own strengths and weaknesses. Such awareness on the part of the teacher is vital to any learning situation and consequently influence effective arithmetic teaching.

The literature reviewed above indicates a growing interest in the education of the mentally retarded, but the experimental field in the area of mathematics is still in the pioneer stage. Material on the teaching of arithmetic is largely confined to courses of study and descriptions of programs. According to Stevens and Heber, the few studies available concern (1) the relation of arithmetic to mental ability, (2) process studies, and (3) the com-

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[8]Walter B. Barbe, "Meeting the Needs of Exceptional Children," Education, LXXXIV (April, 1964), p. 476.

parison of different methods of teaching.[9] They also state that there have been few studies which compared different methods of teaching arithmetic to the mentally retarded and recommend that research is needed concerning instructional procedure by which quantitative ability can be developed in mentally retarded children.[10]

One of the earliest studies comparing methods of instruction in arithmetic for mentally retarded children was conducted by Helen M. Costello.[11] She used methods of instruction called the verbalization method, the socialization method, and the sensorization method. By verbalization was meant the use of word or symbols, either spoken or written, to describe a situation through recalled imagery based upon prior experiences. Socialization was a purposeful, cooperative, group endeavor enlisting the active interest and participation of the pupils. Sensorization was described as experiences involving the use of sense organs.[12] Taken as a whole the sensorization

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[9]Harvey A. Stevens and Rick Heber, Mental Retardation - A Review of Research (Chicago: The University of Chicago Press, 1964), p. 80.

[10]Ibid. pp. 82-83.

[11]Helen Marjorie Costello, Responses of Mentally Retarded Children to Specialized Learning Experiences in Arithmetic (unpublished Ph.D. dissertations, University of Pennsylvania, 1941).

[12]Ibid. pp. 15-16.

groups showed the best comprehension, but from the standpoint of achievement, tests showed that sensorization was not as satisfactory as the socialization method.[13]

Another study referring to methods and teaching of arithmetic to mentally retarded children was made by Anne Dawe. In her ten-year survey (1948-1957) of literature on curriculum and methods including approximately twenty journals as well as six hundred books and pamphlets and articles, she found that not a single article on the teaching of arithmetic to mentally retarded children had appeared since 1948.[14]

In 1954 Capobianco gave arithmetic tests to two groups--exogenous and endogenous--of mentally retarded children.[15] For his research, institutionalized subjects were matched according to chronological age and mental age. Using covariance to control for length of institutionalization, he found no significant differences on the battery of arithmetic tests between the endogenous and exogenous groups in general achievement in arithmetic, reversal errors, zero errors or work habits. It was expected that exogenous mental defectives would have difficulty in learning arithmetic, but the results of Capobianco's study did

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[13] Ibid. p. 41.

[14] Ann Dawe, "Progress in Curriculum and Method with Mentally Handicapped Children," American Journal of Mental Deficiency, LXIV (July, 1959), p. 22.

[15] Apparently Dawe overlooked this study by Capobianco which was published in 1954.

not support this hypothesis.[16]

Three investigations were related to the reasoning methods and reasoning abilities in normal and mentally retarded children. Jones, Merrill, Dunn and Cruickshank found in studying achievement on standardized arithmetic tests that the retarded did not differ significantly in arithmetic computation. In regard to the reasoning tests, Dunn and Cruickshank found that normal children surpassed retarded children. Cruickshank showed that normal subjects were superior to the retarded in abstract and verbal problems, understanding of operations required for solution in arithmetic problems, explanation of practical situations in which arithmetic terms are encountered and an arithmetic vocabulary. In another approach dealing with normal and retarded subjects of comparable mental ages, Merrill compared retarded subjects to the test norms for children in the normal population who had chronological ages comparable to the mental age of the retarded. She utilized the Revised Stanford-Binet, and found that in arithmetic, reading and spelling there were no significant differences between the over-all scores obtained by the

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[16]Rudolph J. Capobianco, "Quantitative and Qualitative Analysis of Endogenous and Exogenous Boys on Arithmetic Achievement," Monographs of the Society for Research in Child Development, (Lafayette, Indiana: Child Development Publications, XIX, Serial No. 58, No. 1, 1954), pp. 100-140.

two groups.[17]

Klausmeier, Feldhusen and Check undertook research in conjunction with the Department of Health, Education and Welfare on learning efficiency in arithmetic of mentally retarded children. This was a study dealing with 120 boys and girls, divided into three groups according to intelligence. There were 40 with a low intelligence quotient, 40 average, and 40 with a high intelligence quotient. Evidence strongly suggested that no difference exists in retention of arithmetic learning among children of low, average, and high intelligence when the learning task is graded to each child's current achievement level and retention is measured in units of practical arithmetic exercises or in time to learn or relearn to solve a novel arithmetic problem.[18]

These studies which are limited in scope as well as in number are a worthwhile beginning but serve to point up the need for additional research.

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[17]Rudolph J. Capobianco et al., An Investigation of 1. The Reasoning Methods and Reasoning Ability in Normal and Mentally Retarded Girls, and G. Orville Johnson, 2. The Reasoning Ability of Normal and Mentally Retarded Boys and Girls (Syracuse: Syracuse University Research Institute, 1958), pp. 6-7.

[18]Herbert J. Klausmeier, John Feldhusen, and John Check, An Analysis of Learning Efficiency in Arithmetic of Mentally Retarded Children in Comparison with Children of Average and High Intelligence (Wisconsin: School of Education, University of Wisconsin, August, 1959), p. 126.

Audio-Visual Instruction

Most of the major contributors to the field of special education have stressed the use of the senses as applied to the learning process of the mentally retarded child. Published research referring to the educable mentally retarded and the use of audio-visual material is quite limited. Only large metropolitan cities such as New York, Denver, Chicago and Detroit issue lists of suggested audio-visual materials for special class teachers. There is a dearth of research in film education with retarded pupils.[19]

One study was undertaken by Mahoney and Harshman, using a control and visual group to measure the value of the sound film in teaching a unit on social studies. The evidence obtained from a comparison of percentage gains in test scores indicated a positive value of using the sound film in teaching a unit in social studies to retarded children. In addition to the actual test results, there was in the visual group an improvement in interest, attendance, and ability in self-expression.[20]

Audio-visual materials not only aid learning, but they also extend and enrich the child's experiences. They

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[19]Edward Goldstein, Selective Audio-Visual Instruction for Mentally Retarded Pupils, (Springfield, Illinois: Charles C. Thomas, 1964) p. 47.

[20]Agnes Mahoney and H. L. Harshman, "Sound-Film Experiment with Handicapped and Retarded Pupils," Educational Screen, XVIII, No. 10, December, 1939) p. 373.

help to stimulate the child, add to his field of information, and foster retention. By stimulating several senses simultaneously, dynamic impressions are created and the possibilities of retention are strengthened. In addition Kearney relates:

> The end product of a teaching-learning experience is dependent upon the skill of the teacher in using available materials, be they books, films, slides, field trips or teaching machines. There are thousands of children who are more knowledgeable because they have been taught by teachers who provided them with creative, imaginative, and concrete learning experiences. Any concrete learning experience is an audio-visual experience.[21]

As the educational horizon expands there is the need to provide teachers with better equipment, and with new learning and teaching aids. Among the latest of these are projected materials. They catch the children's attention and create a feeling of excitement, and thus promote quick learning and good retention. Price says that the retarded child does adapt to programmed learning and appears to make as much progress as with conventional teaching methods and in less time.[22]

If the teachers are well prepared, the teaching is likely to be effective in helping pupils attain the goals of the school. But the most effective teacher is one who keeps her planning and instruction in tune with the new

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[21]William Kearney, "Value of A-V Materials, " The Instructor, LXXI (June, 1962), p. 46.

[22]James E. Price, "Automated Teaching Programs with Mentally Retarded Students," American Journal of Mental Deficiency. LVIII (July, 1963), p. 72.

audio-visual materials.

Since audio-visual instruction offers an experimental basis for learning, learning is more meaningful. In contrast to the symbols, audio-visual materials are much more like real-life experience. The direct appeal, by producing strong interest and clear meaning, increases the retention of what has been learned. Because of their short attention span and limited ability to concentrate, retarded children will learn more rapidly from audio-visual materials than from textbooks or lectures.[23] Projected materials motivate by stimulating and awakening pupil interest and activity. Hoban tells us:

> Projected materials maintain interest and attention of every individual. These experiences result in increased enrichment and retention, besides making work more enjoyable and meaningful.[24]

One of the functions of audio-visual materials is to provide experience, more or less direct, whereby a child can build up his storehouse of meanings. Audio-visual materials can make these meanings more exact and concrete.

In some cases it is believed that the teaching of facts has been more efficient by audio-visual aids than by traditional teaching methods. Wendt explains:

An outstanding value of audio-visual materials is

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[23]Malinda Dean Garton, Teaching the Educable Mentally Retarded (Springfield, Illinois: Charles C. Thomas, 1962), p. 127.

[24]Charles F. Hoban, The Audio-Visual Way (Talahassee, Florida: State Department of Education, Bulletin No. 22B, 1948), p. 44.

> that the learning acquired through them is retained for a significantly longer period than the learning acquired by purely verbal teaching. The information acquired through audio-visual instruction tends to be retained longer.[25]

If this be the case--that audio-visual aids will help the child retain longer what he learns--the teacher should give serious consideration to these materials.

It is well to remember that audio-visual materials should not be used as single teaching method. In teaching retarded children, these procedures cannot take the place of instruction by the teacher. Audio-visual materials are of value only when used as an integral part of the instructional process.

In a recent book Goldstein notes that research is needed to explore the effects of audio-visual aids such as filmstrips, recordings and educational television on educable retarded children.[26]

Summary

This review of literature on the teaching of mathematics to the mentally retarded and the survey of research that has been undertaken in this area seem to indicate a need for further study of this important phase of

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[25]Paul R. Wendt, Audio-Visual Instruction (Washington D. C.: National Education Association, 1957), p. 10.

[26]Goldstein, p. 65.

education--the procedures and processes in teaching and learning arithmetic.

Although audio-visual aids have received widespread use in education, experimental evidence of their value as an aid in teaching academic subjects to retarded children is limited. Scientific studies involving their use in teaching arithmetic and an evaluation of their worth on the basis of standardized tests appear to be non-existent.

CHAPTER III

EXPERIMENTAL PROCEDURE

Restatement of the Probelm

This experimental study was undertaken to determine the effect of a specialized teaching device on the arithmetic achievement of mentally retarded children. Because of the mentally retarded child's slow educational development, much ingenuity is needed on the part of the teacher to present arithmetic facts orally, kinesthetically, and visually, for repetition is an integral factor in the academic program. It is necessary for the teacher to take into account the child's inability to deal with abstractions and his limited power to transfer learning. The purpose of this study was to determine whether there is a significant difference in the arithmetic achievement of mentally retarded children using a specialized teaching device--the Math Builder--and a matched group of retardates using a traditional flash card drill method.

Population

The population was selected from Saint Maurice School, a private day school located in Potomac, Maryland. Twenty-six children participated, 13 in the experi-

mental group and 13 in the control group. The experimental group consisted of seven girls and six boys while in the control group there were four girls and nine boys. Both groups were taught by the writer.

Testing Program

To establish criteria for the selection of an experimental and control group, a standardized intelligence test and an arithmetic achievement test were administered.

The Stanford Binet Intelligence Test, Form L-M, was the intelligence test used. The range of mental ages for the experimental group was 7 years 2 months to 9 years 6 months; for the control group, 7 years 4 months to 9 years 8 months. The intelligence quotients derived from the test were used in equating the two groups.

The Stanford Achievement Arithmetic Test, Elementary Form J, was given to measure the arithmetic achievement of the children in the study. Achievement test results were used as a basis for grouping for instructional purposes.

The Stanford Achievement Arithmetic Test, Elementary Form K, was administered at the completion of the experiment. Results from this test were compared with results from initial tests to determine the amount of progress made.

Equivalency of Experimental and Control Groups

Table 1 presents the data showing the equivalency of the experimental and control groups in mental age, intelligent quotient, and initial arithmetic test scores. On the variable of mental age, the obtained t-ratio of .77 indicates no significant difference between the two groups. The obtained t-ratio of 1.61 between intelligence quotients for the experimental and the control groups indicates no significant difference between the groups. On the variable of initial arithmetic achievement the obtained t-ratio of .11 again indicated no significant difference between the groups.

Though the control group enjoyed slight superiority in two of the three variables, differences between the means were all statistically insignificant. It is apparent that the two groups were comparable in all pertinent variables and were thus suited for experimental purposes.

Procedure for Experiment

The experimental procedure consisted of presenting the arithmetic facts to the control and experimental groups in the same manner. The dependent variable was introduced in the type of drill used. The Math Builder was the device used with the experimental group. For the control group the abacus and flash cards were utilized for drill purposes.

TABLE 1

CHARACTERISTICS OF THE EXPERIMENTAL AND CONTROL GROUPS

INITIAL TESTING

Variable	Test used	Group	Range	Mean	S.D.	$S.E._M$	Diff.	$S.E._{D_M}$	t-ratio	Confidence level
I.A.	Stanford Binet	E	86-114 mos.	98.23	8.2	2.37	.54	.70	.77	Insignificant
		C	88-116 mos.	97.69	8.7	2.51				
I.Q.	Stanford Binet	E	54-83	70.23	9.10	2.63	2.46	1.53	1.61	Insignificant
		C	57-86	72.69	9.50	2.75				
Arith. Scores	Stanford Achievement	E	2.2-3.6	2.93	.39	.11	.02	.13	.11	Insignificant
		C	2.0-38	2.92	.54	.16				

A special room was set up and used specifically for this experiment. Both groups came to this room each day for the teaching and drilling of the arithmetic processes. The fact that both groups of children left their classrooms and came to this special room was in itself a motivating factor.

Over and above the progress made by the experimental and control group during the experiment was the gradual development in responsibility seen in both groups. That they looked forward eagerly to their special class period was evidenced by their exactness in reporting directly to the assigned classroom for the experiment. The children in this research came from five different classrooms, and all were responsible about leaving their classroom on time for this arithmetic period. It is felt that over-all progress was made, in addition to arithmetic achievement.

The experiment was conducted over a period of twenty weeks. A twenty-minute period per day was devoted to the teaching or drilling of the arithmetic facts to the experimental and control groups.

For both the experimental group and the control group the same addition, subtraction, multiplication and division facts were presented. The method of drill for the experimental group was the use of the Math Builder. This device is a filmstrip projector which presents arithmetic number facts or story problems at controllable

rates. There is a special masking control which makes it possible to cover the answer varying the type of drill. Each filmstrip contains exercises for both oral and written responses. Along with serving as a motivating factor the Math Builder also helps the child to focus his attention and concentrate. Although the number facts are presented at controllable rates, accuracy was stressed during the experiment, not speed.

In the beginning of the research project, the experimental group had to be reminded many times to focus attention on the screen or they would miss the problem. By the end of the twenty-week period the group as a whole concentrated much better and the facts could be flashed at a much more rapid pace.

If the teaching lesson had to be prolonged for a better understanding of the facts and the drill on the Math Builder had to be delayed until the next day, the children showed a real disappointment in not using the machine. On some occasions the children requested to stay over time. Thus, the group did show a real interest in learning arithmetic and also seemed to enjoy it.

The arithmetic filmstrips are composed of three sections, two for oral responses and one for written. In the beginning the films were presented at the lowest speed, and as the weeks went by it was gradually in-

creased. It was not the purpose in this experiment to increase speed, but it was felt that this was an asset to the children in being able to respond quicker.

All of the facts on the filmstrips are horizontal. It was felt that this might cause difficulty when approaching carrying and borrowing, but it did not present a problem to the children. In general the processes of carrying and borrowing were the most difficult, but once they had a complete understanding they did very well on the filmstrips.

Since this experiment was limited in time, and progress was made up to the fives in multiplication and division, it is felt that had it been carried on for a longer period, the children would have continued making progress in mastering the facts.

For the experimental group and the control group the beginning of the program moved very quickly, for this was familiar work. After the facts 1 to 10 were drilled thoroughly, the teen facts were presented. Although this was more challenging everyone mastered them. The greatest difficulty for the control group children involved the processes of carrying and borrowing. Multiplication tables and short division were taught up to the fives. This group utilized flash cards and the abacus for drill.

Although the control group did not have the extra motivation of the machine, the other materials held their

interest and all subjects derived enjoyment from it. Many activities and games were devised with the flash cards and abacus. For the teens the numbers 1 to 20 were printed on cards and passed out. A child would call out his number, saying: I am 7, who can make me 13? It was up to number 6 to respond. For multiplication and division a quiz program was introduced. One child was selected as the leader and manipulated the flash cards. Another child kept the score. These are only two of the many activities and games that were utilized during the experiment. At the termination of the twenty-week period the children could use these instruments very profitably, and needed much less drill time.

At the end of the experiment both groups were retested with the Stanford Achievement Arithmetic Test, Form K.

Summary

This chapter included a statement of the purpose of the study and listed the various characteristics of the sample population. The tests administered to the two groups were described. The results of the initial testing established the equivalency of the experimental and control groups. Procedure for the experiment was explained.

CHAPTER IV

INTERPRETATION OF THE DATA

This experimental research was undertaken to study the effect of a specialized teaching device utilized for drill, on the arithmetic achievement of mentally retarded children.

Results of initial testing indicated that there were no statistically significant differences in mental age, intelligence quotient, and arithmetic achievement between the experimental and control groups.

Necessary data for this study were secured through standardized test procedures. Tables were prepared to show the statistical results of this investigation and to summarize the initial and final comparisons between the experimental and control groups.

For each set of tests the mean, standard deviation, standard error of the mean, difference between means, standard error of the difference of the means, and the t-ratio were found. Arithmetic gains were also compared.

Sample Population

The experimental and control groups each consisted of thirteen children who were given twenty weeks

of instruction in arithmetic with special emphasis on the type of drill used. All of the children remained in their groups until the end. There were no drop-outs or transfers.

Pupils of both the experimental and the control groups were tested initially and finally by the writer to ascertain progress made in arithmetic achievement during the course of the experimental period.

Final Arithmetic Scores of Experimental and Control Group

Table 2 illustrates the difference between the experimental and the control groups at the time of the final testing. The range of arithmetic grade scores for the experimental group was from 3.3 to 4.5. The range of arithmetic scores for the control group was from 2.4 to 4.5.

The final test shows the mean arithmetic grade score for the experimental group is 3.80 with a standard deviation of .35. The mean arithmetic grade score for the control group is 3.42 with a standard deviation of .61. The mean difference of over three and one half months in arithmetic grade scores favors the experimental group, and as shown by a t-value of 2.83, is significant at the .01 level of confidence.

TABLE 2

FINAL ARITHMETIC SCORES,

EXPERIMENTAL VS. CONTROL GROUPS

Group	Range	Mean	S.D.	$S.E._M$	r	Diff.	$S.E._{D_M}$	t-ratio	Confidence Level
Experimental	3.3-4.5	3.80	.35	.101	.65	.38	.134	2.835	.01
Control	2.4-4.5	3.42	.61	.176					

Analysis of Initial and Final Test Results

At the close of the experimental period, Form K of the Stanford Achievement Arithmetic Test was administered to both groups, experimental and control. When the initial and final test scores were compared and evaluated, there was a gain in favor of the experimental group, statistically significant at the .001 level of confidence.

Table 3 presents statistical data comparing initial and final arithmetic scores for both experimental and control groups. The arithmetic grade scores for the experimental group ranged from 2.2 to 3.6 in the initial testing with a mean of 2.93, and a standard deviation of .39. The range of arithmetic scores at the final testing was from 3.3 to 4.5 with a mean of 3.80, and a standard deviation of .35. The mean difference was .87 almost nine months in arithmetic achievement. The obtained t-value of 19.77 indicated significance of the difference at the .001 level of confidence.

From the data of the experimental group it was concluded that the experimental procedure was successful in promoting arithmetic achievement.

The control group's range in arithmetic grade scores for the initial testing was from 2.0 to 3.8, with a mean of 2.91, and a standard deviation of .54. The final arithmetic grade scores ranged from 2.4 to 4.5 with a

TABLE 3

COMPARISONS OF INITIAL AND FINAL ARITHMETIC SCORES

EXPERIMENTAL AND CONTROL GROUPS

Group	Test	Range	Mean	S.D.	$S.E._M$	r	Diff.	$S.E._{D_M}$	t-ratio	Confidence Level
E	Initial	2.2-3.6	2.93	.39	.113	.92	.87	.044	19.77	.001
	Final	3.3-4.5	3.80	.35	.101					
C	Initial	2.0-3.8	2.91	.54	.156	.89	.51	.080	6.37	.001
	Final	2.4-4.5	3.42	.61	.176					

mean score of 3.42, and standard deviation of .61. The mean difference was five months. The obtained t-value of 6.37 indicates that the difference is significant at the .001 level of confidence.

Though the children included in the control group did not follow the experimental procedure they were supplied with a good drill and presentation of the number facts as is evident by the significant difference between original and final scores.

Summary

In interpreting the data, the scores obtained on the arithmetic tests given initially and finally to both groups were compared. The findings indicated a significant improvement for both the experimental and control groups, but in addition to this the experimental group showed a statistically significant gain over the control group in arithmetic achievement as measured by the Stanford Achievement Arithmetic Tests, Forms J and K. It can be tentatively assumed that this difference is accounted for, at least in part, by the audio-visual device used with the experimental group.

CHAPTER V

SUMMARY

The purpose of this study was to determine the effect of a specialized teaching device on the arithmetic achievement of mentally retarded children.

The objectives considered in the development of this study were:

1. To provide training in developing accurate responses to the basic number facts.
2. To afford practice with the basic number facts as met by the child in everyday experiences of his life.

Initial tests were administered in order to equate the groups on the basis of mental age, intelligence quotient and arithmetic achievement. The experiment extended over a period of twenty weeks. During this period, both the experimental and the control groups received equal amounts of practice and drill of the arithmetic facts. Both groups were presented the facts in the same way, but the method of drill, the use of the Math Builder, was the variable in this experiment. For the experimental group the Math Builder was utilized and the control group used flash cards and the abacus for the variable of the drill.

From the final results obtained in this research, it would appear that the experimental variable was the cause of the difference favoring the experimental group's greater gain at the end of the study.

Conclusions

The analysis of data was made by statistically comparing scores obtained by the experimental and control groups. Results of the Stanford Achievement Arithmetic Test were analyzed and comparisons were made between the two groups. When the initial and final scores on the arithmetic tests were compared and evaluated it was found that while both groups made statistically significant gains in arithmetic, these gains were decidedly in favor of the experimental group.

The experimental and control groups were equal in arithmetic achievement at the beginning of the study. After a twenty-week period the experimental group had achieved a mean arithmetic grade score of 3.80 as compared with a mean grade score of 3.42 achieved by the control group.

The resulting mean difference may be attributed to the variable of the Math Builder device which was utilized for the experimental group throughout the study.

Educational Implications

The investigation demonstrated the desirability of providing a motivating drill for reinforcing arithmetic facts in order that pupils may more adequately master these

facts.

A highly motivating factor such as the Math Builder used in this experiment may prove particularly useful for retarded children.

This study gave evidence that a program of highly motivated drill can take place without additional class time and without any change in the organization of classes.

Limitations

Various factors limit the conclusions made in this study. The size of the sample is one of the factors. Each of the groups was composed of a small number of subjects; consequently the findings are less significant than those from a large sampling.

Mentally retarded children do not perform to the best of their ability under test conditions. Children with brain damage may test lower than their level of actual classroom achievement because of the tendency to be distracted by changed circumstances.

Another limiting factor is the time element. Twenty weeks is a relatively short period for an experiment of this kind.

Suggestions for Further Research

For further research it is suggested that an arithmetic study be undertaken that will include a more intensified program whereby the Math Builder device will

be utilized over a period of three years with a group of educable mentally retarded children.

The possibilities of research involving techniques and motivating factors that are suitable for teaching arithmetic to the mentally retarded are limitless.

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APPENDIX I

CUMULATIVE TEST DATA

TEST RESULTS OF THE EXPERIMENTAL GROUP

Pupil	M.A. (mos.)	Stanford Binet I.Q.	Stanford Achievement Arithmetic	
			Initial	Final
1.	92	59	3.0	3.9
2.	106	63	2.6	3.4
3.	86	54	3.3	4.2
4.	110	83	2.9	3.8
5.	90	83	2.5	3.3
6.	90	70	3.0	3.8
7.	96	76	2.2	3.4
8.	104	64	3.6	4.5
9.	94	73	2.6	3.6
10.	98	66	3.3	4.2
11.	103	76	2.8	3.5
12.	114	82	2.8	3.8
13.	94	64	3.5	4.0

TEST RESULTS OF THE CONTROL GROUP

Pupil	M.A. (mos.)	Stanford Binet I.Q.	Stanford Achievement Arithmetic	
			Initial	Final
1.	90	57	3.8	3.9
2.	104	66	2.9	3.5
3.	90	57	3.7	3.8
4.	110	83	3.1	3.9
5.	90	86	2.5	3.0
6.	88	67	3.0	3.5
7.	96	76	2.0	2.4
8.	104	73	3.1	3.9
9.	94	64	2.3	2.4
10.	96	76	3.6	4.5
11.	104	79	2.7	3.0
12.	116	86	2.9	3.8
13.	88	75	2.3	2.9

APPENDIX II

SAMPLES OF TESTS ON THE MATH BUILDER FILMSTRIP AND TEACHER-MADE TESTS

Following are a sample of the tests that were given to both the experimental and control groups. The filmstrip tests were used for the experimental group; the control group had a teacher-made test of the same problems as on the filmstrip. It can be observed here that these facts presented on the filmstrips are all horizontal. Although this could have presented a problem, due to the fact that most arithmetic books have the facts vertically, the children did not find reading the facts in this position difficult. It also can be noted here that due to the fact of the moving filmstrip, the children in the experimental group read the problems to themselves and only wrote the answers. They did not have the advantage of going back to a problem again as did the children in the control group. Both groups had a test once a week. Before beginning the multiplication and division exercises a teacher-made test was devised to check on the addition and subtraction facts, especially carrying and borrowing. A teacher-made test was given on multiplication and division through the fives which brought the experiment to a close. For the purpose of finding if there was a gain in arithmetic scores the Stanford Achievement Test, Form K was administered.

MATH BUILDER

FILMSTRIP 4 ADDITION TEST

January 29, 1965

1 + 6 =	0 + 9 =
4 + 4 =	6 + 4 =
8 + 2 =	8 + 1 =
9 + 0 =	0 + 7 =
7 + 2 =	7 + 3 =
5 + 4 =	5 + 3 =
4 + 3 =	4 + 5 =
6 + 3 =	3 + 6 =
2 + 6 =	0 + 8 =
1 + 8 =	3 + 7 =

MATH BUILDER

FILMSTRIP 6 ADDITION TEST

February 26, 1965

77 + 5 =	75 + 6 =
61 + 7 =	68 + 9 =
80 + 1 =	98 + 1 =
53 + 6 =	55 + 4 =
84 + 7 =	73 + 3 =
63 + 8 =	91 + 8 =
96 + 2 =	86 + 4 =
72 + 8 =	54 + 9 =
58 + 2 =	89 + 5 =
92 + 5 =	66 + 3 =

MATH BUILDER

FILMSTRIP 9 SUBTRACTION TEST

March 19, 1965

12 - 8 =	13 - 6 =
11 - 7 =	13 - 9 =
16 - 7 =	17 - 9 =
15 - 9 =	12 - 5 =
16 - 9 =	14 - 7 =
12 - 6 =	11 - 5 =
13 - 8 =	14 - 9 =
15 - 8 =	11 - 6 =
15 - 6 =	13 - 4 =
11 - 2 =	11 - 8 =

MATH BUILDER

FILMSTRIP 11 SUBTRACTION TEST

April 9, 1965

76 - 8 =	69 - 4 =
65 - 6 =	92 - 7 =
88 - 8 =	54 - 4 =
51 - 4 =	98 - 6 =
93 - 5 =	85 - 8 =
71 - 3 =	79 - 3 =
87 - 8 =	90 - 6 =
64 - 6 =	60 - 8 =
82 - 9 =	96 - 9 =
75 - 7 =	73 - 5 =

TEACHER-MADE TEST

ADDITION AND SUBTRACTION

April 12, 1965

6 +1	7 -4	4 +4	9 -3	2 +7	7 -5	4 +5	8 -3
8 +4	11 -4	5 +6	18 -9	4 +7	12 -7	6 +6	14 -6
15 -8	8 +3	14 -8	9 +8	15 -6	7 +9	11 -9	6 +7
51 +9	25 -9	84 +1	17 -7	72 +6	43 -5	53 +2	13 -8
92 -8	68 +8	73 -6	67 +9	34 -8	79 +8	23 -9	55 +3
65 +7	25 -8	85 +6	36 -9	74 +6	23 -8	58 +7	45 -9

MATH BUILDER

FILMSTRIP 13 MULTIPLICATION TEST

April 30, 1965

2 x 8 =	4 x 3 =
3 x 4 =	1 x 9 =
1 x 6 =	3 x 2 =
5 x 6 =	4 x 8 =
3 x 8 =	4 x 2 =
4 x 4 =	2 x 7 =
4 x 5 =	5 x 8 =
5 x 5 =	3 x 9 =
1 x 4 =	5 x 2 =
5 x 0 =	5 x 3 =

MATH BUILDER

FILMSTRIP 17 DIVISION TEST

May 14, 1965

36 ÷ 4 =	40 ÷ 5 =
7 ÷ 1 =	3 ÷ 3 =
4 ÷ 4 =	9 ÷ 3 =
2 ÷ 2 =	6 ÷ 3 =
24 ÷ 4 =	12 ÷ 3 =
45 ÷ 5 =	8 ÷ 4 =
8 ÷ 1 =	18 ÷ 3 =
12 ÷ 2 =	35 ÷ 5 =
20 ÷ 4 =	28 ÷ 4 =
18 ÷ 2 =	10 ÷ 2 =

TEACHER-MADE TEST

MULTIPLICATION AND DIVISION

May 17, 1965

3 x2	9 x4	3 x3	8 x1	9 x2	0 x2
7 x3	6 x2	4 x5	4 x2	6 x4	5 x3
7 x5	6 x3	9 x5	1 x5	7 x4	5 x2

$5\overline{)5}$	$5\overline{)10}$	$2\overline{)8}$	$4\overline{)12}$
$3\overline{)15}$	$1\overline{)1}$	$4\overline{)16}$	$5\overline{)30}$
$3\overline{)27}$	$5\overline{)15}$	$2\overline{)16}$	$2\overline{)14}$
$2\overline{)4}$	$3\overline{)12}$	$5\overline{)20}$	$2\overline{)6}$
$1\overline{)9}$	$5\overline{)25}$	$3\overline{)24}$	$4\overline{)32}$

APPENDIX III

SAMPLE LESSON PLAN

SAMPLE LESSON PLAN

Objective:

To introduce borrowing in subtraction.

Procedure:

1. Give a rapid review of fundamental subtraction facts to insure mastery of these.
2. Review subtraction of two-place numbers.
3. Introduce borrowing from the tens' place.

Bundles of sticks will be utilized so the children can watch the procedure. The children will also use the bundles several times to become more familiar with the idea "take away" or borrowing.

After several children manipulate the bundles, write the problem on the chalkboard.

Explain the change in the minuend, and if the children seem to need it show them the crutch of crossing out and writing in the number.

$$\begin{array}{r} 5\ 13 \\ \not{6}\ \not{3} \\ -2\ \ 8 \\ \hline \end{array}$$

Drill:

Experimental Group - using the Math Builder will be drilled for the beginning procedures of borrowing on filmstrip no. 11. The first part of the filmstrip will be done together, with all the children answering together. For section two of the filmstrip the children will take turns answering to give an insight into each child's understanding. Then the children will write the responses and we will check each answer for accuracy before proceeding to the next fact.

Control Group:

Examples involving borrowing will be written on the chalkboard and the children will write it on their papers, but will show the process of borrowing on their abacus's before writing the answer. A ditto sheet will be passed out in which we will work together, to make sure there is a thorough understanding of the process of borrowing.

Musical Activity: (At Music Time)

Song steps in borrowing.

Tune - "Farmer in the Dell."

1.

If you would like to take
A unit that is great
From a smaller unit,
Then you'd better hesitate.

2.

Suppose the question reads
"15 from 34"
Well, 5 from 4 you cannot take,
So you must go next door.

3.

To tens' house you must turn
Politely knock and say,
"May I please borrow just one ten
To do this work today?"

4.

Then back to Units' house
You proudly take that ten;
You change it to ten units,
And then start your work again.

5.

You add the ten to four,
The number's now 14;
And 5 from 14 leaves a 9
As you have always seen.

6.

Then back you go to tens,
And, oh, remember, do,
That you've already borrowed
So it now is 1 from 2.

7.

You write the answer then,
How quickly it was done;
Don't you all agree with us
That borrowing is fun?[1]

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[1]Sister M. Rose Anita, I.H.M., Progress in Arithmetic, Grade 3 Teacher's Manual and Key, (Chicago: William H. Sadlier, Inc., 1958).

APPENDIX IV

PHOTOGRAPH OF MATH BUILDER