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The Extent of Transfer of Learning in Simple Addition and Substraction

Cecilia Helen O'Brien
Loyola University Chicago

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THE EXTENT OF TRANSFER OF LEARNING IN SIMPLE ADDITION AND SUBTRACTION

BY

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A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Arts in Loyola University

1935
VITA

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CHAPTER I

THE PURPOSE OF THE STUDY

The purpose of this experiment is threefold: first, to present the opinions of the outstanding psychologists on the existence and nature of transfer; secondly, to summarize the experimental studies of transfer in mental functions, particularly, some of the experiments performed in arithmetic; thirdly, to conduct a controlled experiment in an attempt to measure the extent of transfer of training in addition and subtraction.

The aim of the experimental study is to determine:

1. The number of combinations the pupils in the experimental group will know after a period of eight weeks when given practice only on a portion of the sixty-four addition and corresponding sixty-four subtraction combinations.

2. Whether a method of teaching employing generalization is more or less effective in promoting transfer than a method which gives the same amount of time to formal drill.
The experiment was conducted in the second grade of a Chicago Public School. The school is located in a colored section of the city. The children have the advantage of coming from homes whose families represent the better class of their race.

Before conducting the experiment, the first step was to test the pupils by means of intelligence tests and arithmetic tests. Standardized tests, planned especially for use in the primary grades, were used to measure intelligence. The tests in arithmetic contained four parts: two tests in addition and two tests in subtraction. The average of the scores on the intelligence tests, the average of the scores in arithmetic tests, and the chronological age of the pupils were used as the basis for equating the groups.

After pairing the pupils into groups, the actual teaching took place. The method used for the control group was based on the assumption that children learn only the simple combinations on which they are drilled and they must, therefore, be taught all of the sixty-four combinations. This method is advocated by the bulletin of the Bureau of Curriculum (29:8) of the Chicago Public Schools in "A Course of Study in Arithmetic." It will not suffice to teach forty-five primary addition facts as was once thought, as there are 100 such associations to be mastered. It is no longer
assumed that the pupil who has learned to associate 13 with 6 plus 7 will respond "13" to the suggestion "7 plus 6." The method used for the experimental group was based upon the theory that if pupils learn the direct number combinations they will also recognize the reverse combinations through association. Also, that a few minutes spent each day in generalizing groups of combinations will be of more value to the pupils in learning the combinations than the same amount of time spent in drill.

During the experiment an effort was made to keep all factors identical for both groups, except the differences in the method used in teaching the combinations and the number of combinations taught. Both groups were taught by the same teacher. The control group was never present when the experimental group was being taught nor was the experimental group present in the room when the control group was taught. All written arithmetic was done in the classroom under the supervision of the teacher.

The third and last step in the study was to compare the amount of gain made by each group, and on the basis of the results obtained to ascertain the value of the two techniques used in teaching.
CHAPTER II

HISTORICAL AND EXPERIMENTAL SURVEY OF TRANSFER OF TRAINING

Transfer of training or formal discipline has always been of tremendous importance to educators. Whipple (117-1) believes is to be the central problem of educational psychology, while Buckingham (21:352) holds it to be the central problem of teaching. Despite Charters' (28:23) claim that in modern education it occupies an unenviable position because it has not added any new subject to the course of study and has probably added no new methods of instruction, Starch (99:219) contends that each year it appears as one of the three or four most perplexing questions in education. Many significant issues in school administration, in curriculum construction, and in the various aspects of school subjects, in fact, the final end of education, depend essentially upon the attitude of educators toward the question of training and mental discipline.

The original doctrine of transfer of training or formal discipline was generally accepted at the close of the seventeenth and the beginning of the eighteenth century. The
psychologists at that time held that the mind was divided into separate faculties or powers such as memory, attention, perception, will, reasoning, and so forth. Each faculty was considered to be a general power or capacity which possessed a definite unity and was more or less independent of the other faculties. The separate faculty could be educated or trained in its entirety and the knowledge acquired could be stored away, in the reservoir of the mind, to be utilized when needed in the same manner that the athlete, who developed his muscle through chopping wood, later uses the developed muscle in rowing or in playing baseball.

The term "formal" expressed the idea that it is the form of the activity, and not the subject matter or its contents, that is important in education. The real spirit of the theory is contained in the word "discipline," which means that a retentive memory, an inflexible will, a pure and impersonal judgment and reason are to be secured only by severe and full exercise of the faculties.

Training was considered to be general; that is, the mental power or mastery gained in one situation could be applied to any other field which called for the functioning of such power or mastery. Training in mathematical reasoning made one better able to reason in other fields such as law, politics, or in religion.
In order to train a faculty, the individual was trained to cope with all the situations in which this faculty appeared. Those school subjects, therefore, which were supposed to have a high transfer or disciplinary value — that is, the ones which trained best the largest number of faculties — were given the preference in the curriculum. The study of Latin was selected, as it was thought to train the powers of observation, comparison, and synthesis; the pursuit of mathematics gave command of attention, and resulted in strengthening and training the reasoning powers. These subjects were considered very important because they are difficult to learn and require a great deal of effort to master them.

Charters (27:12) gives the credit to Locke, philosopher and psychologist, as the one who "crystallized the idea, germs of which are found scattered throughout the writings of the great educators before his day, that mental training can be transferred from one subject to another." If Locke were a believer in formal discipline, many of his theories are not in harmony with formal disciplinists, according to Horne (43:81), for he rejected the "discipline" he received at Westminister and at Oxford. He also opposed the writing of Latin themes. On memory he writes:

The learning pages of Latin by heart no more fits the memory of one substance of anything
else than the graving of one substance in lead makes it the more capable of retaining firmly any other characters.

I hear it said that children should be employed in getting things by heart to exercise and improve their memories. I could wish this were said with as much authority of reason as with forwardness of assurance and that this practice were established upon good observation more than old custom. For it is evident that strength of memory is owing to a happy constitution and not to any habitual improvement got by exercise (60:176).

Prior to 1890 no experimental study of the problem of mental discipline had been made by the formal disciplinists to prove their assertions that the improvement in one special power means equal improvement in general, nor was there any attempt made to disprove the theory by those who questioned it. The attack on the problem was really started when James (45:666-68) made his pioneering experiment in 1893 of non-transference of memory. While the results of his experiment were not of much educational importance, because of the faulty technique, still it is of interest and importance because of its historical value, in that it opened the avenue of experimental approach to the problem of transfer. James' experiment was followed by one by Bergstrom (10:33-42) in 1894 and by Gilbert and Fracker (38:62-76) in 1897. Then the more elaborate and more significant work of Thorndike and Woodworth (105:236-61) appeared in 1901. The problem which Thorndike and Woodworth sought to determine was "The Influence of Training in One Mental Function upon the Efficiency of Other Func-
The conclusions reached by these authors were:

- Improvement in any single function need not improve the ability in functions commonly called by the same name. It may injure it.
- Improvement in any single mental function rarely brings about equal improvement in any other function, no matter, how similar, for the working of every mental function-group is conditioned by the nature of the data in each particular case.

In other words, the authors found that the amount of transfer was very limited even in mental functions which are very much alike, and as a result concluded that mental functions appear to be highly specific. In the writer's next chapter on "Modern Theories of Transfer of training," under the heading of "Methods of Securing Transfer," it will be pointed out that the fact these authors secured such a limited amount of transfer was due to the absence of the proper conditions favorable to transfer.

Regardless of the experimental evidence against formal discipline submitted by James (45:666-68) and Thorndike and Woodworth (105:236-61), there were still some psychologists and teachers who believed in it. Among them are such men as Roark (91:27), Morgan (66:192), Lodeman (61:104), and Babbitt (2:126), who remarks:

I wish to understand by mental discipline the exercise of some faculty of the mind, which results in increasing the power of readiness of that faculty.

Thomas (104:27) expresses the same idea regarding formal discipline:
The value of the study of German lies in the scientific study of the language itself, in the consequent training of the reason, of the powers of observation, comparison, and synthesis; in short, in the upbuilding and strengthening of the scientific intellect.

Some of these educators, according to Pressey (88:492-93) still adhered to the doctrine of formal discipline because certain subjects thought of as disciplinary were first put into the curriculum primarily for practical reasons. Latin was taught because it was the language of scholarship and the common medium of intellectual exchange. Mathematics was related to surveying and navigation. When conditions changed so that certain subjects no longer had any apparent usefulness, the teachers of foreign languages and of mathematics used the doctrine of mental training to vindicate their particular subjects in the curricula. At the present time, no subject has a place in the curriculum if its general disciplinary characteristic is the chief recommendation.

In spite of the evidence given in the quotations of Babbitt (2:126) and Thomas (104:27) supporting general belief in formal discipline, O'Shea (63:251) complains because he cannot get any formal disciplinists to say that any particular sort of mental activity will benefit the mind on every side. This same complaint is also voiced by Heck (40:125). Many of the psychologists who opposed the theory of formal discipline wrote as though they thought the formal disciplinists believed in equal transfer in all directions. Thorndike (106:80-85),
in his "Educational Psychology" of 1903, writes in this manner when he says:

The common view is that the words accuracy, quickness, discrimination, memory, observation, attention, concentration, judgment, reasoning, etc., stand for some real and elemental abilities which are the same no matter what material they work upon; that these elemental abilities are altered by special disciplines to a large extent; that they retain those alterations when turned to other fields; that thus in a more or less mysterious way learning to do one thing well will make one do better things that in concrete appearance have absolutely no community with it.

The mind is regarded as a machine of which the different faculties are parts. Experiences being thrown in at one end, perception perceives them, and so. By training, the machine is made to work more quickly, efficiently and economically, with all sorts of experiences. Or in a still cruder type of thinking, the mind is a storage battery which can be loaded, with will power or intellect or judgment, giving the individual a surplus of mind to expend.

But Thorndike did not approve of such a theory, for he says:

General names for a host of individual processes -- such as judgment, precision, concentration -- are falsely taken to refer to pieces of mental machinery which we can once for all get into working order, or still worse, to amounts of something which can be stored up in bank to be drawn on at leisure.

The explanation of the doctrine of formal discipline offered by Bagley (3:203-13) is similar to the one given by Thorndike. Bagley writes:

A pupil may acquire the specific habit of producing neat papers in arithmetic. The doctrine of formal discipline assumes that if this habit is once thoroughly established, this same habit will function equally well in similar situations. For example, a pupil may acquire the
specific habit of producing neat papers in arithmetic and, since it functions so successfully in this case, it cannot fail to insure neatness of person and dress; and that the habit of neatness thus ingrained upon the pupil will surely be carried over into mature years.

Bagley does not agree with this theory, for he condemns the idea of a "generalized habit," as the very essence of a habit is the specific character of its response. If habits were inclined to become generalized, neat adjustment in one activity would mean neat adjustments in all activities in all individuals. Since it holds with some individuals, but not with all, is sufficient to prove that the habit, as such, is not generalized (204 and 212).

Formal discipline is also denounced by Dewey (34:80) as another influential but defective theory which conceives that:

The mind has a birth, certain faculties or powers, such as perceiving, remembering, willing, judgment, generalizing, attending, etc., and that education is the training of these faculties through repeated exercise. This theory treats subject matter as comparatively external and indifferent, its value residing in the fact that it may occasion exercise of its general power.

In his "Educational Psychology" of 1913, Thorndike (112:358) writes that the notion of mental machinery, used by him in 1903 to explain transfer of training, would entirely misrepresent the standard view then current. The idea that the mind is a reservoir for potential energy which could be filled by any one activity and drawn on for any other, has now disappeared from the expert writings on psychology. Thorndike
holds that the psychologists' hopes of general mental discipline have shrunk to decidedly modest dimensions. To substantiate his claim, he selects random quotations from the writings of modern psychologists, the majority of whom are in favor of specific mental training. These quotations are in strong contrast to those given by Babbitt (2:126) and Thomas (104:27) in favor of general mental training. The opinion given by Horne (44:521) reads:

My business is not to give a general mental training by means of my subject, for that is not possible, but to give a specific mental training such as my subject affords.

Mental discipline is held by Heck (41:198) as

the most important thing in education, but it is specific, not general. The ability developed by means of one subject can be transferred to another subject only in so far as the latter has elements in common with the former.

The evidence from observation and experiment and from the facts of physiology are the arguments used against formal discipline by Bode (11:45). He observes how easily one can recall the fact that swindling stock promoters often have on their "easy mark list" the names of teachers and physicians to whom they sell fake stock. In spite of their intellectual training, they do not use good judgment or exercise much reasoning in buying stock, which is contrary to what one would expect from the theory of formal discipline. Referring to those experiments of Thorndike and Woodworth (105:246-61) and Bagley and Squire
Bode says: "If there is so much falling off of transfer when the shift is slight, there is clearly no warrant for the assumption that training in a subject like mathematics is good preparation for reasoning in an unrelated field, like politics or real estate." In this criticism, Bode does not consider that the proper conditions for transfer were not present when Thorndike and Woodworth (105:246-61) and Bagley and Squire (5:208) performed their experiments and that as a result these authors found little evidence of transfer. Bode (12:45-46) states that "retentiveness of the brain is a physiological property and it is probably true that our native retentiveness is an unchangeable thing." He felt that there is no such thing as a center for memory, because:

At one time memory has to do with color, then sound or may be taste, smell or shape. If we talk in terms of centers, we seem compelled to infer that specific acts of remembering are processes which combine a variety of centers and that these centers differ according to the nature of remembering. We have no memory, but memories.'(13:52).

This view of memories is also held by Hinsdale (42:134).

As mentioned before, prior to 1890 no experimental study had been made to defend or deny transfer of training until James (45:666-68) made the first attempt to test it. In the years following his experiment, similar ones were conducted by psychological and educational laboratories all over the world. The results of a great majority of these experiments were decidedly unfavorable to the idea of mental discipline prevailing
at that time. Some evidences of transfer were found, but, on whole, the claims of the formal disciplinists had been greatly exaggerated. Training in memorizing words was not found to be of any help in memorizing numbers (107:487-88), nor was the ability to write neat papers in arithmetic found conducive to writing neat papers in other subjects (5:208). The results of the above and similar experiments were used by those who opposed the theory of formal discipline to shatter any belief one might have in general training. No analysis was made of the technique of the experiments, by the objectors, to determine why transfer did not take place. After making a thorough analysis of the above experiments, Orata (70:52) concludes that these experimenters did not get much transfer because the conditions favorable to transfer were not present.

As a result of these experiments, according to Orata (71:5), there has developed in recent years a general skepticism concerning any sort of transfer. It is claimed by some psychologists that all training is specific, inasmuch as the mind is not a collection of general powers or functions, such as observation, attention, memory, reasoning, and the like, but that it is the "sum total of countless particular capacities." Pressey (88:493) and Starch (100:247) support Orata's argument that general training has been minimized or practically denied altogether.

Thus, in reviewing the literature on the theory of trans-
fer of training, we have seen the pendulum swing from a belief in general transfer of training, as viewed by the formal disciplinists, to the opposite extreme, to a belief that all training is specific, as advocated by Thorndike and his followers.

Judd (49:404-05) believes there is no one who denies that transfer of training takes place, or any one who argues that it is uniform and absolute. The real questions at issue are what is the degree of transfer and what are the best methods of securing transfer.

Before making a study of the experimental evidence to determine the degree to which transfer takes place, and whether the effect of training is general or specific, let us examine some of the methods used in the early experiments.

The experimental technique used in earlier studies was very simple. The experiments were conducted in the laboratory and were performed on trained psychologists, graduate students in psychology, or persons with some psychological training. Previous to 1916, as reported by Rugg (34:12), out of the thirty studies recorded, only nine were used with normal-college and graduate students; and only six of the thirty experiments concerned school activities. The number of subjects in most investigations has been so small as to render questionable the generalizations that have been made in interpreting the results of the experiments and in drawing inferences for school practice. In twelve of the thirty experiments, the number of subjects used was six or less. The few classroom experiments,
however, have larger number of subjects, usually from twenty to fifty.

Another objection often raised, in connection with the early experiments, is the absence of a control group which is needed in order to compare whether the gain was due to practice and how much was due to indirect training.

Probably the strongest criticism raised against the early experiments is in their study of abilities which have been for the most part isolated peripheral functions, as studies dealing with memory abilities, or studies dealing with sensory, perceptual data, or motor-habit formation. Rugg (95:17) argues that the early investigators in studying transfer through laboratory investigations used to only a limited extent, the higher powers of observation and reasoning and these he believes are largely inapplicable to the complex situations of our actual every day mental life.

A radical modification in experimental technique has taken place within the last twenty-five years. All of the recent experiments read by the writer contain either two or three groups. At least two of the groups are necessary in an experiment, as it is only by finding the difference between the gain of the experimental group and that of the control group can one obtain some indication as to the special contribution of certain methods of teaching or of a certain subject, or of the influence of one subject upon another. Sometimes a third group, a training group, is used as in the experiments of Judd (55:30-31).
Meredith (62:37-45), and Woodrow (121:159-72), to determine
the amount of transfer obtained from the different types of
teaching. The use of the groups has helped to make the experi-
ments more scientific. The groups must be equated or matched
by some method. The common methods used for equating are the
pupil's I. Q., sex, age, average previous school work, and the
initial test in the particular subject which is being tested.
The more factors thus equated, the more clearly can the in-
fluence of the particular training in question be determined.

In his recent article, Orata (80:267) brings up to date
the survey made by him in 1927 of the number of classroom and
laboratory experiments which have been performed since 1890.
In table form* he lists:

The Number of Classroom and Laboratory Studies from
1890 to 1927  1927 to 1935  1890 to 1935
Classroom    51     45      96
Laboratory   48     23      71

From 1890 to 1927, there were fifty-one experiments con-
ducted in classroom activities and forty-eight in the labora-

*In a letter to the writer, dated June 12, 1935, Mr. Orata
accepts as correct her criticism of his data as given in the
Mathematics Teacher for May, 1935. The typographical errors
there occurring have been corrected in the table as given here.
There were twice as many experiments conducted in the classroom as there were in the laboratory from 1927 to 1935, making a total of ninety-six classroom experiments and seventy-one laboratory experiments from 1890 to 1935. A period of thirty-seven years, from 1890 to 1927, records only fifty-one classroom and forty-eight laboratory experiments. In the eight years from 1927 to 1935, there have been almost as many experiments as there were from 1890 to 1927. During these eight years, however, the laboratory experiments have declined by more than fifty percent.

Inasmuch as this thesis is a study of transfer of training in arithmetic, a detailed review of the experiments in arithmetic will be given. Mention should be made, however, of the names of some of the experimenters and the results obtained in some of the early experiments, as well as some of the most recent experiments in subjects other than that of arithmetic.

Under the heading of peripheral functions, as studies dealing with memory abilities, are found the experiments of James (45:666-68), Bergstrom (10:433-42), Meumann (63:355), and Peterson (85:491-92). In studies dealing with sensory perceptual data, or motor-habit formation appear the work of Thorndike and Woodworth (105:246-61), Coover and Angell (32:328-40), Foster (36:11-22), Gilbert and Fracker (38:62-76). The names of Bagley and Squire (5:208), Briggs (17:50-71), and Ruediger (92:364-71), appear among the pioneer experimenters in school activities. All of the above experiments took place
from 1890 to 1916, and all the experimenters record either clear evidence of gain or at least a slight gain indicating some transfer, with the exception of James (45:666-68), Bagley and Squire (5:208), and Briggs (17:50-71). James admits that the lack of transfer in his experiment was due to his being "perceptibly fagged with other work at that time." Bagley explains that transfer did not take place in his experiment because neatness as a mere habit does not transfer. It must be made a conscious ideal in order for it to spread to other situations.

The tone of research has changed within the last twenty-five years. The center of interest in the transfer of training experiments is now in the classroom, where transfer is being measured in the interrelations of the various subjects, as well as the types of techniques used in teaching.

Under the subject of interrelations of subject matter one finds the experiments of Thorndike and Ruger (108:417-18), "The Effects of First-Year Latin upon Knowledge of English Words of Latin Derivation"; Thorndike (113:176-68), "The Influence of First-Year Latin upon Ability to Read English"; Coxe (33:244-47), "Influence of Latin on the Spelling of English Words"; and the Johnson, Hinerman, and Ryan Study of "Language Transfer (47:579-84)."

The importance of the technique used in teaching, as an aid to transfer is brought out in the experiments of Johnson (46:191-201), "Teaching Pupils the Conscious Use of Technique of Thinking"; Meredith (62:37-45), "Consciousness of Method
as a Means of Transfer of Training"; Woodrow (121:159-72), "The Effects of the Type of Training upon Transference"; and Hamlin (39:315-17), "Measurement of the Effects of School Instruction through Changes in Community Practice."

All of the above experimenters agree that the amount of transfer depends at least as much upon the organization of knowledge, habits, and skills that are to be transferred, as upon the amount of practice in the training exercises.

We may here profitably review Thorndike's (Ill:83-98) study of "Mental Discipline in High School Studies," as it is one of the best experimental studies of transfer of training from the point of view of the number of persons examined and the real life situations involved. Thorndike discovered, by a rough method, certain studies which were of about average influence, in order to compare the average gain by groups of pupils to determine the effect of studies on intelligence. In Group I he placed only the subjects which he considered of about average influence such as English, history, music, shops, Spanish and business training; Group II, contained civics, economics, psychology, or sociology; biology or agriculture in Group III; arithmetic or bookkeeping in Group IV; geometry, algebra or trigonometry in Group V. Thorndike then sought to compare the gain of pupils taking Groups I, II, III, IV, with the gain of pupils taking V, II, III, and IV. The influence of taking Group V is compared with the influence of taking Group I.
and Relational Thinking and the Institute of Educational Research Test of Generalization and Organization were given to 8,564 high-school pupils who were in Grades IX, X, and XI in May, 1922. Pupils in certain schools took Selective A and General B of the above tests in 1922, and Selective B and General A in 1923. Pupils in other schools took the tests in the reverse order.

The difference in gain between a pupil taking a given subject and one of the same sex and ability in the initial test of intelligence who took Group I or nothing in place of it was as follows:

For arithmetic or bookkeeping  Gain 2.92

" chemistry, physiology or general science  2.64

" algebra, geometry or trigonometry  2.33

" Latin or French  1.64

The author concludes that the general results of the gains in intelligence scores during the year bore only a slight relation to the studies taken. The bright pupil gained more than the dull, and the white pupil gained more than the colored; but pupils who took Latin or geometry, English, history, and so forth, gained a little more than the pupils of equal intelligence who took arithmetic or bookkeeping, cooking, and sewing.

Thorndike is of the opinion that transfer is not as easy to detect as it should be if it occurred to a large degree. He does not agree with the disciplinary theory that some subjects are more important than others in producing transfer of train-
The amount of general improvement due to the studies is small; and that the difference between the studies in respect to it are small.

The results of the above tests were of such enormous practical importance to Thorndike (19:377+404) that he repeated the experiment, with the aid of his assistants, on other individuals. The same type of tests were used. Form B was given to about five thousand pupils in September, 1924, of Grades IX and X of City 2. In May, 1925, Form A was given to the same pupils. At the end of the school year 1924-25, Form A was given to the pupils then in Grades X and XI in City 1, and a year later Form B was given to as many as were found in Grades XI and XII. A record was kept of the studies taken by pupils in each city during the year in which the first and second examinations were taken. When a comparison was made of the gain of the pupils who took any subject with the gains of others who took the subjects under Group I or nothing in place of it, it was found there is a difference of about ten between relatively dull pupils taking the least intellectualistic programs which high schools offer, and relatively bright pupils taking three-fifths of their work in mathematics, Latin, and physical sciences.

The authors conclusions are that those who take such subjects as Latin, mathematics, and physical sciences as compared with the pupils of equal mental ability taking commercial and manual subjects, are probably more ambitious for "intellectual
advancement or intellectual pursuits," and are from the more intellectual homes. Their lives outside the school very probably are more occupied with selective thinking and generalizations than the pupils who take typewriting, sewing, and the like, in school.

One of the earliest experiments in arithmetic was conducted by Brown (18:81-88), in January, 1911, in an effort to secure information concerning the value of short drill exercises in the fundamental operations in arithmetic. The Stone Tests in Fundamentals and Reasoning were administered to the eighteen boys and thirty-three girls of the sixth, seventh, and eighth grades of the practice school of the Eastern State Normal School at Charleston, Illinois. The pupils were equated on the basis of their test score into two groups, one of twenty-five drill pupils and the other of twenty-six non-drill pupils. Pupil teachers were placed in charge of the sections. All work was done under controlled conditions. Each section of each grade covered the same amount of subject matter, except that in the drill group the first five-minutes of each recitation period was devoted to drill work in the four fundamentals; the other group received no drill whatever. This practice continued for thirty recitations periods, when a second series of tests were given to both groups. The results of the test showed that the drill group of the sixth grade made the greatest increase in speed, 35 per cent. The seventh grade made a gain of 20 per cent, and the eighth grade 13.8 per cent in speed. It also
disclosed that the drill group increased 5.8 per cent in accuracy in fundamentals while the non-drill class decreased 2.4 per cent.

The author conducted a similar experiment in the sixth grade in four large cities using the procedure as above. The drill class improved 11.7 per cent in accuracy, whereas the non-drill class actually lost in accuracy, -1.8 per cent.

An experiment was carried on by Winch (119:262-71) to learn whether improvement in numerical accuracy transferred. Seventy-two boys, in a municipal boy's school in a rather poor neighborhood in London, were selected. The class was divided into two groups on the basis of the results of six preliminary tests in arithmetic reasoning. One group was drilled in arithmetic computations, while the other group practiced drawing. After ten practice exercises had been given, the two groups were given final tests in arithmetical reasoning. Although Group B, the practice group, made a score of 42.0 in the initial test, they made a score of only 45.3 in the final test. Group A, the control group, made a score of 42.2 in the initial test and 45.7 on the final test. The author concludes that even though the practice group did improve over 40 per cent in ten practice exercises in computations, the results of the drill did not appear to have produced any improvement in the accuracy of arithmetical reasoning.

Starch (103:306-10) made a study to determine whether transfer of training in arithmetical operations actually took
Eight observers practiced for fourteen days on mental multiplication, consisting of three digits in the multiplicand, and one in the multiplier, ranging from 4 to 9 in the multiplier, and 2 to 9 in the multiplicand, with fifty problems on each sheet. Before and after the practice test, the observers in the practice group and the seven observers in the control group were given six tests in arithmetical operations and two in auditory memory-span. The memory-span tests were made by reading to the subjects groups of words or numbers at the rate of one word or one number per second. After each reading, the observers wrote down what they remembered. The results of the tests disclosed that the practiced observers improved from 20 to 40 per cent more in the arithmetic tests than the unpractised observers. There was little change in memory-span with either group. The author believes that training in one type of arithmetical operation improves very consistently the ability to do other fundamental arithmetical operations. The improvement in the end tests was due, therefore, to the identical elements acquired in the training series and directly used in the other arithmetical operations. The two main factors were the increased ability to apprehend and hold the numbers in mind and the increased ability acquired in visualizing arithmetical operations.

An experiment was performed by Poffenberger (86:470-74) to discover the influence of improvement in one simple mental process upon other related processes.

A. The influence of training in simple addition upon
ability in subtraction. Eleven subjects were used in the experiment; four in the trained group and seven in the control group. The material used for the trained group was a series of fifty two-place numbers ranging between twenty and eighty, excluding zeros. The task was to add seventeen as rapidly as possible to each number. The subtraction test consisted of subtracting seventeen from each of a list of twenty-five numbers as rapidly as possible. All errors were corrected after each test. The results were given in terms of time. The final test showed that the gross gain in the trained group was only 8.8 seconds, whereas in the control group it was 15.1 seconds. The large gain in the control group, as explained by the authors, was due to the initial performance of three subjects. Poffenberger concludes that there is no identity either in the situation or in the response.

B. The influence of training in addition upon ability in multiplication. The training series is the same as in the preceding experiments except that in this test the practiced group had to multiply each of twenty-five of these same figures by seven. In multiplication of a one-place number, the author found that addition plays no part in the multiplication of a two-place number, but there is a certain amount of identity with addition since it is involved as a part process. The trained group gained 11.4 seconds, while the control group gained 29.7 seconds. The author explains the lower score of the trained group on the basis of interference -- occasioned
C. The influence of training in addition upon ability in division. The training series is again similar to the above experiment. The test series consisted of dividing a series of twenty-five numbers by seven as rapidly as possible. The results showed no difference in the gain made by either groups. The author interpreted the results as indicating that the processes involved in the experiments show neither a specific situation nor a specific response in common with the training series.

Another experiment was conducted by Winch (120:370-81) to solve the answer to the problem as to whether improvement in arithmetical problematic reasoning involves improvement in logical reasoning which is not arithmetical. Fifty-eight Girls in grades V and VI B were used in the experiment. Initial tests in logical reasoning were given to the pupils to determine their capacity in logical reasoning and arithmetical reasoning. The pupils were equated on the basis of their initial score and their age. One group, the experimental group, was trained especially in problematic arithmetic; the other group, the control group, was taught reading, geography, and dictation. The practice lasted for ten weeks. The results of the final test showed a decided gain of 29.9 per cent of the practiced group over the control group. The author contends that the mere juggling of figures until a correct solution ap-
pears, more or less by accident, is not problematic arithmetic and will have little if any transfer value. The problems which the pupils worked were developed inductively, and a generalization, which is a statement of the general principle involved in the solution of the problem, was then formulated.

Knight and Setzafant (57:781-87) attempted to measure how much training in addition of fractions transfers when using different denominators. A group of pupils who were just learning fractions were used in the experiment. The pupils were divided as evenly as possible into two groups, A and B. Group A was given practice in addition of fractions using an even and thorough spread of integers such as 2, 3, 4, 5, 6, 8, 10, 12, 14, 15, 16, 18, 21, 24, 28, and 30. Group B was given similar practice except that only the numbers 2, 4, 6, 8, 10, 12, 16, and 24 appeared as denominators. After the instructions were started two tests were given to both groups on successive days. Each test contained two parts: (1) problems in addition involving the denominators practiced in both groups; (2) problems in addition containing only the denominators practiced by Group A. The results showed a loss in the number of problems worked in the test having a limited number of denominators as compared with the test having all of the denominators. The authors infer that transfer took place and was the same for both groups. The ability of the pupils to work unfamiliar problems in the test, almost as well as the familiar ones, is explained by the author on the basis of the common-
denominator idea transferring from one group of denominators to another with great ease.

The results of Poffenberger's (86:470-74) experiment interested Cole (30:32-39) so much that he made a similar study of the effects of practice in addition upon addition, subtraction, multiplication, and division, and likewise of the effects of practice on the other three arithmetical processes. Two groups were used, each containing four persons. One group was practiced in addition and the other in subtraction, each serving as a control group upon the other. The practice consisted of five periods of forty-minutes each, each group working ten-minutes with a two-minute period of rest in between. Initial and final tests of addition, subtraction, multiplication, and division were each twenty-minutes in length. The author doubted the significance of the results, since only four persons were used in each group, and consequently repeated the experiment with nine persons in each group. Contrary to the findings of Poffenberger (86:470-74), Cole found that addition and subtraction are not independent functions but rather very closely related. The group practiced in addition gained 3 per cent in accuracy in subtraction and 6.6 per cent in time. The subtraction group gained 23 per cent in accuracy in addition and 16.7 per cent in speed in that process. The group practiced in addition showed no gain in accuracy in division. This is also true of the group practiced in subtraction. The gain in speed in division was the same for both groups. The author accounts
for this gain on the grounds that both groups practiced computations. There was a loss in the final scores in multiplication by those practiced in addition and no loss by those practiced in subtraction. The author explains that the success in subtraction of those who practiced in addition, and the success in addition of those who practiced subtraction, was due to the fact that the subjective identity of the combinations in addition and subtraction was realized as a help by all who took the practice.

Brueckner and Beito (20:369-89) conducted an experiment with beginning second-grade pupils in three schools in St. Paul, to determine to what extent the teaching of a fundamental number combination in the direct order transfers to the reverse order of the same combination, for example 7 plus 5 is 12, 5 plus 7 is 12. Drill cards with the combinations on one side and combination and answer on the reverse side were used in the experiment. The individual progress, by means of individual graphs, was noted by the child. The authors found that the greatest number of combinations was learned the first day and fewer each succeeding day. Although the reverse forms were never mentioned except in the pre-test and final test, the pupils made adjustment to the reverse combinations to such an extent that a very large percentage of reverse combinations were learned. The pupils with the highest I. Q. showed the greatest gains in the direct order of the combinations, but those with the lowest I. Q. showed greatest gain in the reverse
combinations. Brueckner and Beito conclude that the amount of carry-over is influenced very little by the method of presentation. Transfer takes place only to the extent that the pupils generalize and comprehend the application of the identical elements in the unfamiliar objects.

Mitchell (64:594-96) gives the procedure and results of his experiment to determine whether problems that contain numbers, thereby becoming specific, and problems that contain no numbers but are of a general nature, have different effects on the pupils; also, whether problems containing numbers are easier or more difficult than problems which do not contain numbers but are more general in type and involve general principles. The author devised two tests, A and B; the former contained problems of a specific nature, while the latter was composed of problems of a general nature. The following are sample problems:

**List A**

1. The width of a room is 10 ft. and its length is 15 ft. Find the perimeter.

**List B**

1. If you know the length and the width, how can you find the perimeter.

Each list contained fifteen problems. The principles for solving the problem in List A were exactly the same as those for solving the problems in List B. The tests were given to seventy-eighth-grade pupils and to sixty seventh-grade pupils. In one-half of the cases, List A was given first, followed by List B, and in the other half of the cases the order was reversed. The majority of the pupils were of the opinion that
List B was easier. Out of a total of 130 pupils, only five pupils made higher scores on List B. In the remaining cases, 125 in number, the pupils made higher scores on List A. The author concludes that, even though a pupil can solve specific problems, it does not necessarily mean that the pupil has formed a general conception which he will apply to all similar problems. The problems with definitely expressed numerical quantities seem to be more readily comprehended and solved than the problems of a general nature involving general principles. The author suggests that some drill in problems of a general nature should be given or that frequent applications of the principle involved in the specific cases be made.

The purpose of Overman's experiment (64:183-90) was to study whether it is possible to increase the percentage of transfer by helping the pupils to generalize consciously, to rationalize the process, (that is, to consider the underlying principles), and to combine generalization and rationalization. The experiment was carried out in fifty-two second-grade classes in Toledo, Findlay, and Bowling Green, Ohio, during the school years of 1927-28, and 1928-29. These classes were divided into four groups, each of which were taught by a different method, twenty-minutes a day for fifteen days. It was started after the children had learned only the addition of three numbers of one digit each, as \(2 + 3 + 4\), and the addition of four digits, as \(5 + 2 + 3 + 4\), and before they knew anything about the addition and subtraction of two and three-place numbers.

The training consisted in instruction and practice of three
specific types of examples:

1. The addition of two numbers of two digits each; for example, $45 + 16$.

2. The addition of three numbers of two digits each, as $52 + 16 + 19$.

3. The addition of a two-place number, a two-place and a one-place number in the order stated, as $24 + 16 + 2$.

In method A the teacher merely showed the pupils how to write and add a two-place number and a two-place number. In B -- Generalization -- the teacher not only showed the pupils how to write the numbers but also helped them to form the generalization that the numbers must always be written in such a way as to keep the right-hand column straight. In C -- Rationalization -- the pupils discussed the principle that one's can only be added to one's and ten's to ten's but nothing was said about keeping the right-hand column straight. In D -- Generalization and Rationalization -- the pupils were taught that the right-hand column must be kept straight in order to add one's to one's and ten's to ten's. All four groups were given four tests. They were given at the beginning and end, and twice during the experiment. The tests included such examples which had not been taught as:

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The pupils were matched on five points: sex, mental age, chronological age, score on preliminary test, and teacher's estimate of general scholastic ability. Matching was not perfect, but the standard deviation showed there was no significant difference between any two pairs. In order to determine whether the training given to the pupils on three types of examples had any effect on their ability to work the remaining type, the percentage of correct examples in the first and last tests for two of the untaught types of examples and all untaught types combined, was found. On the first test the pupils worked 21.4 per cent of untaught examples correctly and 73.8 per cent in the last test. The improvement on the last test would indicate that there was a considerable amount of transfer from the instruction and practice used. In comparing the results of the other three methods over method A, it was found that B produced 21.5 per cent more transfer than A; C was only 5.4 per cent higher, while D was 20.5 per cent higher. This was for the different types combined. When the results of transfer were compared in the examples containing different number of digits, it was found that method B increased again the amount of transfer by 45.1 per cent; that produced by C was 15.5 per cent and that by method D was 36.9 per cent. The author admits that, while transfer from one type of example to another related type may occur in large amounts and may even be complete, still it is seldom complete for the group as a whole. Since transfer is seldom complete, all the essential facts and steps in the
process should be taught. Even though transfer from one type of example to other related types is possibly never complete, this experiment, the author believes, shows that it occurs in related amounts that cannot afford to be ignored. Overman is of the opinion that the value of a method does not lie in its immediate end, but rather in its ability to secure the maximum transfer to related types, as best mastery of the specific type taught. In addition to teaching any given type of examples, teachers should help the pupil to use it as a basis for generalizing the process.

Olander (69:358-69) sought the information: If children receive practice on a portion of one hundred addition and one hundred subtraction combinations, will they know as many of the total number as if they had practiced all of them; also, is a method of employing a few minutes of generalization each day more or less effective in promoting transfer than a method which gives the same amount to drill? The experiment included about thirteen hundred children in low second-grade in Detroit, Fordson, and Hamtramck, Michigan. The experiment lasted over a period of seventeen weeks. The pupils were divided into four groups. One group studied 200 number combinations; the second studied only 110 combinations. No instruction in arithmetic was given during the last twelve weeks of the experiment to the third group, while the fourth group received no formal arithmetic instructions during the entire seventeen weeks. Each teacher in the experiment was provided with daily lesson plans
containing specific directions as to content and method of
teaching for each day's recitation. The teachers were the only
ones who used an arithmetic text-book from which concrete prob-
lems and certain teaching techniques were selected according to
the directions in the lesson plans. Some of the teachers
taught all the one hundred addition and one hundred subtraction
combinations to their classes, while others taught only fifty-
five combinations in each of the two processes, or one hundred
ten in all. An addition test and a subtraction test, with one
hundred combinations in each, were given at the close of the
five-week period, at the end of the eleven weeks, and again at
the close of the seventeen-weeks' period. In order to inter-
pret the results, the author equated the groups by pairing
pupils who had similar initial scores, pupils who had similar
gains in arithmetic scores over a period of five out of seven-
teen weeks of arithmetic instruction, and pupils who had been
taught by similar methods. The problem of the extent of trans-
fer from taught to untaught number combinations was attacked by
comparing (1) the scores of the children who were taught all
the two hundred combinations with those of the children who
were taught only the one hundred ten combinations; (2) scores
of all children on combinations which were taught with the
scores of the same children on combinations which were untaught.
There should have been little difference in the scores up to
Test 3, but the results of the test favor the group studying
the one hundred combinations. Between Test 3 and Test 4, the
ninety new combinations were given to groups studying the two hundred combinations. This group averaged 60.09, while the one hundred ten combination group averaged 62.72. In other words, the children who studied only the one hundred combinations throughout knew as many number facts at the close of the experiment as those who were taught all the two hundred combinations. In combining the averages of taught and untaught combinations in addition and subtraction, it was found that the two hundred combination group did slightly better in the ninety combinations which had received emphasis in that group, whereas the one hundred ten group did slightly better on the one hundred ten combinations which had received extra drill in that group.

The author concludes:

1. That ability gained by pupils who were drilled in one hundred ten combinations transferred almost completely to the ninety untaught combinations.

2. In early number work teachers need not teach every number combinations since children learn them as a system of interrelated experiences.

3. Generalizations showed no significant effect.

   a. The function was too narrow to necessitate special stress on generalizations. The children did the generalizing whenever necessary.

   b. Children were too young to profit from abstract verbal generalizations.

4. A comparison of the scores of one group of children who had no formal instruction in arithmetic for twelve out of seventeen weeks of the experiment, with another group having no formal instruction during the entire seventeen weeks, shows that, during the time when no instruction in numbers was being given, the children learned from approximately a third to less than one-
half as many combinations as did the children who were being taught the regular class instruction.

What transfer takes place from arithmetic problems which are specially taught to those which are not given particular attention in instruction, was the question Osburn and Drennan (82:123-28) sought to solve. Their experiment was conducted in the Madison Elementary School in Wheeling, West Virginia. A series of problem cues in addition, subtraction, multiplication, and division were so arranged as to include the problems which should be done in the third grade. A cue is defined as the part of a problem which is expressed in language. The "cues" were taught only during the first six-weeks of the semester. At the end of the six-weeks, tests containing other cues, but no new vocabulary, were used to see if the pupils could handle them without direct teaching. On the thirty-first day another examination, with new cues and added difficult vocabulary, was given. The results showed a marked amount of transfer. On the second test even with a vocabulary difficulty the pupils did even better. The authors seem to think that pupils are able to sense the meanings of the problems even if they do not understand all of the words. They suggest that a few of the most important problem types should be thoroughly taught, and that the teacher should then depend upon the transfer for the rest.

There appears to be a difference of opinion among the experimenters as to how transfer takes place. Of the authors of
the twelve arithmetic experiments reviewed, only three offer the theory of identical elements in explaining transfer effects while seven of the authors interpret the transfer effects through some form of generalization. The other two authors offer no suggestion or explanation as to how transfer takes place. The explanations offered are:

1. Brown (18:81-88)  
2. Winch (119:262-71)  
3. Starch (103:306-10)  
4. Poffenberger (86:470-74)  
5. Winch (120:37-81)  
6. Knight and Satzafant (57:781-87)  
8. Brueckner and Beito (20:353-540)  
9. Mitchell (64:594-96)  
10. Overman (84:183-90)  
11. Olander (69:358-69)  
12. Osburn and Drennan (82:123-28)  

No explanation offered  
No explanation offered.  
Identical elements in training series.  
Identical bonds, the results of his experiment show transfer to be highly specific.  
Generalization.  
Identical elements.  
Generalization.  
Generalization.  
Generalization.  
Generalization.  
Generalization  

Regarding the degree of transfer, the writer believes no one in the face of the experimental evidence given above can deny that transfer to some degree takes place. Transfer of training is not as wide-spread as the formal disciplinists would have us believe, nor is it as specific in its effects as
Some psychologists would have us believe. The writer agrees with Rugg (96:20) that the results of the experiment place us in the middle ground in reference to the degree to which transfer takes place.
CHAPTER III

MODERN THEORIES OF TRANSFER OF TRAINING

Since the weight of the experimental evidence appears to be in favor of those who agree that transfer of training does take place, the important question at issue is not: Does transfer take place but:

I. How does transfer take place?

II. What are the best methods of securing transfer?

I. Regarding how transfer takes place:

The psychologists who attempt to explain this may be grouped into two schools:

A. Thorndike and his followers, who believe in the Theory of Identical Elements

B. Those who hold that the effects of transfer can be generalized. This view is held by Judd and his followers.

A. Thorndike's Theory of Identical Elements:

The answer which I shall try to defend is that a change in one function alters any other only in so far as the two functions have as factors identical elements. The change in the second function is in amount
that due to the change in the elements common to it and the first. The change is simply the necessary result upon the second function of the alteration of those of its factors which were elements of the first function, and so were altered by its training. To take a concrete example, improvement in addition will alter one's ability in multiplication because addition is absolutely identical with a part of multiplication and because certain other processes, e.g. eye movements and the inhibition of all save arithmetical impulses, -- are in part common to the two functions.

Chief among such identical elements of practical importance in education are associations including ideas about aims and ideas of method and general principles, associations involving elementary facts of experience such as length, color, number, which are repeated again and again in differing combinations (112:358-59).

These identical elements may be in the stuff, the data, concerned in the training, or in the attitude, method taken with it. The former kind may be called identities of substance and the latter, identities of procedure.

Identity of Substance -- Thus special training in the ability to handle numbers gives an ability useful in many acts of life outside of school classes because of identity of substance, because of the fact that the stuff of the world is so often to be numbered and counted. The data of the scientists, the grocer, the carpenter, and the cook are important features the same as the data of the arithmetic class (114:245-46).

Identity of Procedure -- The habit acquired in a laboratory course of looking to see how chemicals do behave instead of guessing at the matter or learning statements about it out of a book, may make a girl's methods of cooking or a boy's methods of manufacturing more scientific because of the attitude of distrust of opinion and search for facts may so possess one as to be carried over from the narrower to the wider field. Difficulties in studies may prepare students for the difficulties of the world as a whole by cultivating the attitudes of neglect or discomfort, ideals of accomplishing what one sets out to do, and the feeling of dissatisfaction with failure (114:246).
If transfer of training takes place, as explained by Thorndike, a common or identical factor must be present in the two situations if the exercise of this common element in one situation is to affect its exercise in the other. Identity of substance means that we get the same practice in different situations. There is a common factor present in the addition which is learned in the classroom and then later applied in adding the cost of groceries. By identity of procedure is meant the attitude or method which is learned in one situation and is then carried over to similar situations. Thorndike, however, fails to explain just how this identity of procedure takes place.

Judd (51:414) believes that the identical element is usually contributed by the generalizing mind and that it may be present in several situations but may be unnoticed by the untrained or indifferent mind. In fact, the discovery, according to Judd, of the identical element in a situation is in some cases the whole problem of training. If Judd gives to generalization the same meaning given by Waples (115:220-21), "the discovery of common elements in a variety of situations," the writer does not agree with Judd that the identical or common element is contributed by the generalizing mind, but rather that the identical or common element must be present for the mind to generalize. Furthermore, Judd says: "The idea is not to always bring out the identical elements but rather to bring out the unlike elements." In order to bring out the identical
element or contrasting element, it must be present in the form of an idea, ideal, a habit or in the methods of work in order that the pupil may be able to generalize. In the statement "it," the identical or contrasting element, is already present and the generalizing mind does not contribute it. The generalizing mind, having found that the identical or contrasting element, disassociates it and then practices in applying the common element to other habits, principles, and situations.

Orata is one of the outstanding critics of Thorndike's theory. His entire book, "The Theory of Identical Elements," is a critical discussion of his opposition to Thorndike's Theory of Identical Elements. In his analysis he writes:

Thorndike is undoubtedly correct... in saying that there must be some sort of identity between the old and the new situation if there is to be any transfer. The problem is not in the presence but in the nature of the identical factor and how it is recognized as such (72:13).

.....The doctrine of identical elements either does not give us a satisfactory explanation of how transfer takes place, or else, it oversimplifies the process of transfer to such an extent that the problem of transfer entirely disappears..... Thorndike based his theory upon the assumption that mental functions are highly specialized. If by specific ability Thorndike means a subdivision of a faculty, he is back to faculty psychology and formal discipline. On the other hand if he makes each specific act dependent upon an equally specific ability, the problem of transfer disappears, since learning to perform a specific act does not help in learning to perform any other act (73:173).

In a later study in further support of his contention against specific abilities, Orata (81:266) offers the results
of his study of the 167 objective studies on transfer of training, made from 1890 to 1935. Forty-seven or 30 per cent of the studies showed considerable transfer, 80 or 50 per cent appreciable transfer, 15 or 10 per cent little transfer, and only 6 or 4 per cent showed no transfer. His investigation (80:267) also disclosed that 70 per cent of the studies support the proposition that the effects of practice is general and that as a result transfer takes place most effectively through conscious generalizations, whereas about 30 per cent of the studies may be classified as supporting the theory that practice is specific and that transfer therefore takes place through identical elements. Orata's conclusions are similar to those given by Rugg (96:21), whose survey shows that of the nineteen investigators who contributed to the discussion of the method of transfer, fifteen take the position that transfer is possible through certain factors of generalization.

The writer agrees with Orata and Rugg in their denouncement of Thorndike's Theory that mental functions are highly specialized. If mental functions are as highly specialized as Thorndike considers them, little or no transfer would have taken place. The results of Orata's experimental study prove that mental abilities cannot be considered as being highly specific, otherwise there would not be such excessive evidence in favor of transfer as found in the greater percentage of the experiments. Transfer is due to training or practice. If training resulted in the learning of only one specific act,
then there would be no transfer, for as Orata says: "Learning to perform a specific act does not help in learning to perform any other act if each specific act is dependant upon unequally specific ability (78:173).

Orata does not believe it is as easy to understand Thorndike's Theory of Identity of Procedure as his Theory of Identity of Substance. Orata (73:16) interprets the theory of Identity of Procedure as

the carrying over of a habit that has been acquired in one connection to another situation.

Thorndike (114:246) explains the Theory of Identity of Procedure in this manner:

The habit acquired in a laboratory course of looking to see how chemicals do behave instead of guessing at the matter or learning statements about it out of a book, may make a girl's methods of cooking or a boy's methods of manufacturing more scientific because of the attitude of distrust of opinion and search for facts may so possess one as to be carried over from the narrower to the wider field. Difficulties in studies may prepare students for the difficulties of the world as a whole by cultivating the attitudes of neglect or discomfort, ideals of accomplishing what one sets out to do, and the feeling of satisfaction with failure.

Continuing his discussion of the above theory, Orata says:

Here the data are different, but the mode of procedure is the same. In one case the data consists of "looking to see how chemicals do behave, instead of guessing at the matter or learning statements about it out of a book." In the other case it is either "the girl's methods of cooking" or "the boy's methods of manufacturing." The identical element that may be transferred is "attitude of distrust of opinion and search
for facts. The question at once arises, how the "attitude of distrust of opinion and search for facts" is transferred from a laboratory course to cooking or manufacturing. However, there are only two possibilities. It happens either automatically or through a process of reconstruction or making over of the reaction to be transferred. If it happens automatically identity of substance and identity of procedure are the same, and there would be no need of distinguishing them. Furthermore, automatic transfer of habit from one situation is like formal discipline.

There remains the other possibility, namely, that transfer involves the reconstruction of a habit or the making over of meanings to fit the new situation. But this position is incompatible with Thorndike's whole psychology, and besides it conflicts with the notion of identical elements. Thorndike's fundamental principle is that of mechanism. "In the same organism the same neurone-action will always produce the same result -- in the same individual the really same situation will always produce the same response." We see at once that if this is the case, there can be no need of reconstruction since given a stimulus, the reaction just goes off as the gun discharges when the trigger is pulled. Reconstruction involves the making over of a reaction, which means, that it is re-directed or modified.

Again, the writer agrees with Orata in his criticism of Thorndike's Theory of Identity of Procedure. Thorndike offers no explanation of how this "attitude of distrust of opinion and search for facts" is transferred from a laboratory course to cooking or manufacturing. It cannot be explained, as Orata reasons, on the basis of automatic transfer, for this would make the attitude develop as a result of general training and this is contrary to Thorndike's belief in specific training. Neither can the suggestion given by Orata of "reconstruction of
the habit nor the making over of meanings to fit the new situation," be used to explain his transfer of "attitude." Thorndike (109:7) says: "In the same organism, the same neurone-action will always produce the same result -- in the same individual, the really same situation will always produce the same response." At one time the situation is the observation of chemicals in the chemistry laboratory and another time it is the method of cooking in the kitchen. Since the two situations, the chemistry and the kitchen, are different, the same response or attitude cannot be produced. Therefore, Thorndike's Theory of Identity of Procedure (114:246) cannot explain the transfer of the "attitude of distrust of opinion and search for facts," from the laboratory to cooking or manufacturing.

After analyzing the entire explanation of transfer through identity of substance and identity of procedure Orata (74:18) concludes that the notion of fixed identities cannot be defended from any point of view. While Thorndike holds: "In the same organism the same neurone-action will always produce the same result -- in the same individual the really same situation will always produce the same response," such a theory of neurone-action fails, according to Orata, to make his theory of fixed identities tenable because there are no ready-made situation elements in nature to which we act with ready-made responses. The situation element, as well as the responses, are flexible and modifiable and through them transfer takes place.
The above argument would find support in the results of Lashley's (58:172-76) study of the brain mechanism. The inferences made are from the results of his study of the structure and function of the nervous system.

1. It is very doubtful if the same neurones or synapses are involved even in two similar reactions to the same stimulus. The results prove that the structural elements are relatively unimportant for integration and that the common elements must be some sort of dynamic patterns, determined by the relations or ratios, among the parts of the system and not by the specific neurones put into action.

2. Lashley questions the statement that the condition of one synapse cannot influence that of others, thereby making the nervous system rigid and mechanistic. From his experiment he has found that the nervous system is flexible and adaptative.

Bode (14:205-6) also agrees that Thorndike's Identity of Procedure is not so easily understood:

We may do absolutely the same thing in different situations. Addition improves multiplication...If we were to limit our notion of transfer to matters of this sort, everything could be explained without difficulty in terms of mechanical habit. The doctrine, so far, means simply that if we have learned to do a particular thing, then we can do that particular thing. But if we turn to what is called "identity of procedure," the scene changes. 'The habit acquired in a laboratory course of looking to see how chemicals do behave, instead of guessing at the matter or learning statements about it out of a book, may make a girl's methods of cooking or a boy's methods of manufacturing more scientific because the attitude of distrust of opinion and search for facts may so possess
one as to be carried over from the narrower to the wider field. (113:246). The thing that is carried over is a "habit" or "attitude." These attitudes are of a general sort which means that the activity varies from one situation to another.

Bode agrees with Orata (72:13) that Thorndike is on solid ground in arguing for identities, but says that Thorndike leaves it to others to determine these identities.

These "identities" cannot be of a general sort, as explained by Bode, because this is contrary to Thorndike's belief in specific training. On the other hand they cannot be specific, since Bode believes the activity varies from one situation to another.

The theory of identical elements looks plausible to Burton (24:405) on the surface, if one does not look beyond the simple habits which make up the bulk of everyday activity. But to use in a second situation a specific habit learned in another place is not transfer at all. It is merely the specific use of one and the same response. Furthermore, if it requires anything more than automatic functioning to carry this specific response from situation A to situation B, then transfer is accomplished through the recognition of the identity, and this is generalization.

Although Jordan (48:213-16) grants that there have been many reasonable explanations as to how transfer takes place, such as through identical elements, generalizations, experiences, improvement in technique of learning, improvement in attention, will power, and concepts of methods, still it ap-
pears to him to be a "tangled-up" question. He does favor Thorndike's theory and holds that this theory may include the explanation of all other psychologists as well. To Thorndike's explanation of how transfer takes place, Jordan adds: identity of content, procedure, moods or attitudes, understanding involved in a principle and its application and ideals.

Whenever transfer takes place Whipple (118:220) considers it fair to assume that the two neutral activities must have some characteristics in common. In other words, his idea is the same as that expressed by Thorndike in his theory.

While Ruediger (93:112) believes that the theory of identical elements explains transfer and is easily understood, still he is of the opinion that it is often hard to tell just when two processes are mentally identical and when they are not, as any apparent resemblance or divergence may prove misleading when subjected to a test. Ruediger (93:114), like Jordan (48:213-16), adds another subclass to Thorndike's theory. He calls it "Identity of Aim" to include such functions as "obedience" and "self-reliance," and "industry." Bagley's (5:208) experiment on the ideal of neatness would fall into this class.

The theory of mental reactions proposed by Gates (37:420) inopposition to the faculty theory, says:

.....the organism deals primarily as a whole with each of the innumerable situations, problems and classes of data that it encounters. This theory assumes that attention, memory, and the like refer not to distinct faculties, powers or entities but to some aspect or artificial classification of the process or organic adjustment to the situa-
tion which life affords. They are aspects of a whole process which cannot actually be broken up although we can think of each phase by itself.

According to this view, learning is reacting in a complex way to some situation or data. What one learns is to react to a particular situation or to deal with particular data. Training, then in one situation or with one type of material will not be expected to improve character, temperament, will, ... in general but will result merely in improved adjustment to one situation or in increased ability to deal in some definite way with one type of data. This view assumed that a specific type of training, while it will not improve any faculty so that it will be more efficient for all purposes, may, nevertheless, result in a transfer of improvement to other situations or types of work which have much in common with the situations or types of work in which the training was conducted.

Gates' belief in a specific type of training and the common elements corresponds to Thorndike's theory of Identical Elements.

The interpretation of transfer given by Wheeler (118:321) compares with Thorndike's Theory of Identity of Substance when he speaks of the similarity of content. In transfer, Wheeler holds:

.....one task facilitates the learning of another.
.....the essential fact about that behavior designated as transfer is a duplication of response in the first and subsequent performances. This duplication can take place, (1) when there is a similarity of content, (2) where similar methods can be emphasized, and (3) where similar attitudes can be assumed. Transfer can take place, then only when the two tasks are so similar that the learner can apprehend them in the same whole, that is, perceive that the responses learned in the first task fits the second. The comprehensiveness of this perception determines the degree of the so-called transfer.
Having studied Thorndike's Theory of Identical Elements, Sandiford (98:298) concludes that it is a perfectly reasonable one. Considering the millions of specific situations, each with its specific connections in the nervous system, some of them are certain to be common to several situations. This interpretation would conflict with Thorndike's theory: "In the same individual, the really same situation will always produce the same response," and "The really same response is never made to different situations by the same organism. (109:7-8).

II. Those who believe that the effects of practice can be generalized.

Judd (52:412-13) is one of the foremost exponents of the theory of generalization and argues that:

Transfer depends on the power of generalization. The first and most striking fact which is to be drawn from school experiences is that one and the same subject matter may be employed with one and the same student with wholly different effects according to the mode of presentation. If the lesson is presented in one fashion it will produce a very large transfer; whereas if it is presented in an entirely different fashion it will be utterly barren of results for other phases of mental life. Formalism and lack of transfer turn out to be not characteristics of subjects of instruction, but rather to the mode of instruction in these subjects. The important psychological fact involved in the above statements is that the extent to which a student generalizes his training is itself a measure of the degree to which he has secured from any courses the highest form of training. One of the major characteristics of human intelligence is to be defined by calling attention...to the fact that a human being is able to generalize his experience.
He believes that pupils should be induced to generalize their experiences. His contention is that one of the most successful methods that can be employed is to give students a verbal statement or conscious ideal as Bagley (7:214) suggests. The teacher must not only give the verbal formula, but also devise ways of presenting it to the student with a view to giving him the opportunity of applying this verbal formula and helping him to make the generalizations. The generalizations can be reached either through comparison or through contrasts. The idea is not to always bring out the identical element, but rather to bring out the unlike elements that may be present.

Judd further holds:

The efforts of the school to induce generalization leads to an attitude of mind which can be described as the generalizing attitude. Whenever a student has seen the possibility of analyzing various situations and discovering productive relationships, he will be stimulated to treat new problems in the same way. He will see the possibility of analyzing everything that comes into his experience for the purpose of discovering general principles (50:434).

Judd's (52:412-13) theory of generalization implies that it is not so much the fact that the elements need to be present in two functions, so that training transfers, as it is necessary that the individual be taught to disassociate the element from the complex and then recognize the element under whatever form it may appear in a new situation. The subject matter is not of much importance. The method of teaching or study and the degree of self-activity in the pupil are the all important
Transfer of training, as viewed by Bode (15:202), is similar to Judd's Theory of Generalization. Bode holds:

Transfer of training centers on the development of concepts. When our habits interpenetrate and form systems of responses which on higher levels grow into concepts, we get the flexibility and adaptability that we have in mind when we speak of transfer of training. This is simply to say that transfer takes place through meanings, or that transfer of training is just another name for intelligence.

Although Bagley (6:213-14) explains transfer through the medium of ideals and Judd (52:412-13) explains it through generalizations, Bode (15:202) believes their explanations are perfectly friendly to his view that transfer centers on meaning.

Waples (115:220-21) defines transfer of training as that which takes place in learning to perform one particular activity, typewriting for example, the learner also improves his ability to spell, to read accurately, to focus attention rapidly, or to use other machines more skillfully.

Waples agrees with Judd that transfer of training takes place through generalization. By generalization he means "the discovering of common elements in a variety of situations." He regards the problem of making classroom instruction transfer to life situations outside the classroom is simply the problem of teaching pupils to generalize. Waples contends that:

Not only ideas may be generalized but also ideals, habits, methods of work, and other teaching objectives. To teach children to generalize the teacher must disassociate these common elements. The pupils must see the same element in many situations.
In order to see it the teacher should break those associations which the pupils combine in their mind, all the elements in a given situation into its constituent parts. Then these common elements should be given in a number of different situations, and the pupils be given a great deal of practice in applying the ideals, principles, or habits to new situations.

After criticizing and thoroughly analyzing Thorndike's explanation as to how transfer of training takes place, Orata (79:176-78) gives his own interpretation of the theory:

Transfer.....is to be defined as the extension and application of meanings to new problems or situations in such a way that we can deal with them effectively. If that is the case, the amount of transfer depends upon the extent to which meanings are identified and applied. This range of extension is much widened by the ability of the individual to detach meanings from their concomitants. The process by which they become detached is also a process by which they become enriched in content. The meaning thus developed is then provided with a name; and in this way meanings become concepts. If transfer is very greatly facilitated by concept formation, then education in order to facilitate transfer must of necessity be concept building. It is a process of equipping the individual with concepts which are rich in meanings so that he can apply them in meeting various life situations. When so conceived, education, becomes world building, inasmuch as our world is what we make it or what it means to us. Our knowledge of any subject when generalized into concepts and enriched in content and application becomes a tool for adjustment to an unlimited number of situations. To say that education is world building implies the power to re-make one's world, for our store of concepts are not mere accumulations of meanings.... Concepts interpenetrate, and it is by their interpenetration that they are made over and enriched in content.....The ability to develop concepts implies the power to re-make them from time to time, and in this process of re-making both the experienced environment and the bodily reactions are transformed.
Orata's explanation of transfer of training is similar to the interpretation given by Judd (52:412-13) in his theory of generalization. Orata's "transfer of training depends upon the extent to which meanings are identified and applied," is comparable to Judd's theory, which holds that training transfers if the individual is taught to disassociate the element from the complex and then recognize the element under whatever form it may appear in a new situation.

Book (16:490-91) holds that:

Facilitation in learning occurs when the habits, knowledge, ideals, attitudes or mental sets that have been acquired as a result of previous learning are successfully carried over into the process of acquiring new knowledge and skills. During the process of learning and in our experiences in life we form certain habits and acquire a certain amount of information about the things with which we come in contact. These habits and this knowledge are what we have to help us in solving new problems. Some of this knowledge and some of these experiences may be applicable to the new situation and may help us in solving the new problem. Whether or not this related knowledge and helpful experience can be recalled and effectively used in meeting the new situation depends upon two things: (1) the knowledge must be correct and applicable, and so well learned that it can be recalled at will. (2) It must have been learned in a way that will enable the learner to apply it to other situations than the one to which it was specifically linked by the original learning. Whether or not it can be successfully used in this new way depends upon how widely and successfully this needed bit of knowledge has been linked to every other fact or experience to which it is fundamentally related. This is what is meant by making a habit plastic and one's knowledge flexible as well as specific and is precisely what takes place when we generalize our experience or make specific habits more
generally useful or flexible.

The Generalization of Ideals gives Bagley's (6:213-14) impression as to how transfer takes place. Bagley considers that the students who come to the psychology from the mathematics class have no generalized habit of study, but they do have an "ideal" of study. Since they have studied abstract problems along with other problems, they must have experienced some delight of achievement, some of the pleasure that comes as a result of successful effort. It may be that mathematics has given them nothing but this, but this is enough to hold them to their new study until a new and specific habit of psychological study has been established.

Similarly, too, with the habit of neatness. According to Bagley, those who appear to carry this habit over from one department of life to another really carry over the ideal of neatness. This explains why some persons are neat in their work and untidy in their dress, while others are neat in their dress and untidy in their work, and still others are neat in both work and dress. "An ideal is an individual factor." One may be neat in one's work from other motives than a general ideal of neatness.

Bagley (8:216) still believes that the mastery of certain subjects gives one an increased power to master other subjects, provided it is understood that this increased power must always take the form of an ideal that will function as judgment and not as an unconscious predisposition that will function as a
habit. Unless this ideal has been developed consciously there can be no certainty that the power will be increased, no matter how intrinsically well the subject matter may have been mastered.

We have read what the different writers, such as Judd, Waples, Orata, Bode, Book, and Bagley, give as their interpretation as to how transfer takes place. Although their explanations are expressed differently, they all have the same meaning—that transfer of training takes place through some form of generalization—such as: through constant application of experience (Judd (50:434); through ideas, ideals, habits, methods of work and other teaching objectives (Waples (115:221); through re-interpretation and re-organization of the pupil's daily experiences (Orata (79:179); through concept forming (Bode (15:202); of habits (Book (16:490-91); and through conscious ideals (Bagley (6:213-14).

The theory of identical elements and the theory of generalization are both approved by Starch (101:242). He does not look upon them as necessarily antagonistic, but, when sanely interpreted they are useful supplements to each other. Thorndike's theory has helped to make the discussion of formal discipline or transfer of training concrete, while the theory of generalization has aided in emphasizing the conscious recognition of the identical elements in as many situations as possible.

The evidence or spread of training in school subjects tend to support for the most part the theory of identical elements. The effects are largest where there is similarity or identity of material as for example, the case of the effect of the study of Latin upon the study of Spanish or upon the knowledge of English grammar (102:293).
Conclusions

After reading the discussion on the transfer of training given by the above mentioned psychologists, the writer is led to draw the following conclusions:

1. An acknowledgement of a belief in both Thorndike's Theory of Identical Elements and in Judd's Theory of Generalization. There appears to be no antagonism between the two theories. The Theory of Identical Elements says that an identical or common element must be present in the two situations if its exercise in one situation is to affect its exercise in the other. The Theory of Generalizations maintains that it is not so much the fact that the elements need to be present in the two functions, so that training transfers, as it is in the fact that the individual must be taught to disassociate the elements into their component parts and then practice in the recognition of the common elements in as many situations as possible. In the process of transfer the presence of the identical element is just as necessary as the ability to recognize whatever common elements may be present. The presence of the identical elements and the ability to recognize the common elements are necessary and neither one is adequate in itself to produce transfer. They must both be present if the process is to continue.
2. Thorndike's theory of identical elements explains the presence of transfer but his theory (109:7): "In the same organism the same neurone-action will always produce the same result—in the same individual, the really same situation will always produce the same response," cannot be used to explain how transfer takes place. The results of Lashley's (58:172-76) experiment proves that the common elements are not determined by specific neurones put into action, but that they must be sort of "dynamic patterns" determined by the relations among the various parts of the system. In other words, Thorndike's theory makes training specific, while Lashley, in his study, found that the brain is not rigid and mechanistic as Thorndike would have us believe, but flexible and adaptative.

3. Thorndike's theory of identical elements is supported directly or through slight changes by:


2. Gates (37:420), identical elements.

3. Jordan (48:213-16), identical elements and identity of content, procedure, moods, or attitude and ideals.

4. Pressey (88:522), through common elements of content.


7. Starch (102:293), identical elements.

8. Whipple (117:200), general claims of identical elements.

The theory of generalization held by Judd is also approved by:

1. American Classical League (1:185), through continued practice in by teacher and pupil.
2. Bagley (8:216), generalization of conscious ideals.
9. Cameron (25:461), generalization through ideals.
11. Colvin (31:223 and 241), generalization through improvement in technique of learning; generalization of habits to the plane of ideas.
12. Dewey (35:212), generalization.
13. Judd (53:420), generalization of experience through constant application.
14. Klapper (56:612), generalization through application of special techniques; generalized habits, and skills.
15. Lennes (59:24), generalization through concepts.
17. Morgan and Gilliland (67:801), Generalization through relationships.
18. Norsworthy (68:206), generalization through emphasis on similarity of methods or of subject matter, or of the desirability of an ideal.

19. Orata (77:170), generalization through thinking, meaning, and conceptualizing.

20. Powers and Uhl (87:422), generalization through relationships.


22. Rugg (97:116), generalization through effectiveness of conceptualizing abilities in developing methods of analysis and attack.


24. Waples (115:220), generalization of ideas, ideals, habits, methods of work and other teaching objectives.

II. What are the best methods of securing transfer?

Judd (54:412) in his theory of generalization holds that the method of teaching or study and the degree of self-activity aroused in the pupils are the all-important factors by means of which transfer takes place. If a lesson is presented in one fashion it will produce a very large transfer, but if it is presented in a different fashion it will be devoid of results for other phases of mental life. The importance of the method is emphasized by Judd when he says that formalism and lack of transfer turn out to be not characteristics of the subject, but a result of the technique used in teaching these subjects. He also believes that the pupils should be induced to generalize, as it leads to an attitude of mind which he calls the "general-
izing attitude."

As previously mentioned, the early experiment in transfer of training conducted by James (45:666-68) and Bagley and Squire (5:208) showed no transfer, while the experiments of Thorndike and Woodworth (105:246-61) showed only a slight gain which indicated that only some transfer took place. Orata (75:99) in his study of Thorndike's Theory of Identical Elements, examined several groups of these experiments, each of which deals with the same or practically the same problem, in order to determine why there was such a difference of opinion as to the amount of transfer which took place. Orata found that the individuals used in the Thorndike and Woodworth (105:246-61) experiment were trained in a routine fashion, without conscious formulation of any principles to guide them. In the experiments conducted by Judd (55:30-31), Woodrow (121:159-172), and Meredith (62:37-45), the individuals were equated into three groups, a control group, a practice group, and a training group. The practice group was drilled in regular routine fashion. In addition to the practice, the training group also received instructions in conscious formulation of guiding principles (Judd (55:28-42), training in technique of memorizing (Woodrow (121:159-72), or in critical analysis of the important features of a definition (Meredith (62:37-45). All of the three experimenters found that the training group surpassed the practice group. The conclusion is inevitable, according to Orata (75:99), that when an individual is trained
in mere routine fashion or drill, he gets fixed and mechanical habits which do not transfer, but when he is trained consciously to organize his knowledge or procedure in such a way that general principles are formulated, the result is not a mechanical habit but generalization, or an adaptive and flexible form of behavior which by virtue of its flexibility transfers.

Orata also compared the results of the experiments in neatness conducted by Bagley and Squire (5:203) with that performed by Ruediger (92:364-71), in which the former experimenters received "no transfer" while the latter states: "Evidently neatness made conscious as an ideal or aim in connection with only one school subject does function in other subjects." The conclusions reached by Orata (76:141) after studying the results of the above-mentioned experiments are that we get transfer of training from one study to another depending upon the method we use in teaching and organizing the subject matter.

Thorndike and Gates (110:104-05) also agree that the studies of transfer of training have shown that the methods used in guiding the pupil's learning activities have marked effect upon the degree of transfer. The more clearly the important element or principle in a situation is brought to the pupil's attention, the more readily the same element may be identified in another situation. By proper selection of experiences and by skillful management of the learning processes, the teacher can greatly aid the pupil in his efforts to identify the essential elements common to different situations, and
thereby help to increase the transfer of experience from one situation to another.

The amount and range of transfer may be increased, according to Buckingham (21:352-53), by a type of instruction intelligently directed towards that end. In arithmetic only a portion of the subject matter is taught, and transfer is relied upon to take care of the rest. Some teachers argue that as few as forty-five addition combinations are sufficient to teach the addition facts, while others teach as many as three hundred twelve. Buckingham believes this is a problem of transfer. Those who teach only a few combinations must devote more time to generalizations. The teaching of verbal problems is also a question of transfer. The children may make the proper responses to abstract numbers, but fail in working concrete problems. Their failure is due to their not having learned the combinations with a definite meaning. Teaching with meaning is the author's way of saying "providing for transfer." Buckingham believes that the method of teaching is the all-important factor in producing transfer.

Colvin also realizes the importance of method when he writes: "General training can best be secured if the children are trained in the technique of learning in the processes that make learning effective and economical (31:241)."

Cameron also holds that improvement through practice is due to improved methods of learning. Ability to memorize is the building up of many associations, and by developing habits
of attention and thought (25:461).

The best method securing transfer of training, according to the suggestions given above, are:

Through the developing of meanings, concepts, and generalizations.

The generalizations may be in the form of an:

Idea, ideal, habits, method of work, attitudes, methods of attack, improvement of methods of learning, better attention, and better methods of teaching.
Chapter IV

THE EXPERIMENT

The Problem

This experiment was planned with the object of teaching certain direct addition and certain direct subtraction combinations to the experimental group during the first four weeks of the experiment. The control group was to be taught both the direct and reverse of the same number combinations. During the second four weeks the experimental group was to continue to learn only certain direct addition and certain direct subtraction combinations, but a special technique of teaching the combinations was to be used. The control group was to follow the same method used the first four weeks of the experiment. Tests were made at the end of the first four weeks and again at the end of the eight weeks to compare and analyze the results obtained and from the analysis to determine the relative merits of each method used and to also determine the number of addition and subtraction combinations which should be taught.
Equating of Groups

Eighteen pupils of the second-grade served in the experiment. They were placed in two groups, a control group and an experimental group, each of which contained nine pupils. The pupils were so matched that the average of one group matched the average of the other group as regard (a) mental age, (b) chronological age, and (c) knowledge of addition and subtraction combinations.

The tests used in the initial tests were the following:

A. Otis Group Intelligence Scale, Primary Examination Form A.

B. Pintner-Cunningham Primary Mental Test.

C. Two tests in addition combinations and two in subtraction combinations.

The four tests in arithmetic contained all the direct and reverse forms of the number combinations which had been studied the previous eight weeks of the semester and all the direct and reverse combinations which the control group was to learn during the eight weeks of the experiment. The time allowed for each test was five minutes. No mention of the time element was made at all during any of the tests. The pupils were told that when they finished they were to look over their work. A few of the pupils, even in the initial test, finished before the five
minutes were up. The arithmetic tests were taken from the Grade 1 Arithmetic Work Book by Clifford B. Upton. Two changes were made in the test, one in the addition and one in the subtraction test, in order that all the number combinations in direct and reverse form which were to be studied, would be found in the test.

TABLE I

Average Mental Age, Chronological Age, I. Q., and Percentage of Total Scores in Arithmetic, for Two Groups of Second-Grade Pupils

<table>
<thead>
<tr>
<th>Group</th>
<th>Mental Age in Years and Months</th>
<th>Chronological Age in Years and Months</th>
<th>I. Q.</th>
<th>Percentage of Total Scores in Arithmetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control</td>
<td>8.3</td>
<td>7.37</td>
<td>110</td>
<td>39.30</td>
</tr>
<tr>
<td>II. Experimental</td>
<td>8.</td>
<td>7.4</td>
<td>106.55</td>
<td>44.23</td>
</tr>
</tbody>
</table>

The average mental age for the control group was 8 years, 3 months, and that for the experimental group, 8 years. The average chronological age for the control group was 7.37 years; that for the experimental group was 7.4 years. The average I. Q. for the control group was 110; that for the experimental group was 106.55. The average percentage of the total scores in
initial arithmetic tests for the control group was 39.30; that for the experimental group was 44.23.

Table II shows the two groups compared in the two initial tests in addition and the two initial tests in subtraction, in the total scores, and the percentage of total scores in the four tests.
### TABLE II

Average and Total Scores and Percentages on Initial Tests in Arithmetic, for Two Groups of Pupils in the Second-Grade

<table>
<thead>
<tr>
<th></th>
<th>Addition</th>
<th></th>
<th></th>
<th>Subtraction</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>B</td>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td><strong>Group</strong></td>
<td></td>
<td>Scores</td>
<td>Percentage</td>
<td></td>
<td>Scores</td>
<td>Percentage</td>
</tr>
<tr>
<td>I. Control</td>
<td></td>
<td>38.11</td>
<td>60.51</td>
<td></td>
<td>25.34</td>
<td>40.22</td>
</tr>
<tr>
<td>II. Experimental</td>
<td></td>
<td>43.33</td>
<td>68.78</td>
<td></td>
<td>41.78</td>
<td>39.34</td>
</tr>
<tr>
<td><strong>Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Control</td>
<td></td>
<td>23.22</td>
<td>36.86</td>
<td></td>
<td>12.33</td>
<td>19.57</td>
</tr>
<tr>
<td>II. Experimental</td>
<td></td>
<td>28.21</td>
<td>44.78</td>
<td></td>
<td>15.11</td>
<td>23.98</td>
</tr>
</tbody>
</table>
Table II reveals that the average scores and average percentage on the initial test for the control group were:

1. Addition "A", 38.11 problems or 60.15% of the 63 problems.
2. Addition "B", 25.34 problems or 40.22%.
3. Subtraction "A", 23.22 or 36.86%.
4. Subtraction "B", 12.33 or 19.57%.

For the experimental group the average scores and percentages were as follows:

1. Addition "A", 43.33 problems or 68.75% of the 63 problems.
2. Addition "B", 24.78 or 39.34%.
3. Subtraction "A", 28.21 or 44.78%.
4. Subtraction "B", 15.11 or 23.98%.
TABLE III

Mental Age, Chronological Age, and Intelligence Quotient of Nine Children in the Control Group

<table>
<thead>
<tr>
<th>Pupils</th>
<th>Mental Age</th>
<th>Chronological Age</th>
<th>Intelligence Quotient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A. B.</td>
<td>7.75</td>
<td>7.1</td>
<td>107</td>
</tr>
<tr>
<td>2. E. C.</td>
<td>9.7</td>
<td>7.5</td>
<td>126</td>
</tr>
<tr>
<td>3. I. J.</td>
<td>8.21</td>
<td>7.3</td>
<td>110</td>
</tr>
<tr>
<td>4. G. L.</td>
<td>8.45</td>
<td>7.2</td>
<td>114.5</td>
</tr>
<tr>
<td>5. G. P.</td>
<td>8.21</td>
<td>7.3</td>
<td>110</td>
</tr>
<tr>
<td>6. Y. R.</td>
<td>8.58</td>
<td>7.2</td>
<td>116.5</td>
</tr>
<tr>
<td>7. I. S.</td>
<td>7.95</td>
<td>8.8</td>
<td>93.5</td>
</tr>
<tr>
<td>8. M. W.</td>
<td>8.34</td>
<td>7.3</td>
<td>114.5</td>
</tr>
<tr>
<td>9. M. W.</td>
<td>7.5</td>
<td>7.6</td>
<td>99</td>
</tr>
</tbody>
</table>

Table III gives the mental age, chronological age, and intelligence quotient of the nine pupils in the control group. The mental age was found by finding the average of the mental age obtained as a result of the Otis Group Intelligence Scale, Primary Examination Form A and Pintner-Cunningham Primary Mental Test. The intelligence quotient was found in the same manner, that is, by finding the average of the intelligence quotients given in each of the above tests.
TABLE IV

Scores and Percentages on the Arithmetic Tests in Addition and Subtraction of Nine Children in the Control Group

<table>
<thead>
<tr>
<th>Pupils</th>
<th>Addition &quot;A&quot; Scores</th>
<th>%</th>
<th>Addition &quot;B&quot; Scores</th>
<th>%</th>
<th>Subtraction &quot;A&quot; Scores</th>
<th>%</th>
<th>Subtraction &quot;B&quot; Scores</th>
<th>%</th>
<th>Total Scores</th>
<th>Average %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A. B.</td>
<td>36</td>
<td>57.14</td>
<td>18</td>
<td>28.57</td>
<td>8</td>
<td>12.69</td>
<td>12</td>
<td>19.05</td>
<td>74</td>
<td>29.36</td>
</tr>
<tr>
<td>2. E. C.</td>
<td>63</td>
<td>100.00</td>
<td>63</td>
<td>100.00</td>
<td>62</td>
<td>98.41</td>
<td>51</td>
<td>80.95</td>
<td>239</td>
<td>94.85</td>
</tr>
<tr>
<td>3. I. J.</td>
<td>24</td>
<td>38.09</td>
<td>14</td>
<td>22.22</td>
<td>22</td>
<td>34.93</td>
<td>12</td>
<td>19.05</td>
<td>72</td>
<td>28.57</td>
</tr>
<tr>
<td>4. G. L.</td>
<td>37</td>
<td>58.73</td>
<td>31</td>
<td>49.21</td>
<td>23</td>
<td>36.51</td>
<td>7</td>
<td>11.11</td>
<td>98</td>
<td>38.89</td>
</tr>
<tr>
<td>5. G. P.</td>
<td>40</td>
<td>63.51</td>
<td>15</td>
<td>23.81</td>
<td>4</td>
<td>6.35</td>
<td>0</td>
<td>0.00</td>
<td>59</td>
<td>23.42</td>
</tr>
<tr>
<td>6. Y. R.</td>
<td>61</td>
<td>96.83</td>
<td>33</td>
<td>52.38</td>
<td>14</td>
<td>22.22</td>
<td>4</td>
<td>6.35</td>
<td>112</td>
<td>44.45</td>
</tr>
<tr>
<td>7. I. S.</td>
<td>30</td>
<td>47.78</td>
<td>25</td>
<td>39.68</td>
<td>31</td>
<td>49.21</td>
<td>4</td>
<td>6.35</td>
<td>90</td>
<td>35.71</td>
</tr>
<tr>
<td>8. M. W.</td>
<td>29</td>
<td>46.03</td>
<td>18</td>
<td>28.57</td>
<td>26</td>
<td>41.27</td>
<td>16</td>
<td>25.39</td>
<td>89</td>
<td>35.22</td>
</tr>
<tr>
<td>9. M. W.</td>
<td>23</td>
<td>36.51</td>
<td>11</td>
<td>17.44</td>
<td>19</td>
<td>30.14</td>
<td>5</td>
<td>7.94</td>
<td>58</td>
<td>23.01</td>
</tr>
</tbody>
</table>

Table IV discloses the individual score and percentage received on each test and also the total score and average percentage of the nine children in the control group.
TABLE V

Mental Age, Chronological Age, and Intelligence Quotient of Nine Children in the Experimental Group

<table>
<thead>
<tr>
<th>Pupils</th>
<th>Mental Age</th>
<th>Chronological Age</th>
<th>Intelligence Quotient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. E. C.</td>
<td>8.58</td>
<td>7.1</td>
<td>117.5</td>
</tr>
<tr>
<td>2. L. G.</td>
<td>8.21</td>
<td>6.9</td>
<td>117</td>
</tr>
<tr>
<td>3. M. P.</td>
<td>8.08</td>
<td>7.3</td>
<td>105</td>
</tr>
<tr>
<td>4. F. R.</td>
<td>8.25</td>
<td>7.2</td>
<td>112.5</td>
</tr>
<tr>
<td>5. M. R.</td>
<td>8.</td>
<td>7.4</td>
<td>108</td>
</tr>
<tr>
<td>6. L. S.</td>
<td>7.37</td>
<td>7.9</td>
<td>95</td>
</tr>
<tr>
<td>7. E. S.</td>
<td>7.34</td>
<td>8.1</td>
<td>91</td>
</tr>
<tr>
<td>8. M. S.</td>
<td>8.17</td>
<td>7</td>
<td>113.5</td>
</tr>
<tr>
<td>9. R. T.</td>
<td>8.</td>
<td>7.11</td>
<td>99.5</td>
</tr>
</tbody>
</table>

Table V lists the mental age, chronological age, and intelligence quotient of the nine pupils in the experimental group. The mental age was secured by finding the average of the mental age obtained from the rating on the Otis Group Intelligence Scale, Primary Form A and the Pintner-Cunningham Primary Mental Test. The intelligence quotient was found in the same manner, by finding the average of the intelligence quotients rated in each of the above tests.
TABLE VI

Scores and Percentages on the Arithmetic Tests in Addition and Subtraction of Nine Children in the Experimental Group

<table>
<thead>
<tr>
<th>Pupils</th>
<th>Addition</th>
<th></th>
<th></th>
<th>Subtraction</th>
<th></th>
<th></th>
<th>Total</th>
<th></th>
<th></th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
<td>Scores</td>
<td>%</td>
<td>Scores</td>
<td>%</td>
<td>Scores</td>
<td>Total</td>
</tr>
<tr>
<td>1. E. C.</td>
<td>44</td>
<td>69.84</td>
<td>19</td>
<td>30.14</td>
<td>17</td>
<td>26.98</td>
<td>8</td>
<td>12.69</td>
<td>88</td>
<td>34.92</td>
</tr>
<tr>
<td>2. L. G.</td>
<td>59</td>
<td>93.65</td>
<td>56</td>
<td>88.89</td>
<td>51</td>
<td>80.95</td>
<td>35</td>
<td>55.56</td>
<td>201</td>
<td>79.76</td>
</tr>
<tr>
<td>4. F. R.</td>
<td>63</td>
<td>100.00</td>
<td>47</td>
<td>74.60</td>
<td>42</td>
<td>66.67</td>
<td>18</td>
<td>28.57</td>
<td>170</td>
<td>67.46</td>
</tr>
<tr>
<td>5. M. R.</td>
<td>43</td>
<td>68.25</td>
<td>18</td>
<td>28.57</td>
<td>20</td>
<td>31.75</td>
<td>6</td>
<td>9.52</td>
<td>87</td>
<td>34.53</td>
</tr>
<tr>
<td>6. L. S.</td>
<td>51</td>
<td>80.95</td>
<td>29</td>
<td>46.03</td>
<td>0</td>
<td>0.00</td>
<td>7</td>
<td>11.11</td>
<td>87</td>
<td>34.53</td>
</tr>
<tr>
<td>7. E. S.</td>
<td>33</td>
<td>52.38</td>
<td>8</td>
<td>12.69</td>
<td>37</td>
<td>58.73</td>
<td>14</td>
<td>22.22</td>
<td>92</td>
<td>36.51</td>
</tr>
<tr>
<td>8. M. S.</td>
<td>33</td>
<td>52.38</td>
<td>5</td>
<td>7.95</td>
<td>34</td>
<td>53.97</td>
<td>10</td>
<td>15.87</td>
<td>82</td>
<td>32.54</td>
</tr>
<tr>
<td>9. R. T.</td>
<td>48</td>
<td>76.19</td>
<td>33</td>
<td>52.38</td>
<td>45</td>
<td>71.14</td>
<td>28</td>
<td>44.44</td>
<td>151</td>
<td>61.11</td>
</tr>
</tbody>
</table>

Table VI reveals the individual score and percentage received on each test and also the total score and average percentage of the nine children in the experimental group.
TABLE VII

Combinations Which Had Been Taught to the Control Group and the Experimental Group Previous to the Experiment

<table>
<thead>
<tr>
<th>Direct</th>
<th>Addition</th>
<th>Reverse</th>
<th>Direct</th>
<th>Subtraction</th>
<th>Reverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>3</td>
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<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>4</td>
<td></td>
<td></td>
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<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>6</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>7</td>
<td>1</td>
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<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>8</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>1</td>
<td>8</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>1</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
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<tr>
<td>5</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>2</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE VII (CONT.)

Combinations Which Had Been Taught to the Control Group and the Experimental Group Previous to the Experiment

<table>
<thead>
<tr>
<th>Direct</th>
<th>Addition</th>
<th>Reverse</th>
<th>Direct</th>
<th>Subtraction</th>
<th>Reverse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

The Technique of Teaching

The Course of Study of the Chicago Board of Education allocates only twenty-nine addition combinations and their corresponding subtraction combinations to be taught during the first semester of second-grade. But in order to use the Grade I Arithmetic Work Book by Clifford B. Upton, the sixty-four number combinations had to be learned in preference to the twenty-nine recommended by the Board of Education if the pupils were to use all the exercises and the tests in the book. Previous to the starting of the experiment, the pupils had been taught forty-six of the sixty-four number combinations as shown in Table VII.

During the experiment both groups were taught by the same teacher for a period of twenty minutes each day. The control group met first during the first four weeks. This procedure
was reversed during the second four weeks, with the experimental group meeting first. While one group was having arithmetic, the other group was reading in another room. The experimental group was taught only some of the direct addition and only some of the direct subtraction combinations, the idea being that if the pupils received extra practice in learning the direct combinations, they would automatically learn the reverse combinations through association. During the experiment the new number combinations were introduced through Upton's Arithmetic Work Book. The pages were removed from the Work Book and given to each pupil the day the particular lesson was learned, so that the pupils in the experimental group did not have the opportunity of seeing any of the combinations in the forms which they were not to study.
<table>
<thead>
<tr>
<th>Control Group</th>
<th>Experimental Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition</td>
<td>Subtraction</td>
</tr>
<tr>
<td>Direct</td>
<td>Reverse</td>
</tr>
<tr>
<td>1 2</td>
<td>1 2</td>
</tr>
<tr>
<td>3 5</td>
<td>3 5</td>
</tr>
<tr>
<td>9 1</td>
<td>10 10</td>
</tr>
<tr>
<td>2 6</td>
<td>8 6</td>
</tr>
<tr>
<td>3 4</td>
<td>7 4</td>
</tr>
<tr>
<td>2 5</td>
<td>7 5</td>
</tr>
<tr>
<td>6 4</td>
<td>10 4</td>
</tr>
<tr>
<td>2 7</td>
<td>9 9</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

TABLE VIII

Combinations Taught during the First Four Weeks of the Experiment
TABLE VIII (CONT.)

Combinations Taught during the First Four Weeks of the Experiment

<table>
<thead>
<tr>
<th>Control Group</th>
<th>Experimental Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition</td>
<td>Subtraction</td>
</tr>
<tr>
<td>Direct</td>
<td>Reverse</td>
</tr>
<tr>
<td></td>
<td>Direct</td>
</tr>
</tbody>
</table>

Table VIII contains the number of combinations taught to each group during the first four weeks of the experiment. Nineteen addition and twenty-one subtraction combinations were taught to the control group. The experimental group received instructions in nine direct addition combinations and twelve subtraction combinations.

In introducing the combinations, Upton presents both the direct and reverse combinations such as \( \frac{4}{3} \) and \( \frac{3}{4} \) on the same page. In order that the experimental group would not see the reverse combinations small pieces of paper were pasted on top of the numbers. The lesson, as Upton wrote it, was taught to the control group.

During the first four weeks of the experiment in teaching the experimental group, the beginning of the arithmetic lesson
was spent in reviewing the number combinations learned the previous day. The new lesson was then taught by means of the Work
book. Drill with flash cards followed for a period of five-minutes, the pupils saying both the combination and the answer. A five-minute period was allowed for blackboard work. Here the pupils wrote the combination and the answer as the teacher dictated the problems in addition and in subtraction. One number at a time was dictated to each pupil until there were five combinations written. The pupils read and corrected their problems aloud. The idea of this test was to speed the pupil in writing the number combinations, especially in writing the subtraction combinations, and in giving the correct answers. A record was kept on the board of the number of one hundreds received by each group in order to stir competition between the groups. The remaining period of the lesson was spent in playing number games such as: "I am thinking of two numbers which when added give 7 or I am thinking of two numbers which when subtracted give 3."

The method used in teaching the control group was like the above method except that during the flash-card drill and the speed test at the blackboard, both the direct and reverse combinations were practiced, although the time allotted to the drills was the same in both groups.

Another speed test, aside from the regular lesson, was given to both groups at the same time, in order to increase their speed and accuracy. This test contained only the direct
number combinations. Both groups did the same daily written work, consisting of direct addition and direct subtraction combinations. Each paper was marked by the teacher and the pupil was showed his errors.

At the end of the four weeks, both groups were given the same test as was administered in the initial arithmetic test.
## TABLE IX

Average Scores and Percentages in Arithmetic on Initial and Second Tests, for Two Groups of Second-Grade Pupils

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Addition</td>
<td>Addition</td>
</tr>
<tr>
<td></td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
</tr>
<tr>
<td></td>
<td>Scores</td>
<td>%</td>
</tr>
<tr>
<td>Initial</td>
<td>38.11</td>
<td>60.51</td>
</tr>
<tr>
<td></td>
<td>43.33</td>
<td>68.78</td>
</tr>
<tr>
<td>Second</td>
<td>53.44</td>
<td>84.85</td>
</tr>
<tr>
<td></td>
<td>54.67</td>
<td>86.78</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Subtraction</th>
<th>Subtraction</th>
<th></th>
<th>Subtraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
</tr>
<tr>
<td></td>
<td>Scores</td>
<td>%</td>
<td>Scores</td>
<td>%</td>
</tr>
<tr>
<td>Initial</td>
<td>23.22</td>
<td>36.86</td>
<td>12.33</td>
<td>19.57</td>
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<td></td>
<td>28.21</td>
<td>44.78</td>
<td>15.11</td>
<td>23.98</td>
</tr>
<tr>
<td>Second</td>
<td>35.67</td>
<td>56.67</td>
<td>20.88</td>
<td>33.14</td>
</tr>
<tr>
<td></td>
<td>36.78</td>
<td>58.38</td>
<td>21.56</td>
<td>34.22</td>
</tr>
</tbody>
</table>
Table IX shows that the average arithmetic scores and the average percent scores in the arithmetic test taken at the end of the first four weeks by the control group were:

1. Addition "A", 53.44 problems or 84.85% of the 63 problems.
2. Addition "B", 28.44 or 45.14%.
3. Subtraction "A", 35.67 or 56.67%.
4. Subtraction "B", 20.88 or 33.14%.

For the experimental group the scores were:

1. Addition "A", 54.67 problems or 86.78% of the 63 problems.
2. Addition "B", 21.33 problems or 33.86%.
3. Subtraction "A", 36.78 or 58.38%.
4. Subtraction "B", 21.56 or 34.22%.
TABLE X

Average Gain or Loss in Percentage Scores of Second Test over Initial Test in Arithmetic, for Two Groups of Second-Grade Pupils

<table>
<thead>
<tr>
<th>Control</th>
<th>Experimental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition</td>
<td>Addition</td>
</tr>
<tr>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
</tr>
<tr>
<td>Test</td>
<td>Gain</td>
</tr>
<tr>
<td>Second</td>
<td>24.34</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subtraction</th>
<th>Subtraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
</tr>
<tr>
<td>Test</td>
<td>Gain</td>
</tr>
<tr>
<td>Second</td>
<td>19.81</td>
</tr>
</tbody>
</table>
An analysis of Table IX discloses that on the preliminary test the experimental group surpassed the control group in all tests except one, Addition "B." The total average per cent of the control group was 39.29; that of the experimental group was 44.23. In the second test the experimental group again surpassed the control group in all but one test, and again it was the Addition "B." In this test the experimental group suffered a loss on its previous score of 5.48 per cent. The total average per cent of the control group on the second test was 54.95, while that of the experimental group was 53.31. The loss in Addition "B" tended to lessen the score of the experimental group and to increase the gain of the control group to 1.64 per cent. A study of the test papers in Addition "B" reveals that three of the nine pupils in the control group and seven of the nine pupils in the experimental group received much lower scores on this test than they did on the initial test. Further study shows that the low scores were not due only to errors, but that they were also due to the fewer number of attempts made to work the problems. The total number of problems attempted by the control group was 294, while the experimental group attempted only 214. The total number of errors made by the control group was forty-six, that in the experimental group was fifty-five. Thirty of the fifty-five errors made by the experimental group was due to one pupil whose particular problems will be discussed later. A similar situation was found in the control group in the case of G. P., who made twenty-seven
of the forty-six errors. This child simply guessed at the answers, but M. P., in the experimental group gives a reason as to why she answered the problems incorrectly.

In an effort to determine how many of the errors made by the two groups were in the reverse combinations, taught only to the control group, the writer marked off on a sample arithmetic test all the reverse combinations which had been taught to the control group during the first four weeks of the experiment. A study of the errors made in these combinations by the control group and the experimental group, discloses the fact that both groups averaged the same number of errors, 5.11. A similar study of the number of errors made in the direct combinations taught to both groups reveals that the control group made an average of 3.78 errors, while the experimental group made an average of 6.22 errors. In other words, the experimental group made more errors in the direct number combinations in which they were drilled than in the reverse combinations in which they were not drilled. The same pupil, M. P., again makes the greatest number of errors in this test, twenty-two of the fifty-six errors.

Although the control group surpassed the experimental group in the second test, the gain of 1.64 per cent is so small that the writer does not believe it to be significant enough to say that all addition and subtraction combinations should be taught to all the pupils. The writer believes that the average pupil can be taught certain direct addition and certain direct
subtraction combinations and that the reverse of these combinations will automatically come to the pupils. The case of M. P., is the exception to the rule. It must be admitted that the great number of mistakes of M. P. tended to increase the number of errors of the experimental group. She contributed 63 per cent of the errors in the reverse combinations and almost 40 per cent of the errors in the direct combinations.

The writer during the last four-weeks of the experiment sought to determine whether a change in the teaching technique, a generalizing procedure, would result in the final test scores of the experimental group being greater or at least equal to those of the control group. A generalizing procedure is the hooking-up of the subtraction combinations with the addition combinations so firmly in the minds of the pupils, that the answers to the reverse combinations would come to them almost automatically.

Table XI contains the number of direct and reverse combinations which the control group learned and the number of direct combinations the experimental group learned during the last four-weeks of the experiment.
TABLE XI

Combinations Taught during the Second Four Weeks of the Experiment

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th></th>
<th>Experimental Group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Addition</td>
<td>Subtraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct</td>
<td>Reverse</td>
<td>Direct</td>
<td>Reverse</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
TABLE XI

Combinations Taught during the Second
Four Weeks of the Experiment

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Experimental Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Addition</td>
<td>Subtraction</td>
</tr>
<tr>
<td></td>
<td>Direct</td>
<td>Reverse</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
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</tr>
<tr>
<td>10</td>
<td>10</td>
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<td>3</td>
<td>6</td>
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<tr>
<td>3</td>
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<td>10</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

At the beginning of the second half or the fifth week of the experiment, a change was made in the method of teaching the experimental group. Instead of simply presenting the number combinations as planned in the Work Book, such as $9 - \frac{5}{4}$, the pupils were led to see that five from nine leaves 4 because when 5 and 4 are added they give 9. The first few minutes of each flash-card drill was spent in generalizing groups of numbers.

With the exception of the above change, the same procedure was followed for both groups as outlined for the first four weeks of the experiment; the control group learning the direct...
and reverse combinations; the experimental group learning only the direct combinations. At the end of the eight-weeks the same arithmetic tests were given as in the initial and second test.

**TABLE XII**

Average Scores in Initial, Second, and Final Tests in Arithmetic, for Two Groups of Second-Grade Pupils

<table>
<thead>
<tr>
<th>Tests</th>
<th>Control Group</th>
<th></th>
<th>Experimental Group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
</tr>
<tr>
<td>Addition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>38.11</td>
<td>25.34</td>
<td>43.33</td>
<td>24.78</td>
</tr>
<tr>
<td>Second</td>
<td>53.44</td>
<td>28.44</td>
<td>54.67</td>
<td>21.33</td>
</tr>
<tr>
<td>Final</td>
<td>62.11</td>
<td>61.11</td>
<td>61.77</td>
<td>58.67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tests</th>
<th>Control Group</th>
<th></th>
<th>Experimental Group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
</tr>
<tr>
<td>Subtraction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>23.22</td>
<td>12.33</td>
<td>28.21</td>
<td>15.11</td>
</tr>
<tr>
<td>Second</td>
<td>35.67</td>
<td>20.88</td>
<td>36.78</td>
<td>21.56</td>
</tr>
<tr>
<td>Final</td>
<td>57.44</td>
<td>46.89</td>
<td>58.56</td>
<td>48.67</td>
</tr>
</tbody>
</table>
Table XII shows the average scores on the initial, second, and final tests in arithmetic for the control group and the experimental group. In the final test the results for the control group were:

2. Addition "B", 61.11.
3. Subtraction "A", 57.44.
4. Subtraction "B", 46.89.

The results for the experimental group were:

1. Addition "A", 61.77 of the 63 problems.
TABLE XIII

Average Percentages in Initial, Second, and Final Tests in Arithmetic, for Two Groups of Second-Grade Pupils

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th></th>
<th>Experimental Group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Addition</td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
<td>&quot;A&quot;</td>
</tr>
<tr>
<td></td>
<td>Tests</td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
<td>&quot;A&quot;</td>
</tr>
<tr>
<td>Initial</td>
<td>60.51</td>
<td>40.22</td>
<td>68.78</td>
<td>39.34</td>
</tr>
<tr>
<td>Second</td>
<td>84.85</td>
<td>45.14</td>
<td>86.78</td>
<td>33.36</td>
</tr>
<tr>
<td>Final</td>
<td>98.57</td>
<td>97.00</td>
<td>98.05</td>
<td>93.13</td>
</tr>
</tbody>
</table>

|                 | Control Group |                        | Experimental Group |                        |
|                 | Subtraction   | "A" | "B" | "A" | "B" | Subtraction       |          |
|                 | Tests         | "A" | "B" | "A" | "B" | "A" | "B" |
| Initial         | 36.86         | 19.57 | 44.78 | 23.98 |
| Second          | 56.67         | 33.14 | 58.38 | 34.22 |
| Final           | 91.17         | 74.43 | 92.95 | 77.25 |

Table XIII reveals the average percentages in initial, second, and final tests in arithmetic. This table also serves as a comparison of the gain made within each group on each test.
TABLE XIV
Comparison of Average Gain or Loss in Scores in the Initial, Second and Final Tests in Arithmetic of Two Groups of Second-Grade Pupils

Addition

<table>
<thead>
<tr>
<th>Groups</th>
<th>&quot;A&quot;</th>
<th>Gain</th>
<th>&quot;B&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>38.11</td>
<td>43.33</td>
<td>5.22</td>
</tr>
<tr>
<td>Second</td>
<td>53.44</td>
<td>54.67</td>
<td>1.23</td>
</tr>
<tr>
<td>Final</td>
<td>62.11</td>
<td>61.77</td>
<td>.34</td>
</tr>
</tbody>
</table>

Subtraction

<table>
<thead>
<tr>
<th>Groups</th>
<th>&quot;A&quot;</th>
<th>Gain</th>
<th>&quot;B&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>23.22</td>
<td>28.21</td>
<td>4.99</td>
</tr>
<tr>
<td>Second</td>
<td>35.67</td>
<td>36.78</td>
<td>1.11</td>
</tr>
<tr>
<td>Final</td>
<td>57.44</td>
<td>58.56</td>
<td>1.12</td>
</tr>
</tbody>
</table>
In Table XIV a comparison is made of the average gain or loss in scores in the initial, second, and final tests in arithmetic. All the tests in the second and final examination show a gain in score over the previous test, except the second test in Addition "B", taken by the experimental group.
TABLE XV
Comparison of Average Gain or Loss in Percentage in the Initial, Second, and Final Tests in Arithmetic of Two Groups of Second-Grade Pupils

Addition

<table>
<thead>
<tr>
<th>Groups</th>
<th>Control</th>
<th>Experimental</th>
<th>Gain Cont. Exp.</th>
<th>Control</th>
<th>Experimental</th>
<th>Gain Cont. Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>60.51</td>
<td>68.78</td>
<td>8.27</td>
<td>40.29</td>
<td>39.34</td>
<td>.88</td>
</tr>
<tr>
<td>Second</td>
<td>84.85</td>
<td>86.78</td>
<td>1.93</td>
<td>45.14</td>
<td>33.86</td>
<td>11.28</td>
</tr>
<tr>
<td>Final</td>
<td>98.57</td>
<td>98.05</td>
<td>.52</td>
<td>97.00</td>
<td>93.13</td>
<td>3.87</td>
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</tbody>
</table>

Subtraction

<table>
<thead>
<tr>
<th>Groups</th>
<th>Control</th>
<th>Experimental</th>
<th>Gain Cont. Exp.</th>
<th>Control</th>
<th>Experimental</th>
<th>Gain Cont. Exp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>36.86</td>
<td>44.78</td>
<td>7.92</td>
<td>19.57</td>
<td>23.98</td>
<td>4.41</td>
</tr>
<tr>
<td>Second</td>
<td>56.67</td>
<td>58.38</td>
<td>1.71</td>
<td>33.14</td>
<td>34.22</td>
<td>1.08</td>
</tr>
<tr>
<td>Final</td>
<td>91.17</td>
<td>92.95</td>
<td>1.82</td>
<td>74.73</td>
<td>77.25</td>
<td>2.52</td>
</tr>
</tbody>
</table>
Table XV shows the average gain or loss in percentage in the initial, second, and final tests in arithmetic. In the initial test the experimental group surpassed the control group 19.20 per cent. In the second test the control group surpassed the experimental group 6.56 per cent. In the final test the control group again surpassed the experimental group but this time the gain was very small, only .15 per cent.

While the average percentage of the control group on the final test was 90.37, and that of the experimental group 90.35, the difference in the gain for the control group of .02 per cent was so very small one would consider such a gain of the control group over the experimental group as almost negligible.
TABLE XVI

Average Gain in Percentage in Final Test Over Second Test in Arithmetic, for Two Groups of Second-Grade Pupils

<table>
<thead>
<tr>
<th>Test</th>
<th>Control Groups</th>
<th>Experimental Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Addition</td>
<td>Subtraction</td>
</tr>
<tr>
<td></td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
</tr>
<tr>
<td>Gain</td>
<td>Gain</td>
<td>Gain</td>
</tr>
<tr>
<td></td>
<td>&quot;A&quot;</td>
<td>&quot;B&quot;</td>
</tr>
<tr>
<td></td>
<td>Gain</td>
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<tr>
<td>Final</td>
<td>13.72</td>
<td>51.66</td>
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<td></td>
<td>34.50</td>
<td>41.29</td>
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<tr>
<td></td>
<td>1.27</td>
<td>59.27</td>
</tr>
<tr>
<td></td>
<td>34.57</td>
<td>43.03</td>
</tr>
</tbody>
</table>
Table XVI shows the improvement made by both groups in the final test as compared with the second test. The greatest gain, 59.27 per cent, was made by the experimental group in Addition "B." On the initial test the experimental group received 39.34 per cent, but on the second test there was a loss sustained and the percentage was only 33.86 per cent. Decided progress was also made by the experimental group in Subtraction "B," showing an increase of 43.03 per cent in the final test over the second test. In Subtraction "B" in the second test, the experimental group gained only 10.24 per cent over the initial test. To appreciate the significant gain made in these two tests in the final examination, let us recall that during the last four weeks of the experiment the pupils in the experimental group spent a few minutes of each lesson in generalizing a few groups of combinations. The pupils not only reviewed, and in many cases learned the direct subtraction combinations for the first time, but they also learned that the subtraction fact 10 - 2 was intimately related to 8 plus 2. In other words, the practice in generalizing the direct subtraction combinations tended to strengthen, not only the pupils knowledge of the direct combinations, but also strengthened their knowledge of the direct addition combinations as well.

The results show the gain in percentage is in favor of the final test over the second test, the greatest gain being made by the experimental group. This gain must be due to some particular factor. Since the only change in the teaching procedure
of both groups was the generalizing method used with the experimental group, it follows that the gain in percentage must, therefore, be due to the method of generalizing. The writer believes as a result of the above evidence, that a few minutes spent each day in generalizing a few number combinations is more beneficial to the pupils than mere practice in flash card drill.

The above results tend to support the opinion of the leading psychologists on the subject of transfer of training, as reviewed in Chapter III, that the extent of transfer of training is dependent upon the method of teaching.

An objection may be raised to the conclusion, by those who oppose the generalizing of the number combinations, that the significant progress made by the experimental group in the final test was due to generalization. The progress of the control group in the final test may be used as a basis for argument. It is true that in the final test in Addition "B," the control group made a very decided gain of 51.86 per cent over the second test. However, in the second test, the control group also made a gain of 4.92 per cent over the initial test, while the experimental group suffered a loss of 5.48 per cent in the second test over the first. The enormous gain made by the experimental group in the final test must be due to generalization, since only one-half the number of combinations were studied, while the control group studied all of them, and the only change in the teaching procedure was the use of generalization.

To continue the analysis in an effort to compare the number
of errors made by both groups in the reverse combinations, the writer again marked off on a sample arithmetic tests all the reverse combinations which had been taught to the control group only. A study of the errors discloses that the control group made a total of sixty errors or an average of 6.67 errors; the experimental group made a total of seventy-eight errors or an average of 8.71 errors. In the control group, the number of errors made by seven of the nine pupils arranged from two to twenty. Of the nine pupils in the experimental group only four made errors, but they arranged from one to forty-nine. A study of the errors made by both groups in the direct combinations shows that the control group made a total of thirty-four errors, or an average of 3.78 errors. The experimental group made twenty-four errors, or an average of 2.56 errors.

The writer made a particular study of the pupil in each group who made the largest number of errors in the reverse combinations. In the control group, M. W. made twenty of the sixty errors in her group. Almost all incorrect answers had the number "one" or the number "two" given as the sum in addition or the difference in subtraction. After the final tests were taken, the writer asked M. W. where she obtained the "one" used in the example $9$ $\frac{-4}{1}$ and $10$ $\frac{-3}{1}$. Her reply was that the answer wasn't "right" and "I really wasn't thinking when I wrote it." During the tests M. W. did not seem excited or hurried, as she finished her tests before the five minutes were used up.
It appears from the analysis of the child's tests and her own admission, that her errors were due to carelessness.

An interesting study is revealed in the case of M. P. in the experimental group. This pupil made forty-nine of the seventy-eight errors recorded against the experimental group in the final test. The results of the study of the errors made in the reverse combinations in the second test, discloses that M. P. made sixteen of the total of forty-six errors. In the Addition "B" in the second test of the experimental group, M. P. contributed thirty to the total number of fifty-five errors. An analysis of both the second and final tests reveal some interesting information. In the addition test, M. P. would add part of the time and then she would subtract the addition problems. It is very obvious that she means to subtract on the addition test. Her answers to some of the addition problems were:

\[
\begin{array}{ccc}
4 & 2 & 3 \\
3 & 5 & 4 \\
1 & 3 & 1 \\
\end{array}
\]

In the subtraction tests she not only subtracts but occasionally she adds as:

\[
\begin{array}{c}
4 \ 5 \\
-4 \ -5 \\
8 \ 10 \\
\end{array}
\]

After the second test, the writer called M. P.'s attention to the fact that she added sometimes in the addition test and that very often she subtracted on the addition. M. P. could offer no reason at the time as to why she did her work in this fashion. The writer at the time was at a loss to understand
why she did this, as she responded very readily in the flash-card drill, and she had no difficulty in remembering and writing the larger number in the minuend in the subtraction problems. The pupils received blackboard practice in writing numbers, particularly for practice in writing the subtraction problems. M. P.'s daily written work also compared with her oral and blackboard work. After the final test, the writer again attempted to ascertain why she wrote the incorrect answers to the problems. This time she explained that in the addition problems when \( \frac{3}{6} \) appeared "I wrote 3," she said, "because 3 from 6 equals 3." She visualized the number combinations the same way before she was taught the generalizing procedure but she was unable to say why she gave the answer that she did. When she learned the expression, "3 from 6 is 3 because 3 and 3 are 6," she used it to explain why she wrote 3 and 6 equals 3. She appears to reverse some of the number combinations in her mind and then to write the answers to the numbers rather than to write the answers to the problems on the page before her. The time element cannot be used as a disturbing factor, since no mention was made of time at any time during the test, nor was the child told to hurry. In the first three of the final tests M. P. attempted to answer every one of the sixty-three problems on each page. On test one she scored fifty-four out of a possible sixty-three; on test 2, a score of thirty-six; on test 3, a score of fifty-two. On test 4 she attempted fifty-five problems and only had thirty-seven correct. M. P.
has a total of sixty-eight errors on the final tests, forty-nine of which were errors made in combinations which were not taught to the experimental group.

The large number of errors made by this pupil tended to lessen the gain of the experimental group as a whole. It does not lessen the value of the generalizing procedure, however.

M. P.'s arithmetic test record is:

**Addition**

<table>
<thead>
<tr>
<th>Test</th>
<th>Score</th>
<th>Per cent</th>
<th>&quot;B&quot;</th>
<th>Score</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>16</td>
<td>25.39</td>
<td></td>
<td>8</td>
<td>12.69</td>
</tr>
<tr>
<td>Second</td>
<td>49</td>
<td>63.51</td>
<td></td>
<td>4</td>
<td>6.35</td>
</tr>
<tr>
<td>Final</td>
<td>54</td>
<td>85.71</td>
<td>37</td>
<td>58.73</td>
<td></td>
</tr>
</tbody>
</table>

**Subtraction**

<table>
<thead>
<tr>
<th>Test</th>
<th>&quot;A&quot;</th>
<th>Per cent</th>
<th>&quot;B&quot;</th>
<th>Per cent</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>8</td>
<td>12.69</td>
<td>10</td>
<td>15.87</td>
<td>42</td>
<td>12.67</td>
</tr>
<tr>
<td>Second</td>
<td>31</td>
<td>49.21</td>
<td>15</td>
<td>23.81</td>
<td>90</td>
<td>35.72</td>
</tr>
<tr>
<td>Final</td>
<td>52</td>
<td>82.54</td>
<td>36</td>
<td>57.14</td>
<td>179</td>
<td>71.03</td>
</tr>
</tbody>
</table>

A study of M. P.'s record discloses that she made an average percentage gain of 22.05 in the second test over the initial test, and a gain of 35.31 per cent in the final test over the second test.

Since the generalizing of the combinations was not taught
until the last four weeks of the experiment, and the results of
the final tests show that M. P. made a greater gain than in the
second test, the writer is again lead to conclude that the best
method of securing transfer of training in addition and in sub-
traction is through generalization.

Thus, in the last half of the experiment we have seen trans-
fer of training take place within the experimental group in the
learning of addition and subtraction combinations. Although
the experimental group learned only half the number of combina-
tions, in the final test the high per cent received shows that
the training of the experimental group in the direct addition
and direct-subtraction combinations transferred to the reverse
combinations which the group had not studied. We have also seen
that in the second test there was a loss suffered by the experi-
mental group. When a different teaching technique was used an
enormous gain was made in the addition "B" test in the final
examination.

In conclusion the writer believes that this experiment
proves that transfer of training takes place but that the
amount of transfer is dependent upon the method of teaching
which is used.
CHAPTER V

CONCLUSIONS

The conclusions of the study may be summarized as follows:

1. In the study made during the first four weeks of the experiment, the average score of the pupils in the experimental group, who were taught only nine direct addition combinations and twelve direct subtraction combinations, was almost equal to that attained by the pupils in the control group, who were taught nineteen direct and reverse addition combinations and twenty-one direct and reverse subtraction combinations.

2. The knowledge gained by the pupils in the experimental group of the direct addition and direct subtraction combinations transferred almost completely to the reverse combinations taught only to the control group. Contrary to what one would expect, the experimental group did not know as many of the direct combinations in which they were drilled as they did of the reverse combinations which they were not taught.

3. The results of the last four weeks of the study disclose, that the experimental group which had been taught only
nine direct addition and nine direct subtraction combinations, averaged a score which was equal to that obtained by the control group, which had been taught twenty-two direct and nineteen direct and reverse subtraction combinations.

4. The training received by the experimental group in the direct addition and direct subtraction combinations did not transfer as much to the reverse addition and reverse subtraction combinations as it did during the first four weeks of the experiment. The higher average received by the experimental group over the control group in the direct addition and direct subtraction combinations balanced the slight loss incurred above.

5. Contrary to the evidence of Olander's (69:436) experiment, considerable improvement was gained in the experimental group when the regular teaching technique was changed, giving a few minutes each day to generalizing the combinations, rather than spending the same amount of time on formal flash-card drill.

6. Transfer of training in arithmetic does take place and pupils can be taught only a portion of the number combinations and then depend upon transfer for the knowledge of the reverse combinations, if the proper method of teaching is used to aid transfer.
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The thesis, "The Extent of Transfer of Learning in Simple Addition and Subtraction," written by Cecelia Helen O'Brien, has been accepted by the Graduate School of Loyola University with reference to form, and by the readers whose names appear below, with reference to content. It is, therefore, accepted as a partial fulfillment of the requirements for the degree of Master of Arts.

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