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The Effects of the Transfer of Training in Teaching Algebra to a Ninth Grade Group

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THE EFFECTS OF THE TRANSFER OF TRAINING IN TEACHING ALGEBRA TO A NINTH GRADE GROUP

by

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CHAPTER I

INTRODUCTION

The basic problem of this experiment is to study the effect of the transfer of training in teaching a ninth-grade algebra group.

The purpose is three-fold: first, to review outstanding opinions of psychologists on the existence and nature of transfer; secondly, to give brief summaries of experimental studies made on transfer particularly as these are related to school subjects; and thirdly, to conduct an experiment similar to recent studies in which an attempt will be made to measure the extent of the transfer of training, positive, negative, or zero in signed numbers in algebra.

Transfer has been defined as a function of relations between antecedent or already learned activities and subsequent activities in process of being practiced. The present thesis proposes to evaluate this hypothesis by testing equated groups which have been taught addition and subtraction of signed numbers. Initial and final scores obtained from experimental and control groups will be used as data. These scores, by careful recording of data, should show significant differences, or they

will show negative results. The scores will be secured from initial and final tests given to the entire group.

The testing of this hypothesis is of special interest when used for educational purposes. Through a better understanding of this problem, greater possibilities exist for improving abilities to learn, to profit by reading, to memorize and to solve problems, all of which are accomplished by definite instruction in effective technique. The problem of transfer is fundamentally one of good teaching. In order to achieve transfer, method is a vital factor, for the law of compensation operates in the realm of the mind as well as elsewhere. Since method is of vital importance, and transfer is the result of proper method, it is a "must" in the teacher's life in the classroom. Today success depends more on the varied methods than on simple drill.

In this experiment two classes of a ninth-grade algebra group, in a large high school in Chicago, will be equated and placed in an experimental and a control group, respectively. The equating will be done from their eighth grade intelligence test scores (the Kuhlmann Anderson or other standard test), and the high school Otis Gamma Test. After the signed numbers have been taught, the experimental group, but not the control group, will be given practice on algebraic multiplication and division, after which final tests will be given to both groups in algebraic

addition and subtraction.

The initial test is made for the purpose of obtaining a measure of the subject's pre-training performance in addition and subtraction of signed numbers from which transfer will be measured.

The second or final test will be given for the purpose of discovering whether transfer took place. The amount and sign of transfer will be determined by subtracting the score of the control group in test two from the corresponding score of the experimental group. If the difference is positive and significant, positive transfer has taken place; if negative and significant, then negative transfer has taken place. Zero or indeterminate transfer takes place when training in one activity has no observed influence on the acquisition of the other.

In this study the factor of importance will be the re-test scores, taken after the experimental group has a practice period in learning multiplication and division of signed numbers, which was to have improved the experimental groups' skill in addition and subtraction of signed numbers. The control group will not have a practice period but will be obliged to take the re-test which the experimental group takes. Use of the control group permits us to know the practice effect from the first test and the leaves any difference between the groups on test two ascribable to transfer. Because of the method of this experiment

the information secured will be quantitive.

This experiment will be limited in the number of subjects available, as the experimenter can draw only from the pupils of the classes. However, there seems to be a wide variety of learning ability in both these classes. Though every effort will be made to make this a worth-while contribution, flaws may appear in the technique. However, that the results will have some value in research or may encourage many others to continue to work in the study of transfer, is earnestly hoped.

The next chapter, will give a detailed account of some of the literature written on this type of experiment, the reading of which led to conclusions given subsequently.

CHAPTER II

REVIEW OF LITERATURE

"Formal discipline" or transfer of training, as we call it today, has been a problem throughout educational history. Its modern form dates back to John Locke (1623-1704). Thus, in his "Conduct of the Understanding" we find the following passage:

> Would you have a man reason well, you must use him to it betimes; exercise his mind in observing the connections of ideas and following them in train. Nothing does this better than mathematics, which therefore should be taught to all those who have the time and opportunity, not so much to make them mathematicians as to make them reasonable creatures. . . . Not that I think it necessary that all should be deep mathematicians but that, having got the way of reasoning, which that study brings the mind to, they may be able to transfer it to other parts of knowledge as they have occassoin.[1]

The literature discussing and criticizing the doctrine of transfer of training has become so extensive that it could not be adequately reviewed in a work of this kind. Most of the data can be classified under two heads: (1) general discussions mainly deductive; and (2) inductive investigations. In the

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1 William Carl Ruediger, The Principles of Education, Boston, 1910, 77-78.

beginning the question of the transfer of training dealt with general argumentative discussions based on common experience and deductions from psychological principles, but in recent years there has been a trend toward careful inductive investigation based on experiments.[2]

Although to Dr. Ellsworth Brown, U. S. Commissioner, who published a paper "How Is Formal Discipline Possible?" in 1893 goes the credit of being the first in America, he did not draw the attention of American educators as did Hinsdale when he wrote on "The Dogma of Formal Discipline." He says:

> The power or skill engendered by driving nails can all be used in driving nails but only partly in shoving a plane. . . . The law appears to be this: in so far as a second exertion involves the same muscles and nerves as the first, and particularly in so far as it calls for the same co-ordination of muscles and nerves, the power created by the first exertion will be available. In other words the results are determined by the congruity or incongruity of the two efforts.[3]

As a result of the use of the vast amount of literature in this field the question has been attacked scientifically, so that we now have objective laboratory data instead of unsupported opinions.

The early disciplinists supposed that a faculty or power is developed like a muscle by exercise on one sort of

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2 *Ibid.*, 95-96.

3 *Ibid.*, 99.

material to prepare it for any use. In its educational application the theory holds that memory trained in learning poetry or vocabularies, will be better able to handle law cases or the details of a business, and that reasoning power exercised in geometry, will prepare the memory to handle scientific or social problems. It is believed that the transfer of principle, of skill, or any achievement does not occur as a matter of course in a novel situation.

Transfer effects are uncertain in two ways: (1) the new situation may not look like the old one and may not seem like the previously acquired principle or habit; (2) even when the old habit or knowledge is revived it may not be perfectly suited to the new situation and may do more harm than good. In other words transfer may not occur or if it does it may produce a negative transfer.[4]

Two opposite views were held. One view is that all learning is general in its effects. According to this teaching the mind is trained by exercise as is the body. The claim was often made that the study of Latin is good discipline, that nature study cultivates powers of observation, and that geometry develops reasoning ability. The idea in each case is that the effects of learning are not limited to a particular study but

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4 Robert S. Woodworth, Experimental Psychology, New York, 1938, 206.

are general."

The other view holds that all learning is specific in its results, that it is confined in its effects to a particular kind of situation in which it is learned. The study of Latin, according to this theory will train the mind for things other than Latin only in so far as Latin is related to these other things, as for example, English; and the training of observation in nature study will increase capacity for natural objects but not for other things as people's faces or pictures. Again, a person who is trained mathematically by the study of geometry to reason mathematically would not be able to reason in matters of politics.[5]

The arrival of the so-called measurement movement greatly stimulated interest in the problem of transfer. However, measurement as it applies to human beings, is not as simple as measurement in other fields. For a time it looked as if all belief in general discipline had to be abandoned, and that only specific training resulted from any other type of training.

Prior to 1890 no experimental studies were made on transfer. Many of the early experimenters were not too successful in the amounts of transfer they received because of the obvious imperfections in the technique adopted, and thus their

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5 Edward Herbert Cameron, Educational Psychology, New York, 1927, 278-279.

results were non-conclusive. The conclusions drawn by these early experimenters aroused considerable dissent at the time:

> Improvement in any single mental 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. . . . There is no inner necessity for improvement of one function to improve other closely similar to it, due to a subtle transfer of practice effect. Improvement in them seems due to definite factors, the operation of which the training may or may not secure.[6]

In this experimental period a few words might be said about the methods, materials, and subjects used in each period of investigation. This period extends also to the more recent experiments of today.

With regard to methods, it is possible to distinguish (a) the individual method, (b) the one group method, (c) the two-group method, and (d) the three-group method.[7]

(a) The individual method of experimenting was done by one person who measured his ability in some specified activity, and trained himself for some time in some related activity. He then measured once more his ability in the specified activity with the intention of discovering, to what extent, if any, the

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6 Woodworth, Experimental Psychology, 194-195.

7 The Twenty-seventh Yearbook of the National Society For the Study of Education, 1928, Bloomington, Illinois, 183-184.

period of training had affected his performance in the specified activity. In his early study of the transfer of training in the memory field James illustrated this method. The defense of this method was weak.

(b) The one group method differs from the individual method primarily in merely increasing the number of subjects. This method was demonstrated by the early experiments of Thorndike and Woodworth in which groups of subjects practiced estimating areas of triangles until a marked improvement was attained. The group then estimated areas of the same size but of different shape and areas of the same shape but of different size. By use of this method individual irregularities in the effect of training were more or less eliminated or compensated. This method did not prove successful because there was no way to determine accurately how much is due to real transfer effect on the one hand, and to the improvement within the series itself, on the other.

(c) The two-group method has been generally employed in all the more recent experiments. In principle the method is this: the subjects are divided on some desired basis, such as age, general intelligence or previous training, into two equivalent groups, one of which is known as the "experimental" group and the other as the "control group." Both groups take the preliminary or initial test and the final test series; but only the

first group takes the intermediate training series. If the division of groups is carefully done, the difference between the performance of the trained group and the control group in the final test may be expected to indicate the amount of transfer effect.

(d) The three-group method is an elaboration of the two-group one which may well be justified under certain conditions of experimentation. The first two groups are treated as they are in the one group method, but a third group, equivalent to the other two, which takes none of the tests except the final, is added.

The two-group method seems to be the most popular with educators and more recent experimenters because it seems to be the most practical in view of the size of the group.

By materials in the experiments is meant the nature of the mental activities chosen as the object of investigation. The investigations were assembled into four groups: (1) those dealing with various aspects of perceiving, including sensory discrimination and apprehension; (2) those dealing with memorizing; (3) those dealing with voluntary effort and motor adjustment; (4) those dealing with schoolroom activities and attitudes.[8]

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8 *Ibid.*, 185.

In the Twenty-seventh Yearbook of the National Society For the Study of Education, we read that type of subjects played a very important part in the investigations of both early and recent experiments. Prior to 1916, out of twenty-five of the studies reported only seven were conducted with school children, while of the eighteen remaining, only eight were graduate students or instructors in psychology and the other ten were college or normal school students. Use of adults, particularly those immediately available as students in the psychological laboratory, is natural enough because of their great steadiness of application, grasp of instructions, and possibility of illuminating introspection. This use of adults, however, had a very definite disadvantage.

There was also a tendency, we are informed in the same source, to confine the investigations of the transfer of training to quite a limited number of subjects: thus in thirteen of twenty-nine investigations conclusions were drawn from the behavior of two, three, four, five, or six subjects only. In twelve other investigations the subjects were ranged from twelve years old to forty-four years. Again in thirty-one investigations reported, two-thirds were laboratory investigations. The generalizations made from experiments on adults, could not be applied too readily to the mental processes of the growing

child.[9]

Experiments can also be divided into four groups. For clarity, each group will be named as it is spoken of in its particular set of experiments.

In the first group, in which we include those studies dealing with memory, James in 1890 reported the effect of training in memorizing a certain kind of material upon efficiency of other kinds of material. He was led to conclude that there was no transfer of training, "that one's native retentiveness is unchangeable, that no amount of culture modifies a man's general retentiveness." This work of James, however, represents pioneer experimentation. The experiment was loosely organized and he claims his technique was not good; and, as has been noted, he had no control group.[10]

The difficulty just mentioned in James' work was recognized, and a repetition of the experiment by Peterson in 1912 was made, but Peterson's data were too meager to permit reliable conclusions. In fact, three of the unpracticed subjects gained as much as one of the two practiced subjects, although Peterson said there certainly was a large amount of transfer of training referring to one of the subjects of the practiced

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9 Ibid.

10 Ibid.

group.[11]

"Ebert and Meuman conducted experiments at the University of Zurich on from two to six laboratory subjects dealing with the effect of memorizing series of nonsense syllables upon the efficiency in memorizing various other materials, such as immediate memory for numbers, letters, words, permanent memory of prose, poetry, etc. The results showed considerable gains in other types of memorizing. The difficulty in interpreting their results, however, is the fact that they did not make a cross section test with a control group from which a deduction could be made regarding the gain in the end tests themselves. The high percentage of Ebert and Meuman is reduced to an average residual of twenty-two per cent."[12]

This same year book reports that "Dearborn repeated the work of Ebert and Meuman at the University of Wisconsin and showed that a large portion of the effect of transfer alleged by them was due to gains made within the test series and that the remainder could be attributed to general improvement in orientation, attention, and better technique of learning."[13]

Pyle says that Ebert's and Meuman's extensive work on

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11 Ibid., 186.

12 Ibid.

13 Ibid., 187.

memory experiments are worthless because they lack a control group. These experiments gave their subjects practice in one aspect of memorizing and found improvement in other aspects. Later Dearborn repeated the experiment and found that the control group improved about as much as Meuman's practice group.[14]

A careful piece of work was done by G. C. Fracker of the University of Iowa in 1908.[15] This work concerned itself with the effect of training in remembering the order of sound intensities upon the efficiency in remembering the order of various other materials. Fracker's results are regarded by him as furnishing clear evidence of transfer under certain conditions, provided "transfer" is thought of not as a mere "spread" of training, but as ability to use in a second situation, a content or a form of procedure that is identical with the one in which the subject has been trained. The average residual gain in four similar memory processes was sixteen per cent, whereas the four dissimilar memory processes was only three per cent.

In 1910 W. H. Winch of London, conducted an experiment which was reported as one of the first attempts to study transfer in children working under normal schoolroom conditions, in

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14 William Henry Pyle, Psychology of Learning, Baltimore, 1928, 298.

15 The Twenty-seventh Yearbook of the National Society For the Study of Education, 1928, Bloomington, Illinois, 187.

which special pains to classify the subjects into two groups of equivalent ability were taken. Winch's experimental groups were trained in rote memorizing of poetry or of meaningless things and the effect that this training produced upon memorizing other forms of material was measured. The transfer was slight: the residual gain over the control group was about three and three-tenths per cent based on initial ability. However, as Winch, himself says, "the amount of transfer cannot be regarded as great when proper allowance is made for the operation of chance and for certain features of method and material used in the study."[16]

W. G. Sleight made a careful and extensive investigation on transference of training in one sort of memory to other sorts of memory. He experimented in the laboratory with twelve-year old children and also adults on training in memorizing poetry, arithmetical tables and prose substance. He gave initial and final tests in many different aspects of memorizing. His results showed that the training in one aspect of memorizing gives little or no increased efficiency in other types of memorizing. The practice covered a period of twelve days, one-half hour a day. In nine cases, according to his table, the un-

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16 W. H. Winch, "Transfer of Training in Reasoning in School-Children," <u>British Journal of Psychology</u>, 13, 1923, 370-373.

practiced group improved more in the aspects tested than did the practiced group. In three cases the practiced group made a poorer record in the final test than they made in the initial test.[17]

In the above memory experiments the subjects were given practice in building bonds necessary to enable them to recite verbatim. It was found that this experience gave increased facility in learning dates and nonsense syllables, slightly increased facility in learning prose verbatim, but none in learning prose substance or in learning letters. Practice in learning the tables gave increased facility in learning dates and prose substance, slight increase in learning nonsense syllables and none in learning letters or prose verbatim. Practice in learning prose substance did not give increased facility in learning any other type of material. All the memory experiments were in substantial agreement. They showed that experience in one type of learning may either facilitate or hinder another type.[18]

The next group of experimental studies dealing with perception, discrimination, and apprehension were performed by Thorndike and Woodworth, Coover and Angell, Ruger and Wang. In

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17 The Twenty-Seventh Yearbook of the National Society For the Study of Education, 188.

18 Ibid.

these experiments all agree that into interpretation or mastery of a new experience we carry our old experiences. Some aspects of the old experience will be available in mastering the new; other aspects will not, and some may actually hinder the mastering of the new.

While working in the Yale laboratory another authority, Charles Judd, trained two subjects in the Muller-Lyer illusion and found that, by dint of practice, and without the aid of abstract judgement, the illusion gradually disappeared, and the practice effect was transferred. The effect was ascribed to the perceptual training.[19]

Six subjects trained in introspection were used by Coover and Angell in their investigation in the field of transfer on sensory discrimination. The effect of training in discrimination of sound intensities was found to transfer to discrimination of grays, but this result is supported by assertions based on introspection rather than on any clear statistical demonstration. The two control subjects seemed to improve as much as the four experimental subjects.[20]

H. A. Ruger conducted an investigation at Columbia

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19 C. H. Judd, "Practice and Its Effects on the Perception of Illusion," <u>Psychological Review</u>, 9, 1902, 37-39.

20 <u>Twenty-seventh Yearbook of the National Society For the Study of Education</u>, 190.

University. "By employing thirty-seven mechanical puzzles and by minute records of the subjects' work he was able to observe to what extent solutions arrived at in given puzzles were transferred to the solutions of varying degrees of similarity. The outcome of this study seems quite unlike that reported by Judd in the practice with illusions of length. Ruger concluded that the presence of imagery was of no avail without conscious generalization of methods of attack and analysis. Other factors making for transfer were ideals of efficiency, attitudes of attention, and satisfaction of success.[21]

At the University of Michigan, C. P. Wang conducted an experiment similar to that of Coover and Angell. He trained a small number of pupils in discriminating the lengths of vertical lines and tested the effects of this training upon their ability to discriminate sizes of figures, and to mark words containing certain letters. Wang found that no transfer appeared unless the children were able to develop an efficient method in the training series and to use purposefully in the test series.[22]

Gates, in his conclusions from studies of memory and perception, says "the significant fact is that when data are used which are but slightly different from those on which practice was

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21 Ibid., 191.

22 Ibid.

given -- as when prose is substituted for poetry, or when i and t are substituted for e and s, or when long lines are substituted for short -- the improvement is relatively small." He gives as his reason that memorizing, far from being a constant process, may involve very diverse elements.[23]

On the third type of studies used in experimental investigations, Gilbert and Fracker were the earliest to experiment with voluntary effort and motor adjustment. They worked in the laboratory with stock forms of reaction-time. Subjects were used in simple reaction to sound, to electric stimuli, to touch etc., and then the complex reaction involving discrimination and choice. The training series consisted in simple and complex reactions to sound only for twelve days. The results of transfer due to indirect factors were probably less than indicated, how much was not known since Gilbert and Fracker made no control tests.[24]

Coover and Angell also made an investigation in which subjects were trained for forty days in rapid sorting of cards. This training was said to have definitely increased their efficiency in certain aspects of typing. This experiment was

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23 A. I. Gates, Psychology for Students of Education, New York, 1927, 359-360.

24 Daniel Starch, Educational Psychology, New York, 1926, 194.

designed to eliminate all identical factors and hence ascribe the statistical improvement to general factors like equitable distribution of attention, and development of power to concentrate attention throughout an entire series of reactions. The four subjects were trained for fifteen days in sorting 4,200; 3,800; 5,200; and 4,000 cards respectively. Before and after this training they were given tests in typewriter-reactions. Three other persons as a control group, were given practice in typewriting at two periods separated by intervals of forty-five days. The results are interpreted by the authors as indicating transfer, but it is doubtful whether there is any transfer, and if there is how much. The trained group reduced its time by twenty-six per cent but increased in errors, while the untrained group reduced its time by twenty-five per cent but decreased in errors.[25]

The fourth type of studies, that which deals with schoolroom activities and attitudes, is most important in this investigation since the present study was conducted in a classroom. Here we are reminded by William Betz, in his article _Transfer of Training with Particular Reference to Geometry_, that when estimating the richness of a school subject, and its rank in the curriculum it was borne in mind that the teacher

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25 _Ibid_., 200.

should take into account: the entire spectrum of the subject; the range and frequency of its application within the classroom and in later life; its actual or potential appeal to the learner; its available resources as a type of learning or activity; and the like. It was concluded therefore, that transfer is a problem of good teaching.[26]

An experiment was conducted by W. H. Winch in a poor neighborhood in London, to learn whether improvement in numerical accuracy transferred. A class of seventy-two boys were divided into two groups on the basis of six preliminary tests in arithmetic reasoning. One group was drilled in arithmetic computation while the other group practiced drawing. After ten practice lessons had been given, the two groups were given a final test in arithmetic reasoning. Although the practice group made a score of 42.0 in the initial test they made a score of 45.3 in the final test. The control group made a score of 42.2 on the initial test and 45.7 on the final test. The author concluded that even though the practice group did improve over forty per cent in ten practice exercises in computation, the results of the drill did not appear to have produced any improvement in the

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26 <u>Twenty-seventh Yearbook of Nat. Soc. of Education</u>, 189.

accuracy of the arithmetic reasoning.[27]

A. T. Poffenberger, Jr., performed an experiment to discover the influence of improvement in one simple mental process upon other related processes. The influence in training in simple addition upon a subjects ability in subtraction was the theme of his experiment. Eleven subjects were used, four of which were 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 20-80, including zeros. The subtraction test consisted of subtracting seventeen from each of a list of twenty-five numbers as rapidly as possible. The results were given in terms of time. The final test showed that the gross gain in the trained group was only 8.8 per second whereas in the control group it was 15.1 per second. The gain in the control group was explained by the author as due to the initial performance of three subjects. Poffenberger concluded that there was no identity either in the situation or in the response.

Poffenberger also noted that influence of training in addition upon the subject's ability in multiplication (in the training series) was the same as in the preceding experiment, except that the practice group had to multiply each of twenty-

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27 W. H. Winch, "Further Work on Numerical Accuracy in School-Children--Does Improvement in Numerical Accuracy Transfer," British Journal of Psychology, 13, 1923, 370-381.

five of the 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, there is a certain amount of identity with addition since it is involved as a part process.[28]

It might be well here to quote Poffenberger's own words used in another experiment:

> 1. Where there are no identical bonds between stimulus and response in two processes, the influence of one test upon another will neither be positive nor negative.
>
> 2. Where one test necessitates the breaking of previously formed bonds and the formation of new ones, there will be negative effect.[29]

Again Poffenberger maintains that influence of training in addition will occur in the training series as in the preceding experiments. The training in addition will be based upon the student's ability in division. The test series consisted of dividing a series of twenty-five numbers by seven as rapidly as possible. The results showed no difference in gain made by either groups. The author interpreted the results as indicating that the processes involved in the experiments showed neither a specific situation nor a specific response in common

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28 A. T. Poffenberger, Jr., "The Influence of Improvement in One Mental Process Upon Other Related Processes," Journal of Educational Psychology, 1951, 6, 470-474.

29 Woodworth, Experimental Psychology, 201-202.

with the training series.

The results of Poffenberger's experiment described above, interested L. W. Cole so much that he made a similar experiment of the effects of practice in addition upon addition, subtraction, multiplication, and division; and likewise the effects of practice by each of the three 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 on the other. The period of practice consisted of forty minutes divided into five periods, each group working ten minutes with a two minute rest period between. Initial and final tests of addition, subtraction, multiplication, division were each twenty minutes in length. The author doubted the significance of the results since only four persons were used in each group so he repeated the experiment with nine persons in each group. Contrary to Poffenberger, Cole found that addition and subtraction are not independent functions but are very closely related. The group practiced in addition gained three per cent in accuracy in subtraction and six and six-tenths per cent in time. The subtraction group gained twenty-three per cent in accuracy in addition and sixteen and seven-tenths per cent in time. The practiced group in addition showed no gain in accuracy in division. This was also true of the group practiced in subtraction.

The gain in speed in division was the same for both groups. The author explains this gain by the fact that both groups practiced computation. 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 were practiced in addition and the success in addition of those who were practiced in subtraction, was due to the fact of subjective identity of the combinations in addition and subtraction. The author also says improvement in addition will alter one's ability in multiplication because certain other processes, for example eye movements and inhibitions of all save arithmetic impulses are in part common to the two functions.[30]

All the above experimental evidence appears to be in agreement that transfer does take place. The important question of the more recent experiments is: How does transfer take place?

Two general theories have been proposed: (1) the theory of identical elements or special connections; (2) the theory of generalization or common capacities.

The only theory of identical elements to arouse widespread discussion is that of Thorndike. According to this theory, training in one activity influences another activity only

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30 L. W. Cole, "Interference Between Related Mental Processes," Journal of Educational Research, 1928, 18, 32-39.

in so far as the two have elements or aspects in common. Thus, training in addition transfers to multiplication because addition is necessary to multiplication -- that is, identical with one phase of multiplication -- plus the fact that other events, such as eye movements and resistance to other stimuli outside the problem, are common to the two activities.[31]

The hypothesis that transfer occurs by means of generalized habits, principles, methods, or ideals, which are learned in the training series and applied to the test series, has often been opposed to the Thorndikean hypothesis of identical elements.[32]

Thorndike and his followers, who believed in the theory of identical elements, form one school; while Judd and his followers support the doctrine of generalization. Thorndike states the theory of identical elements as follows:

> 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 due to the change in the elements common to it and the first. The change is simply the necessary results 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 arithmetic will alter one's ability in multiplication because addition is

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31 John A. McGeogh, The Psychology of Human Learning, New York, 1942, 435-36.

32 Ibid., 437.

absolutely identical with a part of multiplication and because other processes e.,g., eye-movements and the inhibition of all save arithmetic impulses, are in part common to the two functions.

Chief among such identical elements of practical importance in education are association including 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.[33]

These identical elements may be in the stuff, the data, concerned in training, or the attitude, method of identities of substance and the identities of procedure.

Identity of substance---Thus special training in ability to handle numbers gives an ability useful in many acts of life outside of school classes because of identity of substance, due to the fact that the stuff of the world is often to be numbered and counted. The data of scientists, the grocer, the carpenter and cook are important features of the same data of the arithmetic class.[34]

Identity of procedure---The habit acquired in the laboratory course of looking to see how chemicals do behave instead of guessing at the matter or learning statements from 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. Difficulty in studies may prepare students for difficulties of the world as a whole cultivating the attitude of neglect or discomfort, ideals of accomplishing what one gets out to do, and feeling dissatisfaction with failure.[35]

Starch maintains that the theory of identical elements

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33 Edward L. Thorndike, Educational Psychology, II, New York, 1913, 358-359.

34 Edward L. Thorndike, Principles of Teaching, New York, 1906, 245.

35 Ibid., 247.

seems to be in harmony with experimental data. He says:

> The evidence on the spread of training in school material tends to support for the most part the theory of identical elements. The effects are the largest where there is a similarity of materials as, for example in the case of Latin upon the study of Spanish or upon the knowledge of English grammar. The fact of the identity of material or the similarity of procedure makes possible a greater control of the spread of improvement through methods of teaching whereby identity or use of identical material may be emphasized in as many desireable relations as possible.[36]

C. H. Judd formulated his theory of transfer which stresses the importance of a conscious recognition of the identical elements, and the deliberate search for identical elements as a basis of generalization. He says:

> When one studies psychology of generalization he becomes aware of the uselessness of some of the formulas which have been proposed by those who hold that transfer of training takes place in cases where there are identical elements present. The identical element is usually contributed by the generalizing mind. On the other hand, there may be identical elements potentially present in various situations, but wholly unobserved by the untrained or lethargic mind. In fact the discovery of identical elements in a situation is in some cases the whole problem of training.[37]

Judd as one of the foremost exponents of generalization argues further:

> Transfer depends on the power of generalization. The first and most striking fact which is drawn from school experience is that one and same subject matter may be employed with one and the same student with wholly different effects

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36 Starch, Educational Psychology, 253.

37 C. H. Judd, Psychology of High School Subjects' New York, 1915, 414.

> 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 characteristic of subjects of instruction, but rather to the mode of instruction in these subjects.[38]

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 course 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.

Judd's 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 dissociate the element from the complex and then recognize the element under whatever form it may appear in the 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 things.

It is interesting to note that the two theories presented above are not diametrically opposed. Their supplementary nature is characterized by Inglis as follows:

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38 *Ibid.*, 412-413.

No two situations in life calling for action or the part of any individual are ever exactly alike in all respects. Hence training for an absolutely fixed and specific reaction to any given situation is an impossible and valueless process. Strictly speaking there is no such thing as specific discipline. Fortunately, for the economy of mental life and efficiency in behavior it is possible for the mind to select certain parts of any total situation and react to those parts with minimum of attention to other parts of the total situation. Since such parts of total situations may be essentially the same it is possible to establish what in all important respects are specific situations, response connections, and hence it is possible to assign values to specific discipline. However through this same characteristic of the human mind comes also the possibility of abstracting from a number of total specific situations, differing with respect to most of their constituent elements, any given element which may be common to all the total situations or a majority of them. Thus we get the law of disassociation expressed by Thorndike.[39]

In any given situation whether or not disassociation or generalization takes place depends on two factors -- mental attitude or mind-set which the individual brings to a situation, and the character of the situation experienced. Subjective elements are no less important than objective elements. It is perfectly possible for generalization to be potential in any set of situations without that generalization taking place because of the mind's attention to other elements than those involved in the disassociative element. On the other hand, it is perfectly possible for the mental attitude to project into objective situations a generalizing factor that is not fostered by the sit-

39 A. Inglis, Principles of Secondary Education, New York, 1918, 397-98.

uation itself apart from subjective elements, though there must be something to which the mind-set may be attached.[40]

The best theory of transfer is the composite theory of Thorndike and Judd.

This composite theory could be summarized by the following key words: (1) identical elements; (2) conscious disassociation; (3) generalization; (4) wide application.[41]

Professor Judd says that transfer is not automatic when he states: "I do not think that any subject transfers automatically and in every case. The real problem of transfer is a problem of so organizing training that it will carry over in the minds of students into other fields. There is a method of teaching a subject so that it will transfer and there are other methods of teaching the subject so that the transfer will be very small."[42]

Starch says that two points should be borne in mind: (1) any effect of transfer, even though it is slight, would probably be worth while if extended to all or a large number of capacities; (2) that while the trend would be to reduce the time devoted to some subjects, particularly in high school and

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40 Ibid., 399.

41 The National Council of Teachers of Mathematics, Fifth-Yearbook Book, New York, 1930, 178.

42 Ibid., 179.

college, as not being conducive to transfer we must be sure that we put something better in their places.[43]

In the composite of the views of Thorndike and Judd, each has his adherents, Thorndike for his theory of identical elements, and Judd for the theory of generalization.

Thorndike claims that identical elements may be in the stuff, the data concerned in the training, or in the attitude, the method taken with it. His followers include some famous experimenters such as J. Brown, principal of a Joliet High School; A. I. Gates, professor of education at Columbia University; A. M. Jordan; Ruediger and D. Starch of the University of Wisconsin.

"Judd's theory attempts to explain spread of improvement in terms of the recognition of application of an experience obtained in one connection to other connections,"[44] says Starch. Judd's followers were: W. C. Bagley, C. Bode, Dewey, N. J. Lennes, W. H. Pyle, D. Starch. Starch seems to support both theories.

Orato gives two summaries on transfer which seem complete. One gives a summary of the experimental findings from

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43 D. Starch, Educational Psych., 255.

44 Ibid., 253.

1927-1935[45] and another more recent one in 1941.[46]

Assuming that they possess a fair degree of validity and reliability, all the studies of 1890-1935 may be generalized as follows: to date no fewer than one hundred sixty-seven objective studies were made, ninety-nine of which were made from 1890-1927 and sixty-eight from 1927-1935. Forty-seven or nearly thirty per cent show considerable transfer; eighty or nearly fifty per cent show appreciable transfer; fifteen or less than ten per cent show little transfer; six or less than four per cent show no transfer, and the rest, which comprise six per cent, show both transference and interference. Since interference is indicative of transfer of a negative character, it is safe, says Orato, that all doubts with reference to possibilities of transfer of training may be cast away.

In round numbers, seventy per cent support the proposition that the effect of practice is general and therefore transfer takes place most effectively through conscious generalization, whereas about thirty per cent may be classified as suporting the theory that practice is specific and that therefore

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45 Pedro Orato, "Transfer of Training and Educational Pseudo-Science," Journal of Educational and Administration and Supervision, 1935, 21, 241-264.

46 Pedro Orato, "Recent Research Studies on Transfer of Training With Implications For Curriculum Guidance and Personnel Work," Journal of Educational Research, 1941, 35, 81-101.

transfer takes place through identical elements. The teacher's job is to train for transfer.[47]

A. A. Douglass, summing up his views on transfer says, "In the minds of many psychologists a theory of transfer based upon the process of generalization is not opposed to one which conceives of transfer as occurring through identical elements." On the contrary the two theories are useful supplements to each other.[48]

The difference between Thorndike and Judd is this: to Thorndike the identical elements are the cause, whereas Judd points out they are the effect of transfer. When two situations are identical the problem of transfer disappears and, as Judd claims, the process of discovering the identical elements by generalization and application is what constitutes the transfer of training. The only entity that is identical in both situations before transfer takes place is the individual himself. Thorndike maintains that the identical elements are inherent in nature awaiting notice whereas Judd holds that they are to be discovered much in the same way that a scientist discovers scientific laws and principles. "If Thorndike is right," says Orato,

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47 D. Starch, Educational Psych., 255.

48 A. A. Douglass, Secondary Education, Chicago, 1927, 298.

"then all generalizations should have been made at the beginning of time except those that arise as a result of natural evolution.[49]

In the final analysis, Thorndike holds that the identical elements are logical in nature, whereas Judd maintains that they are psychological; in the former, transfer takes place automatically; whereas, in the latter, transfer is very largely conscious and deliberate.[50]

In the more recent article published by Orato he confirms those findings on transfer from 1927-1935 namely: (1) transfer is a fact revealed by eighty per cent of the studies; (2) transfer is not an automatic process that can be taken for granted, but it is to be worked for, even as democracy as a way of life has to be nurtured from the cradle to the grave; (3) the amount of transfer is conditioned by many factors among which are age, mental ability, time interval between learning and transfer; degree of stability attained by the learning pattern; knowledge of directions, favorable attitude toward the learning situation and efficient past experience, accuracy of learning; conscious acceptance by the learner of methods, procedures, principles,

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49 Pedro Orato, "Transfer of Training and Educational Pseudo-Science," _Journal of Educational and Administration and Supervision_, 1935, 246.

50 _Ibid_.

sentiments, and ideals; meaningfulness of the learning situation; personality of the subject, greater transfer in extroverts than introverts; method of study; suitable organization of subject-matter presentation; and provision for continuous reconstruction of experience.[51]

Orato summarizes the results in transfer of training in the following tables.[52]

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51 Ibid.

52 Ibid., 251.

TABLE I

STATISTICAL RESULTS OF EXPERIMENTS ON THE TRANSFER OF TRAINING COMPILED BY ORATA FOR THE YEARS 1890-1940 SHOWING THE ABSENCE OR THE DEGREE OF TRANSFER PRESENT IN TWO HUNDRED AND ELEVEN EXPERIMENTS

Amount of transfer claimed	1890-1927		1927-1935		1935-1941		Total	
	No.	%	No.	%	No.	%	No.	%
Considerable	32	32	15	22	6	14	55	25
Appreciable	49	49	31	44	15	35	95	45
Values with condition of lesson			4	7	12	28	16	8
Very little	8	8	7	10	5	12	20	9
No transfer	2	2	5	8	2	5	9	4
Other duplication excluded	9	9	6	9	3	6	18	9
	100	100	68	100	43	100	211	100

The above table can be summarized into Table II.

TABLE II

A SUMMARIZED STATEMENT OF THE RESULTS OF EXPERIMENTS ON THE TRANSFER OF TRAINING COMPILED BY ORATA FOR THE YEARS 1890-1940 SHOWING THE ABSENCE OR THE DEGREE OF TRANSFER PRESENT IN TWO HUNDRED AND ELEVEN EXPERIMENTS

Amount of transfer claimed	1890-1927		1927-1935		1935-1941		Total	
	No.	%	No.	%	No.	%	No.	%
Clear Evidence of transfer	81	81	50	73	33	77	16	78
Very little no transfer Ambiguous-interference	19	19	18	27	10	23	47	22

Evidence which tends to disprove Thorndike's theory of identical elements continue to accumulate, despite Woodworth's efforts to rehabilitate the theory by changing the word "identical" to "component." Cook points out that the theory of identical elements offers little insight into problems of cross education.[53]

The most outstanding work on transfer during this

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53 *Ibid.*

period in 1941 was that of George Katona who undertook an exhaustive study of this problem. Katona experimented with a large number of human subjects in school and life situations and attempted, with great success, to distinguish between meaningful and senseless learning. He measured the relative effects of understanding and repetition as methods of learning, to solve problems upon retention and ability, to apply what is learned to problems or situations. His experiments were repeated many times to safeguard against errors, and the results proved to be consistent in showing that while senseless learning does not transfer meaningful learning does.[54]

Brownell supports Katona's implied theory of transfer as reconstruction of experience when he says:

> The process of learning thus becomes one of organization and reorganization of behavior experience. The fundamental issue in learning is not practice but rather the creation of a series of reaction patterns, each of which in turn gives way to a pattern at a higher level of organization. Danger lies, not in the absence of practice, but in possible complacency with performance at a low level, and this danger is a real one when intelligent adjustment is involved as it is involved in the kind of life we should set as the goal of experience.[55]

After reviewing the literature here discussed, the writer is led to the conclusion that in the process of transfer the presence of the identical elements is just as necessary as

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54 Ibid.

55 Ibid.

the ability to recognize the common elements, and that neither one is adequate in itself. They must both be present if the process is to continue.

It is the common view of all the writers here reviewed that transfer does take place even though, because of faulty technique in experiments, some investigations have not been able to prove it. All agree that there is positive transfer, and a large majority agree that there is a possibility of negative transfer and zero transfer owing to interference effects. Katona and a few recent experimenters have shown one-hundred per cent transfer. The majority show a residual amount between twenty to thirty per cent.

Many authors have shown that transfer is largely dependent on methods of teaching. Most have said that to obtain transfer one must specifically make it his aim in teaching.

The balance weighs heavier in favor of general elements or generalization, than specific or identical elements.

A variety of methods have been tried, but the most common and most satisfactory in recent investigations is the two-group method of an experimental and a control group, the control group serving as a basis for the measurement of transfer. This is the method used by the writer and described in the following pages.

CHAPTER III

DESCRIPTION OF EXPERIMENTAL MATERIALS--PROCEDURE FOLLOWED

The materials used in this experiment were lessons taken from the pupils' own Algebra text.[1] The experiment extended over a period of twenty days. Tests were made from those that came with each chapter unit. Reasons for the choice of this material were as follows: (1) material was interesting and followed logically the pupils' work of the year; (2) economy in terms of time was important (the experimenter was in service and the pupils had a definite plan of work to be covered); (3) the material was devoid of extreme complexity since the experiment had to be conducted with individuals in a group situation under limitations of class periods of a normal high school; (4) the text supplied a teacher's manual that also gave help in best method of approach to the exercises.

The effectiveness of transfer was to a certain extent to depend on three factors; namely, the pupil, the teacher, and the method of instruction.

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1 R. Shorling, R. R. Smith, J. R. Clark, Algebra First Course, New York, 1949.

In the two classes of algebra taught by the writer there were sixty-two pupils, thirty-one in each group. These groups were sorted so that each group still had thirty-one pupils after equating.

The group furnishing the data for this experiment were girls from both parochial and public school population of the South Side of Chicago. The girls represented an IQ range from 91 to 122 established by the Otis Gamma Test. The mean IQ's of the two groups, experimental and control, were 105.7 and 104.7 and a standard deviation of 8.10 and 6.05, respectively. Their age range was from twelve years to fourteen years and seven months. All came from average or better than average homes. Many of the mothers worked part time and others were housewives working in the homes. The fathers ranged from skilled laborers to business men, dentists, doctors, office clerks and some executives.

The groups were equated by two sets of intelligence tests namely, the Kuhlmann Anderson Test and the Otis Gamma Test. Most of the pupils had taken the Kuhlmann Anderson Test or some standard test in the eighth grade, and the Otis Gamma Test was the placement test given to all the freshman who entered school in September. From the two classes, only those IQ's that agreed within a score of ten points in the two tests were used in this experiment. Since there was agreement between both sets of tests, it was thought the Otis results would be used, since these

were given most recently and at the same time in a Chicago high school.

When the groups were equated according to intelligence and used as matched groups,[2] the teacher, the writer of this thesis, planned the lessons in signed numbers so that the pupils in both classes were taught the same lesson each day. The pupils were informed that since the numbers used in their problems would be very elementary there would be no question of difficulty as far as the numerical combinations were concerned. The real problem in both addition and subtraction was the manipulation of four sets of signs; namely,

$$\begin{array}{cccc} + & - & + & - \\ \underline{+} & \underline{-} & \underline{-} & \underline{+} \end{array}$$

and that the signs would occur through the different processes, addition, subtraction, multiplication and division.

During the first five days addition was taught and drilled. The pupils were instructed that in addition there were eight possibilities of signs in any set of signed numbers:

$$\begin{array}{cccccccc} +6 & -6 & +6 & -6 & +4 & -4 & +4 & -4 \\ \underline{+4} & \underline{-4} & \underline{-4} & \underline{+4} & \underline{+6} & \underline{-6} & \underline{-6} & \underline{+6} \\ + & - & + & - & + & - & - & + \end{array}$$

also,

$$\begin{array}{cccc} 0 & 0 & +6 & -6 \\ \underline{+6} & \underline{-6} & \underline{0} & \underline{0} \\ + & - & + & - \end{array}$$

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2 Henry E. Garrett, Statistics in Psychology and Education, 1947, New York, 213.

The drill consisted of individual board work each day and home work each night provided by the text book. This also served as extra drill.

During the next week subtractionof signed numbers was taught to the two groups. For the sake of association as well as repetition the same numbers were used in the teaching of subtraction as were used in addition. Stress was placed on the subtraction rule. "To subtract one signed number from another, change the sign of the subtrahend and proceed as in addition."

$$\begin{array}{cccccccc} +6 & -6 & +6 & -6 & +4 & -4 & +4 & -4 \\ \underline{+4} & \underline{-4} & \underline{-4} & \underline{+4} & \underline{+6} & \underline{-6} & \underline{-6} & \underline{+6} \\ + & - & + & - & - & + & + & - \end{array}$$

along with,

$$\begin{array}{cccc} 0 & 0 & +6 & -6 \\ \underline{+6} & \underline{-6} & \underline{0} & \underline{0} \\ - & + & + & - \end{array}$$

At the end of a week of work and drill exercises, a review of the exercises in both addition and subtractionof signed numbers was given. The review exercises contained both columns i., e., vertical as shown above and horizontal as indicated here:

$-(4) -(-6) +(-6) -4 =$ or $(-4) -(6) +4 -(-4)=$

$(4) +(-6) -(-6) +4 +$ or $-(-4) +(-6) -4 +(-4) =$

Both types were given in the tests as may be seen in the sample tests in the appendix.

The development and use of initial and final tests were important, as both tests had to be of equal difficulty for the

testing of addition and subtraction of signed numbers. The algebra text which the classes used furnished chapter tests for the teachers use. From these the writer made two sets of tests of equal difficulty containing fifty items each. To determine time for completion of the tests a third or trial test was made, similar in difficulty but different in content from the other two, and administered to a third group that had been taught addition and subtraction of signed numbers. The result was that in a class of thirty-five, thirty-two finished in fifteen minutes which was therefore, judged to be ample time for the tests of this experiment.

When the addition and subtraction had been reviewed, until the experimenter thought each pupil had sufficient opportunity to be drilled and supervised on the work, a test was given. This was the initial test that was given to both groups. The time limit was fifteen minutes and the test was scored according to the number correctly answered.

After the initial test was scored it was found that both groups had a mean average of 40.5 and a standard deviation of 8.70. This meant that there was no significant difference because of sampling; the group also showed no significant difference according to their mean IQ's.

Now that the group was similar with respect to intelligence and performance on the initial test, a definite

practice procedure had to be followed in order to obtain valid and reliable data. The experimental group was taught multiplication and division of signed numbers. This group practiced ten days and through this medium of multiplication and division it was hoped that the experimental group would improve its scores in addition and subtraction of signed numbers. While the experimental group had this practice period the control group was given a study period in which to do their homework or some other work that was not algebra.

To the experimental group only multiplication and division of signed numbers was taught stressing the sign rules: "The product of two numbers which have like signs is positive." "The product of two numbers which have unlike signs is negative." "The quotient of two numbers which have two like signs is positive." "The quotient of two numbers which have two unlike signs is negative." Multiplication:

$$\begin{array}{cccccccc} +6 & -6 & +6 & -6 & +4 & -4 & +4 & -4 \\ \underline{+4} & \underline{-4} & \underline{-4} & \underline{+4} & \underline{+6} & \underline{-6} & \underline{-6} & \underline{+6} \\ + & + & - & - & + & + & - & - \end{array}$$

Division:

$$\frac{+6}{+4}=+ \quad \frac{-6}{-4}=+ \quad \frac{+6}{-4}=- \quad \frac{-6}{+4}=- \quad \frac{+4}{+6}=+ \quad \frac{-4}{-6}=+ \quad \frac{+4}{-6}=- \quad \frac{-4}{+6}=-$$

The multiplication and division, unlike addition and subtraction, could be taught simultaneously as the sign rule was the same for both processes. The sign rules did not hold in the zeroes as

the answer was always zero whether it was a product or a quotient and therefore did not have any sign.

At the end of the ten day practice period, when all the pupils had equal opportunity to be drilled and supervised by the teacher, a re-test was given. This, the final test, was given to both the experimental group which had been practiced in multiplication and division and the control group that had no practice in algebra for ten days. The results were recorded and the formula for transfer was used on the results to determine whether transfer had taken place.

The following chapter gives an account of the findings and an interpretation of the results.

CHAPTER IV

AN ANALYSIS OF FINDINGS -- INTERPRETATION OF RESULTS

From Table III it may be seen that when the Otis intelligence tests of both groups were equated there was no significant difference between them.

TABLE III

MEAN, DIFFERENCE, STANDARD DEVIATION, STANDARD ERROR AND CRITICAL RATIO OF THE DIFFERENCE BETWEEN THE EXPERIMENTAL AND CONTROL GROUP IN THE OTIS GAMMA TEST FOR SIXTY-TWO HIGH SCHOOL GIRLS

	Experimental Group		Control Group
Mean score	104.7		105.7
Difference		1.00	
Standard Deviation of Mean	6.05		8.10
Standard Error of Mean	.781		1.04
Critical Ratio or "t"		.77	

Table III shows that both groups were equated according to intelligence by the Otis Gamma Test. The mean and standard deviation of the experimental and control group being 104.7 and 6.05, and 105.7 and 8.10 respectively. The critical Ratio of .77 clearly indicates the absence of any real or statistically significant difference between the two groups for intelligence.

The table of "t" shows that a score of 2.75 at the .01 level according to the degrees of freedom of this group is required for significance. In other words, the null hypothesis is not disproved which is what is desired in this instance.

After the experimental and control groups were taught addition and subtraction,an initial test was given to both groups. The results indicated a mean and standard deviation of 40.5 and 8.70 for both groups. This coincidence of identical means and standard deviation obviously made it unnecessary to calculate a critical ratio since with no difference the null hypothesis must be accepted for the pre-test comparison as well as for the equation of the two groups in intelligence.

As was explained in the last chapter the experimental group was taught multiplication and division and was practiced in these processes for ten days. At the end of this period both groups, those who had the multiplication and division practice and those who had not, took Test II in addition and subtraction. The experimental group had a mean and standard deviation of

42.06 and 8.95 while the control group had scores of 40.55 and 8.70. When the calculations were made it was found that the experiment yielded a positive transfer.

The small sampling technique was used to determine whether or not the gain was significantly different from what could be expected. This is known as "t" which evaluates the significance of the difference ratio.[1]

Table IV gives a complete picture of the both tests and their findings.

In this table it looks as if both groups, since they were equated on intelligence previously, learned addition and subtractionof signed numbers equally well from the results of their mean and S.D. of the initial test. As we examine the table further, however, we see the final test scores show a gain in the experimental group. This gain is shown according to the calculations of "t" to be significant, since according to the grouping, as mentioned previously, at the .01 level "t" is 2.75 and this table calculates "t" as 2.96. Therefore there was a positive transfer shown in this experiment which cannot be attributed to the operation of chance factors.

As may be seen in the accompanying graph, the top scores of the two groups differ very little. Little or no spread

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1 Henry Garrett, Statistics in Psychology and Education, New York, 1926, 132.

TABLE IV

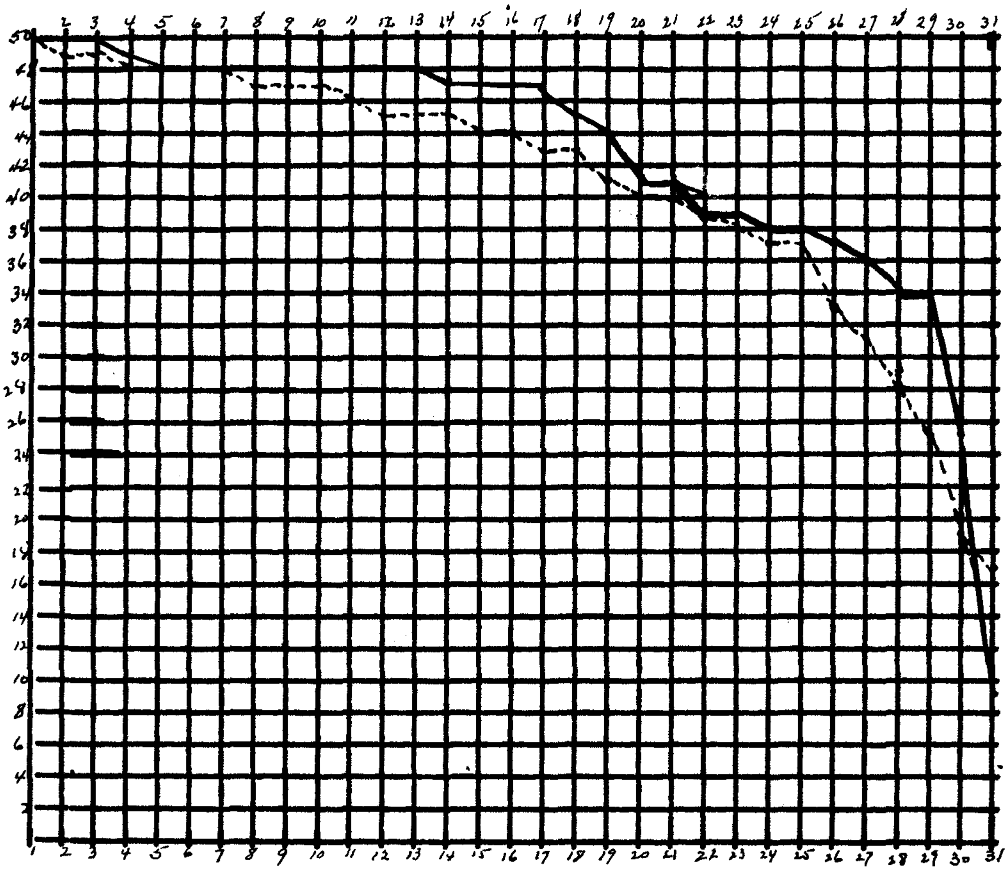
MEAN, STANDARD DEVIATION, GAIN, STANDARD ERROR, CORRELATION, AND CRITICAL RATIO OF THE INITIAL AND FINAL TESTS IN AN EXPERIMENTAL AND CONTROL GROUP OF SIXTY-TWO HIGH SCHOOL GIRLS

	Experimental Group		Control Group
No. of girls in each group:	31		31
Mean scores on initial test:	40.5		40.5
S.D. on initial test:	8.70		8.70
Mean score on final test:	42.06 (M_1)		40.55 (M_2)
S.D. on the final test:	8.95 (O_1)		8.70 (O_2)
Gain M_1-M_2:		1.51	
Standard Error of Mean on final test	1.15		1.11
Correlation between final scores (Experimental and Control groups)		.90	
"t" or critical ratio		2.96	

is seen between the scores of 50 to 48. The experimental group scores are higher throughout until the last score. The greatest difference or spread between the two groups is between scores 46 to 39 and again between 37 to 18. The lower scores between 37 to 18 seem to have the greatest spread. It is interesting to note that, suprisingly, the lowest score of the control group is

_______ Experimental
- - - - - - - Control

Scores



Pupils

FIGURE I

RESULTS OF THE SCORES ON THE EXPERIMENTAL AND CONTROL GROUPS ON THE FINAL TEST OF SIXTY TWO HIGH SCHOOL GIRLS

seventeen while the lowest score of the experimental group is nine. This may account for the small transfer results. It shows that there must have been some interference in transfer for at least some students, as a result of teaching multiplication and division to improve addition and subtraction of signed numbers.

Using the formula:

$$\frac{\text{Experimental Score} - \text{Control Score}}{\text{Control Score}} \times 100,$$

we obtain the per cent of improvement in transfer.[2] With the results of the final tests of the present experiment, the transfer obtained was 3.7 per cent in the positive direction.

Since both groups were equated according to IQ and according to initial test, and since, in both cases, the differences were not significant, it is evident that a greater measure of transfer might have been obtained if the experimental group had a longer period of practice in multiplication and division of signed numbers.

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2 Robert, Gane, H. Foster, M. Browley, "The Measurement of Transfer of Training," Psychological Bulletin, 1948, 45-97.

CHAPTER V

SUMMARY AND CONCLUSION

In the beginning of this experiment, the writer set out to determine what were the transfer results, if any, from the practice in algebraic multiplication and division to the performance in algebraic addition and subtraction when equated groups of ninth-grade algebra students were used as subjects. The investigation included a study of the definition of the term transfer, and a review of accepted opinions of outstanding psychologists on the existence and nature of transfer.

From the literature reviewed, it would seem that experiments on the effect of transfer of training have a history dating back to 1890. Studies range from those on "formal discipline" to the more recent ones on generalization and identical elements. The most popular theorists favor interpretation in terms of either Judd's generalization or Thorndike's identical or specific elements. Today the pendulum swings in the direction of generalization.

The literature gives poor techniques as the main reason why the early followers obtained little or no transfer. These poor techniques included: (1) limited number of subjects

for experimentation; (2) no control group as a basis of measurement; (3) lack of standardization of time for reaction.

The reports seem to indicate that transfer depends in a measure on instruction, and on generalization of experience. The amount of transfer in life-situations depends upon whether the subject matter taught is useful to situations commonly encountered in life outside the school. Orato's most recent report tells us that the generalization theory is supported by seventy per cent of the experimenters while only thirty per cent support the identical elements theory. Orato's work seem to be complete as his two reports cover experimentation on transfer from 1890-1940. He says while most of the early experiments produce only a small amount of transfer (from 20-30 per cent), the experiments of Katona and some of the recent experimenters have obtained 100 per cent.

Out of the many types of experiments described in the field, the writer chose to experiment with classroom activities.

Two classes of algebra were equated according to intelligence and initial tests. Both the experimental and control group were taught addition and subtraction of signed numbers before the initial test was given. When the initial tests were scored and the group equated, the experimental group was trained in multiplication and division of signed numbers. The results of the final test showed an amount of positive transfer which

was signifioent at the one per cent level of confidence.

According to the transfer formula a 3.7 per cent gain was recorded. This was not as much as had been expected. Since both groups were equated on intelligence and initial test scores which showed no significant differences according to calculations, the small measure of transfer obtained may have been due to several factors. It is possible, for example, that if the training period had been extended, the results would have been more encouraging.

In looking for possible reasons why the experiment did not produce more effects, the writer found a solution that may be plausible. Sterch has a summation:

> The transfer effects of the training abilities on school subjects is very much less than is commonly assumed. This is probably due, in the first place, to the fact that improvement in capacities exercised especially by school subjects is usually not as great as is commonly believed by teachers. The modifications produced in the minds of pupils are considerably less than teachers assume as judged by the modifications produced in their minds after much longer and harder study.
>
> The small effects of transfer are probably due, in the second place, to the fact that conditions of securing transfer are not favorable on the whole in the case of school subjects as in the case of the special laboratory experiments on transference.
>
> In formulating an opinion concerning general training effects resulting from training of special capacities, we must bear in mind that even where the transfer is considerable, as much as one-fourth to one-third as much as in the capacity especially trained, it is obviously more economical to give practice directly to the capacities which we want to train rather than to do it indirectly with the

hope that improvement may be transferred.[1]

This summation gives clearly what the writer believes to be the reason for the slight results in the present experiment. It is possible that a greater amount of transfer could have been achieved: (1) if the method could be improved so that more stress would be placed on the zero difficulties of the signed numbers, because it was here that many made mistakes in the final tests; (2) if a longer period of time had been allowed for the experiment.

In spite of the great progress that has been made in this problem of transfer, it will always remain a critical one for children and teachers alike. Because of its necessity and importance, it is hoped that some other students may continue the search in this field. Further investigation may verify and broaden the area explored by this limited study.

---

1 Starch, Educational Psychology, 253-254.

APPENDIX A

IQ OF EQUATED GROUPS

Experimental Name	IQ	Control Name	IQ
C.H.	122	C.E.	120
G.D.	119	E.O'K.	119
K.H.	118	E.B.	118
E.B.	116	J.A.	117
M.G.	113	D.B.	115
MA.B.	113	B.E.	112
M.T.	111	M.J.	112
L.P.	110	A.D.	111
M.K.D.	109	C.McG.	109
W.W.	109	P.M.	109
J.H.	109	J.W.	108
A.S.	108	I.O'L.	107
M.K.	107	M.A.K.	107
V.W.	107	M.K.	107
M.S.	106	D.T.	106
N.G.	104	Jo.H.	105
D.K.	103	J.T.	104
D.C.	103	H.M.	103
C.S.	103	B.P.	103
Ja.H.	103	J.K.	102
R.C.	102	D.McD.	102
M.C.	102	S.P.	102
S.F.	101	P.S.	100
M.R.	100	M.C.	100
D.H.	99	J.F.	97
V.S.	97	D.S.	97
L.L.	96	N.D.	96
K.O'S.	96	A.C.	96
P.D.	95	R.F.	94
P.R.	94	N.M.	94
M.F.	91	C.L.	92

APPENDIX B

SAMPLE OF TESTS

TEST I

Time--15 min. Name________________________

1. If John's score in a game is -30, he must make _____ points to raise his score to zero.
2. When the temperature drops from 0° to -10°, the change is _______.
3. The highest of these temperature readings, 25°, 10°, 15° and -30° is _______.
4. Fred's scores in a game were -5; -7; 3; -4 and 10. His final score was _______.
5. ADD

+6	-6	-6	6	-11	-11	11	11
+11	-11	11	-11	6	-6	-6	+6

3	-3	0	0	6n	-8n	9x
0	0	-3	3	-4n	5n	-8x

$6+(-4)+(+5)=$ $9+6-3=$

$6+(+4)+(-5)=$ $9-6-3=$

$+6+(-3)+(-5)=$ $-9+6-3=$

$-6+(-3)-(+5)=$ $-9-6-3=$

-12	+15f
-29	- 9f
+37	-17f
-18	+20f

6. SUBTRACT the lower number, subtrahend, from the upper number, minuend.

9	9	-9	-9	+4	-4	-4	4
4	-4	-4	4	+9	9	-9	-9

5	-5	0	0	6n	-5b	9a
0	0	-5	5	-4n	9b	-3a

7. Add or subtract as indicated.

$+7-(+5)+(-3)=$

$7-(-5)-(+3)=$

$7+(-5+(-3)=$

$7-(-5)-(-3)=$

$-9a-(2a)+5a=$

$-(-4)+(+6)+(-7)=$

TEST II FINAL TEST

Time 15 min. Name____________________

1. Mary's score is a -10. She must make _____ points to have a score of 15.

2. When the temperature drops from 70° to 65°, the change is _______.

3. The highest of the temperature readings 0°; -10; -5°; -25°, is _______.

4. John's scores in a game -10; 5; -8; 13; -2. His final score is _______.

5. ADD

8	-8	8	-8	-13	-13	13	+13
13	-13	-13	13	-8	8	-8	+8

-7	7	0	0	-4y	7o	-6a
0	0	-7	7	9y	-6o	-10a

+5+(-3)+(+7)= 8+6-2=

+5+(+3)+(-7)= -8+6-2=

5+(-3)-(+7)= -8-6-2=

-5+(-3)+(-7)= 8-6-2=

-15	+20b
+35	-7b
-40	-14b
+8	+13b

6. SUBTRACT the lower number, the subtrahend, from the upper, the minuend.

10	-10	+10	-10	-7	7	7	-7
-7	7	+7	-7	10	-10	10	-10

0	0	9	-9	5a	9a	4g
-9	9	0	0	+12a	-6a	-10g

Test II (cont'd) Final Test

7. ADD or SUBTRACT as indicated.

$-6+(+8)-(-4)=$

$-6-(+8)+(-4)=$

$-6-(-8)-(+4)=$

$6+(+8)-(-4)=$

$8b-(+10b)+4b=$

$-(-9)+(-11)-(+9)=$

APPENDIX C

Results of the Final and Initial Tests of Both Groups

	Experimental Group			Control Group		
	Name	Tests		Name	Tests	
No.		Final	Initial		Final	Initial
1.	E.B.	50	50	M.T.	50	48
2.	M.T.	50	47	C.McG.	49	48
3.	M.A.K.	50	47	J.A.	49	50
4.	D.K.	49	43	K.O'S.	48	48
5.	N.D.	48	47	S.F.	48	49
6.	M.G.	48	47	H.M.M.	48	49
7.	O.S.	48	45	J.W.	48	49
8.	V.W.	48	47	J.H.	47	47
9.	E.O'K.	48	44	D.H.	47	47
10.	M.K.D.	48	50	K.H.	47	47
11.	W.W.	48	47	M.A.B.	46	46
12.	M.J.S.	48	48	B.E.	45	44
13.	G.D.	48	49	L.L.	45	46
14.	I.O'L.	47	40	E.B.	45	47
15.	Ja.H.	47	45	D.S.	44	45
16.	Jo.H.	47	47	P.S.	44	45
17.	D.C.	47	49	P.M.	43	43
18.	M.K.	45	46	M.K.	43	45
19.	N.G.	44	44	M.C.	41	43
20.	C.L.	41	39	L.P.	40	40
21.	R.C.	41	42	R.P.	40	41
22.	M.J.	39	38	P.D.	39	38
23.	P.R.	39	42	D.T.	38	44
24.	D.B.	38	32	C.E.	37	37
25.	B.P.	38	38	N.M.	37	33
26.	M.C.	37	44	A.D.	33	42
27.	A.S.	36	40	J.F.	31	37
28.	J.K.	34	34	C.H.	28	28
29.	M.F.	34	34	V.S.	25	22
30.	S.P.	25	24	D.McD.	19	22
31.	A.C.	9	9	J.F.	17	16

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APPROVAL SHEET

The thesis submitted by Sister Mary Roserita McGuire, R.S.M. has been read and approved by three members of the Department of Psychology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Arts.

June 11, 1958
Date

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Signature of Adviser