The relationship and importance of graphical representation to learning

by Henry Lehner Parsons

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
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Abstract:
The study originated because of the belief that graphical representation is one of the more important means through which the major concepts of subject matter of a general educational nature can be developed to insure the learner the maximum benefit from his educational experience. It was based upon the belief that ideas, when learned, become images in the mind and that when meaningful images become a part of an individual's experience, that individual is better prepared to adapt to change.

The problem of the study had three phases: (1) to determine what has been reported about the nature, of learning, (2) to determine what has been said about the nature of graphical representation and its relationship to learning, and (3) to determine the importance of graphical representation in a classroom learning situation. In the third phase, an examination was made of the effects of the graphical representation of the major ideas in a course in educational psychology on (1) final learning, (2) critical thinking, and (3) reasoning.

Literature revealed the following information which concerns the relationship of graphical representation to learning in general education: (1) authorities are not in agreement as to definitions of learning, intellect, and the related area of ability and aptitude, (2) intelligence is considered a variable factor in the learning process, (3) similarity of content, contrast between content, contiguity of ideas, vividness of material, frequency of use, and recency of association are factors important in learning, (4) memory, perception, cognition, discrimination, generalization, and transfer are mental processes which affect learning, (5). learning involves at least three major processes, concept formation, communication, and creativity, (6) three types of content, figural, symbolic, and semantic are known to be related to the learning process through intellect although the exact relationship is not known because the structure of intellect is a purely theoretical concept, (7) graphical representation of ideas tends to make learning an active process, meaningful, interesting, transferable, individualized, satisfying, and unified, and (8) teaching of general educational subject-matter concepts can be done more effectively with more permanent learning and transfer resulting when graphical representations are used.

The results of the classroom experiment on the effects of the graphical representation of the major ideas in a course in educational psychology revealed a significant difference in final achievement in learning the major ideas in the course. However, the use of graphical representations in teaching the course in educational psychology caused no significant improvement in students' abilities to think critically or to reason in terms of mechanical applications.

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THE RELATIONSHIP AND IMPORTANCE OF GRAPHICAL REPRESENTATION TO LEARNING

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ABSTRACT

The study originated because of the belief that graphical representation is one of the more important means through which the major concepts of subject matter of a general educational nature can be developed to insure the learner the maximum benefit from his educational experience. It was based upon the belief that ideas, when learned, become images in the mind and that when meaningful images become a part of an individual's experience, that individual is better prepared to adapt to change.

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CHAPTER I

INTRODUCTION

Education in its broadest sense is intended to impart the heritages that have accrued through the ages and to prepare youth for useful membership in society. Today, more than ever before, because of the tremendous technological advances which are causing social change in the United States, education should aid in successfully interpreting the present civilization to youth so that their needs will be met.

In this fundamentally industrial society, as well as in the past, the adult members of society have been charged with the responsibility of keeping the entire educational program up-to-date. It appears, however, that this obligation is not being met fully as revealed by the fact that one out of every five boys between the ages of sixteen and nineteen who looks for work fails to find it.[1] Because of inadequate education, one out of every six persons in the 16-21 age group is unemployed.[2]

Idleness due to basic changes in industry and an increase in the number of teenagers looking for jobs pushed the number of unemployed persons as of May, 1963, to 5.9 per cent of our labor force.[3] October, 1963, marked the 71st consecutive month that unemployment was above the five per

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[1] Velie, Lester, "Why Johnny Can't Get a Job," Reader's Digest 82: 149, January, 1963.

[2] U. S. Department of Health, Education, and Welfare, Office of Education, High School Dropouts: A 20th Century Tragedy, 4 pp.

[3] Brodinsky, Ben, editor-in-chief, "Trends and Issues," Education Summary 16:1, July 12, 1963.

cent level.[4] There has been little decline to date and the outlook seems to be that by the end of the 1960's, unemployment will reach 11 per cent.[5]

Labor Secretary Willard Wirtz, in commenting on unemployment problems, said that teenage unemployment could develop into "one of the most explosive social problems in the nation's history."[6] Many of the older persons who are unemployed and a large number of youth who are school leavers have not received an organized body of knowledge and skill and are not prepared to adapt to the requirements of new jobs. Efforts need to be made to emphasize to youths that "they are likely to have to hold many different jobs in their lifetime; . . ."[7]

McDaniel recognized the tremendous problem which exists in preparing youth for employment and said that "with community recognition and support for education of youth for employment as a legitimate school goal, programs and procedures as dynamic as the changing times and as varied as individual differences among people can be established."[8] Hernandez, in referring to recent changes in the relation of education to industrial and technical society and the needs resulting, stated:

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[4] von Fremd, Charles, in a news report broadcast by Columbia Broadcasting System, October 31, 1963.

[5] Townsend, Ed, "Where Are the Jobs in the '60's?" The Christian Science Monitor 55:9, September 21, 1963.

[6] Brodinsky, op. cit., p. 1.

[7] Townsend, op. cit., p. 9.

[8] McDaniel, H. B., "Expertness in Preparing Youth for Employment," Journal of Secondary Education 38:67, April, 1963.

> During the past two or three decades, technological developments in industry have compelled all interested individuals to examine the public schools from the elementary level through the post-high school area. There have been innumerable studies carried out with respect to the relationship of education to an industrial and technological society. Such studies and observations have made us aware of the necessity of adjusting our educational system to the scientific age in which we are living.[9]

Abramson specifically emphasized the need to revise high school curricula by the following comments: "The average high school graduate is still ill-prepared to earn a satisfactory wage. He has almost no marketable skills, can find few really rewarding jobs, is hardly better off than the dropout."[10] Wrage concurred that the school curriculum is in need of revitalization and said that "industrialists are beginning to realize that they, through taxes and other means, have paid for training programs to train their personnel and are not getting what they want or need."[11]

Perhaps the most noted group to recently study the problems of vocational education, the Panel of Consultants on Vocational Education, proposed an almost eight-fold increase in federal funds for vocational education for the 1963-1964 school year. Their recommendation was based

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[9]Hernandez, L. G., "Education in a Scientific Age," Industrial Arts and Vocational Education 47:274, November, 1958.

[10]Abramson, Paul, editor, "How to Teach Data Processing in Your School," School Management 7:77, May, 1963.

[11]Wrage, John, "Why Industry Conducts Its Own Training Programs," American Vocational Journal 38:15, April, 1963.

upon the estimate that by 1970 there will be 87 million Americans working full time. Of these, 58 million are working now but will need further training "to keep pace with new methods, new materials, new opportunities."[12] Also, there will be 26 million young people entering the labor market during the decade, 1960-1970. These young people will need skills and education to "adapt to the needs of a changing economy."[13] The panel believed that all levels of education should be designed to provide a basic general education because:

> Of every 10 students now enrolled in the elementary grades, 3 will probably not attain high school graduation. . . . Of the other seven boys and girls who will finish high school in this decade, three will not go on to college. . . . Of the remaining four students who will eventually enter college, only two will receive baccalaureate degrees.[14]

Chamberlin has indicated that "we can expect the schools to become more technical for the many, more liberal for the few, . . ."[15] He believes that the American society will become increasingly more automated and has stated that there is one common denominator underlying all

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[12] U. S. Department of Health, Education, and Welfare, Office of Education, Education for a Changing World of Work, p. xv.

[13] Ibid.

[14] Ibid, p. 3.

[15] Chamberlin, L. J., "Automation--Society and the Schools," The American School Board Journal 145:8, September, 1962.

research on the effects of automation:[16] "More emphasis must be placed on education."[17] Dudley substantiated the belief that automation is confronting education with two main problems: "The first is the pressing need for immediate training or retraining of people for the existing technological changes. . . . The second problem is one of educating our future citizens, some of whom will be thrust directly into an automated world."[18]

One solution to the problem of unemployment may lie in giving children a broad basic education and allowing them "flexibility to continue some form of education all during their life."[19] The Panel of Consultants on Vocational Education supported the belief that basic general education is the best foundation for vocational education. They quoted the following statement of Brookover and Nosow in their report to the President:

> Skills in reading, mathematics, and other general education fields are essential for acquiring specific vocational competence and the higher levels of education needed for many occupations. It is therefore essential for the schools to increase their efficiency in teaching the fundamental school subjects to all students. The early school leaver who has not acquired the basic skills is not only unable to find satisfactory permanent employment but is also greatly handicapped in acquiring specific vocational training as an adult.[20]

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[18] Dudley, A. J., "Automation and Education," Industrial Arts and Vocational Education 52:40, April, 1963.

[19] Francis, D. R., "What Price Automation?" The Christian Science Monitor 55:9, September 28, 1963.

[20] U. S. Department of Health, Education, and Welfare, Education. . ., op. cit., p. 5.

There is no doubt that there is increased interest in education designed to offset the unemployment problem. Financially, at least, the picture is promising. In December, 1963, President Johnson signed into law a $1.56 billion bill broadening federal support of vocational education, extending the impacted areas program, and boosting college student loan funds.

As already noted, however, it will take more than finances to insure that youth will be able to meet the challenges of automation. The school curriculums will have to be designed to aid in providing students a good basic education. It was reported in The Curriculum Letter[21] that the Educational Policies Commission recently stated that the central task of the schools is to teach the student to think. The commission is reported as saying that a mature sense of social responsibility requires "the exercise of reason" and "a knowledge and analysis of events that cannot be obtained by the uneducated or the uninterested."[22] The commission went on to say that the schools needed, among other things, "experiences that will develop communications skills to a high degree and give the student philosophical perspectives--for these 'are essential to the acquisition and interpretation of social knowledge'."[23]

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[21] "Responsible Citizenship," The Curriculum Letter 3:1, September, 1963.

[22] Ibid.

[23] Ibid.

The basic implications to education of technological change, including the effects of automation, are not entirely clear. However, it seems evident that the schools in the United States will need to be tremendously more effective in the future to meet the changing demands of society. Experts agree that education will have to be a continuing process with the learning of new skills becoming more important as job opportunities change more frequently. The learning of required new skills must stem from major concepts already learned, just as new products in industry come from the use of tools already available.

Robinson remarked that "education, whether you call it life or preparation for life, is certainly part of the preparation for adulthood. If it is to be a thinking adulthood, the education had better be based on thinking."[24] The philosophy of education which we in education decide upon must include recognition of the importance of critical thinking; of teaching for understanding the few important concepts in each field of knowledge; of educating to the limit of his educability each person in our society; and of the need for education of each member of society so that leisure time will be used effectively, citizenship through participation in decision making will be increased, and adaptation to changing world conditions will be effective in maintaining our ideals.[25]

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[24] Robinson, Don, "Scraps from a Teacher's Notebook," Phi Delta Kappan 43:345, May, 1962.

[25] Johnson, Leon H., "The Knowledge Explosion and Its Implications on Education," an address at the Twelfth Annual Administrators' Conference, Montana State College, Bozeman, Montana, November 8, 1963.

As the volume of knowlege in the world increases, the importance of learning major ideas also increases. Since persons can no longer hope to be specialists in all or even in several areas of knowledge, it is increasingly important to know the importance of conceptual understandings in learning. Educators recognize that there is a need for a better understanding of how to present ideas to a student so that effective learning will take place.

The writer believed that ideas, when learned, become images in the mind and that when meaningful images become a part of an individual's experience, that individual is better prepared to adapt to change. More specifically, it was believed that graphical representation is one of the more important means through which the major concepts of subject matter of a general educational nature can be developed to insure the learner the maximum benefit from his educational experience. Those beliefs led to this investigation of the relationship and importance of graphical representation to learning.

Statement of the Problem

The problem of this study had three phases: (1) to determine what has been reported about the nature of learning, (2) to determine what has been said about the nature of graphical representation and its relationship to learning, and (3) to determine the importance of graphical representation in a classroom learning situation. In the third phase of the investigation it was planned to examine whether the graphical representa-

tion of the major ideas in a course would cause improvement of the students' abilities to think critically and to reason more effectively.

Procedures

It was necessary as a first procedure to make a cursory examination of the literature pertaining to learning and graphical representation to reveal how it could be best organized and grouped for understanding. Four categories appeared obvious into which the writings of most authorities in the field of learning would fit. These categories were: (1) the meaning and scope of learning, (2) the major stimulus-response and cognitive theories of learning, (3) the theories of the nature of intellect, and (4) the mental processes essential for effective learning. The writings on the nature of graphical representation and its relationship to learning appeared to be most meaningful when considered under three main headings: (1) graphical representation in concept formation, (2) graphical representation and communication, and (3) graphical representation and creative expression.

The second procedure was to extensively examine the literature pertaining to learning and graphical representation and to organize the information within the categories previously established.

Third, a classroom experiment in educational psychology was designed and conducted to determine the extent of the effect of the graphical representation of the major ideas of the subject on final learning achievement and on the students' abilities to think critically and to reason effectively.

Design of the Classroom Experiment

A classroom experiment was designed to test the belief that the graphical representation of the major ideas of a subject was important to the learning of that subject and would cause an improvement in the students' abilities to think critically and to reason effectively. A course in educational psychology was selected because its nature and emphasis on the factors considered by authorities as important to learning made it readily adaptable to such an experimental study. In addition, a course in educational psychology was selected because of the willingness of the professors to participate and because of its accessibility to the writer.

Comparison of the effects of the professors on final learning. Since two professors of educational psychology were to be assigned to teach the classes during the quarter the experiment was to be conducted, it was necessary to conduct a preliminary investigation of the comparative influence on final learning achievement of the personal characteristics of the two professors involved. This preliminary study was made during the two regular academic quarters immediately preceding the classroom experiment.

The two groups of students taught by the professors during those quarters were equated at the beginning of the quarter they registered for the course. Both professors taught the same major ideas in the course and used similar instructional methods and materials. A general knowledge test in educational psychology which was agreed upon by the two professors

and the writer as being a valid measure of the learning of the important ideas in the course was administered at the ends of the quarters. The test data revealed no significant difference in the final achievement of the two equated groups of students. Therefore, the assumption was made that the personal characteristics of the two professors involved in the experiment was not a factor which influenced final learning.

Selection of experimental and control groups. Two groups of students, an experimental group (E) and a control group (C), were selected at the beginning of the classroom experiment without any specific prior knowledge of the background of the students involved. The students in the two groups had registered by chance in a section of the course in educational psychology without knowledge of who the professor was to be or that an experiment was to be conducted in the course during the quarter.

A check was made of the comparability of the students in the two groups on the basis of the raw score results of the Minnesota Scholastic Aptitude Test and the American Council on Education Psychological Examination for College Freshmen. The raw scores were provided by the Montana State College Testing and Counseling Service which administers tests to all students during their first quarter in residence at Montana State College.

The experimental and control groups were given four additional tests at the beginning of the experiment to determine the students' knowledge of educational psychology before formal instruction began and to determine their abilities to think critically and to reason. The tests

used were: (1) a comprehensive test in educational psychology which was developed by the writer from selected questions published by authorities in the field,[26] (2) the Watson-Glaser Critical Thinking Appraisal, Form YM, (3) the Differential Aptitude Test, "Abstract Reasoning," Form L, and (4) the Differential Aptitude Test, "Mechanical Reasoning," Form L.

Determination of instructional areas. Both groups of students were taught the major ideas in ten areas of educational psychology which appeared to be considered important by authors in the field. The determination of the instructional areas was made through reviewing numerous current educational psychology textbooks. These areas appear to include the same general content which was reported by Nunney[27] to have been represented as the core of educational psychology by the major introductory textbooks during the period 1956-63. The titles selected for the major instructional areas were: (1) introduction to educational psychology, (2) growth and development, (3) psychology of learning, (4) guidance of

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[26]Test items were taken from the following sources and used by permission of the publishers: Blair, G. M., Jones, R. S., and Simpson, R. H., Instructor's Manual to Accompany Educational Psychology, Second Edition, The Macmillan Co. New York; Frandsen, A. N., Instructor's Manual for Educational Psychology: The Principles of Learning in Teaching, McGraw-Hill Book Co., New York; Jandron, E. L., Student Guide with Programmed Units to Accompany Sawrey and Telford's Educational Psychology, Second Edition, Allyn and Bacon, Inc., Boston; Klausmeier, H. J., with assistance of Richard Ripple, Instructor's Manual to Accompany Learning and Human Abilities: Educational Psychology, Harper & Brothers, New York; Mouly, G. J., and Walton, L. E., Schaum's Outline of Test Items in Education, Schaum Publishing Co., New York. See Appendix B.

[27]Nunney, D. N., "Trends in the Content of Educational Psychology, 1948-63," The Journal of Teacher Education 15:372-376, December 1964.

learning, (5) motivation, (6) memory, (7) transfer, (8) other mental processes--discrimination, generalization, perception, cognition, (9) individual differences, and (10) educational measurement.

Selection of measurement instruments. The students were tested at the end of the classroom experiment through the administration of the Watson-Glaser Critical Thinking Appraisal, Form ZM, the Differential Aptitude Test, "Abstract Reasoning," Form B, the Differential Aptitude Test, "Mechanical Reasoning," Form B, and the same form of the comprehensive achievement test in educational psychology that was given as a pre-test. The test-retest data gathered were used to test the belief that the graphical representation of the major ideas of a subject was important to the learning of that subject and would cause an improvement of the students' abilities to think critically and to reason.

Limitations

The portion of the investigation related to the review of literature was confined to an extensive study of what authorities in the field have stated about the nature of learning and the nature of graphical representation and its relationship to learning. This was necessary because a cursory examination of literature revealed no composite writings which would provide a sufficient background for designing an experimental study of the importance of graphical representation in learning.

The experimental portion of the investigation was limited to a period of one college quarter and was conducted within the course, Education 302, Educational Psychology, at Montana State College. A

longer period for controlled experimentation was considered impractical because it was not possible to hold the student groups intact for longer than the normal length of the educational psychology course, one quarter.

The measurement of the effect of the use of graphical representation in a classroom was limited to four areas: (1) final achievement in the course in educational psychology, (2) critical thinking, (3) abstract reasoning, and (4) mechanical reasoning. Measurement was made through the use of four group tests: (1) a comprehensive achievement test in educational psychology,[28] (2) the Watson-Glaser Critical Thinking Appraisal, Forms YM and ZM, (3) the Differential Aptitude Test, "Abstract Reasoning," Forms L and B, and (4) the Differential Aptitude Test, "Mechanical Reasoning," Forms L and B.[29]

In order to establish a foundation for the remainder of the investigation, the first part of the examination of literature was devoted to the writings of authorities on the nature of learning and intellect. The review of this portion of the literature is presented in Chapter II.

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[28] See footnote 26, p. 12.

[29] For reviews of the Watson-Glaser and Differential Aptitude Tests see Buros, O. K., The Third Mental Measurements Yearbook, p. 570; The Fourth Mental Measurements Yearbook, pp. 676-681; and The Fifth Mental Measurements Yearbook, pp. 669-676, 796-799.

CHAPTER II

NATURE OF LEARNING AND INTELLECT

With automation a governing concept of production and distribution, the American society must necessarily be a truly educated society. Knowledge through education must be the central resource for its existence. Thus, more than ever before in our society, a situation exists where the educator must clearly understand the nature of learning and intellect.

The writer's desire to understand these factors, learning and intellect, suggested that an investigation be made, first, of several major theories. The findings of this investigation comprise this chapter.

Meaning and Scope of Learning

An extensive investigation into theories of learning revealed evidence that there are several kinds of learning. In fact, the term "learning" can cover many factors. The following definition of learning as a process was offered by Hilgard:

> Learning is the process by which an activity originates or is changed through reacting to an encountered situation, provided that the characteristics of the change in activity cannot be explained on the basis of native response tendencies, maturation, or temporary states of the organism (e.g., fatigue, drugs, etc.).[1]

Learning may also be viewed as a product if the actual changes that are produced as a result of learning experiences are of primary

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[1] Hilgard, E. R., Theories of Learning, p. 3.

importance. "In other words," according to Crow and Crow, "learning considered as a product refers to the total of changes that result from the summation of interactions between the individual and environmental stimuli."[2]

Learning may take place under either formal or informal situations but such factors as social sensitivity, health status, and degree of emotional tension affect the nature and extent of learning in any situation.[3] In view of the purpose of this discussion, that of setting a background for the investigation of the relationship of graphical representation to effective learning in general education, a rigid definition of the learning process does not seem appropriate.

Ideas regarding learning have been set forth as theories by educators and psychologists in an attempt to explain human behavior. These theories divide on certain issues and fall into several groups. This investigation has been limited to the two principal groups of learning theories, stimulus-response and cognitive, and to the theories of the nature of intellect.

Major Stimulus-Response Theories of Learning

The major stimulus-response theorists tend to believe that some sort of chained muscular responses, linked by anticipatory goal responses,

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[2]Crow, L. D., and Crow, Alice, "Meaning and Scope of Learning," in Readings in Human Learning, p. 1.

[3]Ibid, p. 3.

cause learning. These theorists believe that what is learned is "habits" or responses. The learner is believed to assemble habits from the past in a way which meets the new problem, or if these do not meet his needs, the learner resorts to trial and error.[4] Brief descriptions of the theories of Thorndike, Guthrie, Skinner, and Hull follow.

Thorndike--Connectionism.[5] The learning theory of Edward L. Thorndike became known as "connectionism." Every idea, sensation, and feeling is a response to a preceding idea, sensation, or feeling. Memory, as a part of behavior, is a series of stimulus-response connections with particular stimuli calling forth particular responses.

Thorndike based his theory upon three laws: (1) readiness, (2) exercise, and (3) effect. The law of readiness deals with physiological preparedness for learning. There are three circumstances under which a learner tends to be satisfied or annoyed.

> 1. When a conduction unit is ready to conduct, conduction by it is satisfying, nothing being done to alter its action.
>
> 2. For a conduction unit ready to conduct not to conduct is annoying, and provokes whatever response nature provides in connection with that particular annoying lack.
>
> 3. When a conduction unit unready for conduction is forced to conduct, conduction by it is annoying.[6]

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[4] Hilgard, op. cit., pp. 9-11.

[5] Ibid, pp. 15-47; Hill, W. F., Learning: A Survey of Psychological Interpretations, pp. 57-60; Thorndike, E. L., The Original Nature of Man, 327 pp.; Thorndike, E. L., The Psychology of Learning, 452 pp.; Thorpe, L. P., and Schmuller, A. M., Contemporary Theories of Learning, pp. 45-84.

[6] Thorndike, The Original . . ., op. cit., p. 128.

His law of exercise indicates that use and practice strengthens connections and lack of use weakens connections. In this sense, strengthen means to increase the probability that response will be made when the situation recurs.

The law of effect states that rewards and success further the learning process. Punishment does not necessarily have a diametrically opposed effect.

To supplement his major laws, Thorndike stated five subordinate laws. They are: (1) multiple response, (2) set or attitude, (3) prepotency of elements, (4) response by analogy, and (5) associative shifting. Although Thorndike did not always refer to these subordinate laws, they occasionally were important in his discussions. Therefore, they are mentioned here.

1. The law of multiple response essentially states that varied reaction or trial and error leads to success and learning is possible.

2. Set or attitude guides learning by determining what the person will do and what will satisfy or annoy him.

3. Prepotency of elements is the third subordinate law and states that the learner can pick out relevant parts of situations thus making analytical and insightful learning possible.

4. Response by analogy indicates that a person responds to a new situation as he has successfully responded to a previous situation somewhat like it.

5. Associative shifting may be summarized by saying that we may "get any response of which a learner is capable associated with any situation to which he is sensitive."[7]

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[7] Thorndike, The Psychology . . ., op. cit., p. 15.

Thorndike's theory of learning as reported in the literature may be summarized by the following five statements.

1. The learning of responses becomes the central process for all behavior.

2. A learner's capacity to learn depends upon the quantity of stimulus-response bonds available.

3. Trial and error, reward and punishment, and the concept of extrinsic motivation are basic to learning.

4. Each situation presented will bring forth a particular response or group of responses either directly or through the principle of analogy.

5. Purposeful drill on structured materials is more important than the role of insight or understanding because the latter are based on the assimilation or transfer of elements previously learned.

Guthrie--Contiguous Conditioning.[8] The learning system of Edwin R. Guthrie is a stimulus-response association psychology much like Thorndike's. Guthrie stated that there is one law of learning from which all else about learning can be understood. He stated that law as: "A combination of

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[8]Guthrie, E. R., "Conditioning: A Theory of Learning in Terms of Stimulus, Response, and Association," in The Psychology of Learning, Forty-First Yearbook, pt. 2, of the National Society for the Study of Education, pp. 17-60; Guthrie, E. R., The Psychology of Learning, 310 pp; Hilgard, op. cit., pp. 48-81; Hill, op. cit., pp. 40-55; Thorpe and Schmuller, op. cit., pp. 87-120.

stimuli which has accompanied a movement will on its recurrence tend to be followed by that movement."[9] Later a second statement was added to complete the postulate: "A stimulus pattern gains its full associative strength on the occasion of its first pairing with a response."[10] Basically, the theory is built upon conditioning with the idea that stimuli and responses are simultaneous and continuous.

Guthrie recognized that motivation affected learning indirectly and that learning with foresight of its consequences may occur. He believed, as did Thorndike, that learning transfers to new situations because of common elements within the old and new, but added that to get desired behavior in a new situation you must practice in that situation. To Guthrie, all learning was permanent unless replaced by new learning responses.

Skinner--Operant Conditioning.[11] B. F. Skinner proposed a stimulus-response psychology termed operant conditioning. It is concerned with both conditioning and reinforcement.

Skinner indicates that there are two types of behavior; (1) respondent and (2) operant. Respondent behavior is that which is elicited by known stimuli; operant behavior is that which occurs although no known stimulus may be present. Skinner believes that operant behavior is most important and maintains that most human behavior is of that type.

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[9] Guthrie, The Psychology . . ., op. cit., p. 23.

[10] Guthrie, "Conditioning: . . .," op. cit., p. 30.

[11] Hilgard, op. cit., pp. 82-120; Hill, op. cit., pp. 60-79; Thorpe and Schmuller, op. cit., pp. 167-202.

Since operant responses are emitted, not elicited by recognized stimuli, their strength cannot be measured according to the usual laws of reflex. Therefore, since the reinforcing stimulus follows the response, the rate of response is used as a measure of the strength of the operant. According to Skinner, operants often are related to prior stimulation but such stimulation does not elicit the response; rather, it becomes an occasion for it.

No reference is made to insight in Skinner's work. Capacity for learning seems to be thought of as an individual behavioral factor. Skinner believes that it is possible to teach a child to think since the technique of problem-solving is merely that of manipulating variables which may lead to the emission of a response.

Although much of Skinner's work has been with animals, he has recently experimented with human learning through use of teaching machines. He feels that classroom learning is largely the result of operant conditioning. The teacher's questions do not elicit the responses; rather, they become the occasion for them. The reinforcing stimulus, perhaps another question, follows the response.

Hull--Systematic Behavior.[12] Hull's theory of learning involves conditioning and reinforcement with much emphasis placed on the intervening

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[12] Hilgard, op. cit., pp. 121-184; Hill, op. cit., pp. 129-156; Hull, C. L., "Conditioning: Outline of a Systematic Theory of Learning," in The Psychology of Learning, Forty-First Yearbook, pt. 2, of the National Society for the Study of Education, pp. 61-95; Thorpe and Schmuller, op. cit., pp. 121-166.

variables within the organism. The stimulus affects the organism and the response depends upon both the organism and the stimulus.

Reinforcement is thought of as drive reduction or drive-stimulus reduction. These are very closely associated in some instances with need. Learning is believed to take place only as a result of reinforcement.

Drive is necessary in the theory because without it there could be no reinforcement or response. Habits are regulated by the needs of the organism and aid in guiding the learning process.

According to Hull, different habits leading to the same goal form a family. This goal directed, habit family, approach is such that when a member of a habit family is blocked in progressing toward the goal another member can take its place. The habits in a family that reach a goal most rapidly and readily are preferred because they result in less inhibition. These habits in a family are arranged in a preference order known as the habit-family hierarchy.

The stimulus-response theories of learning have provided a basis for thought on the learning process. Because they are theories difficult to prove, they have been criticized as well as accepted. Seagoe has given the following criticisms which are pertinent in education.

> (1) The associationists presuppose specific stimulus-response bonds, whereas, the stimulus to any reaction above the reflex level affects a group of cells rather than single units, the response being to a ratio. Actually, there are mutually inhibiting and reinforcing effects present in each situation, determined not only by the nature and complexity of the stimulus but also by the disposition of the learner.

(2) The emphasis on the element or part as the primary unit is questionable. Our perceptions are not built up additively, but fall into patterns. Our perceptions are of wholes.

(3) The emphasis on chance success and habituation rules out the possibility of intelligent behavior. Understanding and reconstruction have no place in such systems. Learning is really concerned with thinking rather than habituation. It is active, not passive. Many of the situations were "blind," making intelligent solution impossible.[13]

Before generalizing on the implications of the stimulus-response theories for education, a review of the major cognitive theories was made. This review is reported in the next section.

Major Cognitive Theories of Learning

The cognitive theorists--Tolman, the classical gestalt psychologists, and Lewin--infer that central brain processes, such as memories or expectations, integrate learning behavior. They believe that "facts" are learned. In understanding problem-solving, the cognitive psychologist tends to look to the contemporary structuring of the problems and to interpretation according to insight. Following are descriptions of the major cognitive theories.

Tolman--Sign Learning.[14] The theory of Edward C. Tolman emphasizes the cognitive nature of learning and represents an affiliation of behaviorism and gestalt psychology. He borrowed ideas from Freud, Guthrie, Lewin, and reinforcement theorists.

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[13] Seagoe, M. V., A Teacher's Guide to the Learning Process, p. 245.

[14] Hilgard, op. cit., pp. 185-221; Hill, op. cit., pp. 114-128; Thorpe and Schmuller, op. cit., pp. 292-325.

Tolman believed that every action had its roots in a purpose or a goal. These goals or purposes may be reached by any of several actions. Although the way to the goal may vary, the result is constant.

When applied to education, Tolman's theory seems to indicate that effective learning results from the ability to make sensible and realistic adjustments to needs in a reasonable manner. Insight is considered more important than memorization and the behavioral facts about learning are explained on the basis of intervening variables such as appetite and biases. Thus, classroom learning is largely related to individual differences.

Classical Gestalt Psychology.[15] The gestalt movement originally was primarily concerned with the study of perception but gradually included the study of learning. It got its name when Max Wertheimer applied the German word "Gestalt" which, when translated, means "form" or "pattern" or "configuration." Wolfgang Kohler and Kurt Koffka contributed to and publicized different aspects of gestalt theory.

The emphasis of the gestalt theory is on whole systems of knowledge in which the parts are dynamically interrelated. The parts derive their meaning from being parts of the whole.

For the gestaltist, learning consists of recognizing both the problem to be solved and the means by which a solution may be realized. It does not consist of any form of stimulus-response connection but rather

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[15] Hilgard, op. cit., pp. 222-257; Hill, op. cit., pp. 92-104; Thorpe and Schmuller, op. cit., pp. 205-253.

involves insight. Insight requires that the means and goals of a situation be seen in relation to one another before learning takes place. In other words, the whole pattern of learning must be seen to understand its parts.

Insight, thinking, and understanding are the keys to effective learning. Repetition and trial and error are discredited by this theory. The most classroom learning takes place when the instructional materials are organized and the students are required to analyze the problems related to the situation. It is believed that in this way the students see the relationships pertaining to their own experiences before learning takes place.

Lewin--Field Theory.[16] Kurt Lewin's field theory of learning grew out of the classical gestalt theory. It emphasizes motivation rather than experience. Lewin attempted to explain psychological structure of behavior through the use of mathematical concepts.

According to Lewin's theory, everybody operates within a psychological "life space," a world of his own through which he perceives and interprets what is happening to him. The behavior of a person is dependent upon degrees of reality and unreality. When the life space corresponds to the real world the individual is in touch with reality; when the life space remains in the world of fantasy the real world suffers. Therefore,

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[16]Hilgard, op. cit., pp. 258-289; Hill, op. cit., pp. 104-113; Lewin, Kurt, "Field Theory and Learning," in The Psychology of Learning, Forty-First Yearbook, pt. 2, of the National Society for the Study of Education, pp. 215-242.

behavior depends on what is occurring at the present time rather than on past or future events.

Knowledge and understanding are important in Lewin's theory because he believed that learning causes changes in cognitive structure. Motivation is of central importance and changes in motivation may require repetition before learning is achieved. For educational achievement, goals must be made attractive and be realistic.

The cognitive theories of learning have also provided a basis for thought on the process of learning. These theories have been subject to criticisms, some of which include:

> (1) The criteria of insightful learning do not differentiate insight from trial-and-error as a mode of behavior. Insight refers to the end-product of learning and is not descriptive of the learning process. Apparently insightful learning is that which takes place without overt activity; trial-and-error is that in which the activity is overt. Essentially they are of the same exploratory and chance-success nature.
>
> (2) The stress on whole-relationships is included in stimulus-response versions of learning, which were never as atomistic as Gestalt psychologists claim. A stimulus has always meant a complex interacting situation and a response a complex form of behavior.
>
> (3) The experimentation is somewhat subjective and perhaps over-interpreted. The very fact that it assumes inner reorganization makes it difficult to test experimentally.[17]

Since in this study of learning theories it was assumed that all of the theorists had accepted all experimental evidence which has been established as fact, differences in theories were assumed to be primarily

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[17] Seagoe, op. cit., pp. 247-248.

differences in interpretations. With the descriptions and criticisms of the two major groups of theories of learning in mind, an attempt was made to determine their implications for current general educational practice. The basic generalizations made are given in the following section.

Synthesis of Learning Theory

In order to understand learning, an investigation of the two major groups of learning theories was made. As a result of that investigation, it is apparent that both groups contribute ideas valuable to understanding the learning process. However, it appears that the ideas of neither group alone are wholly adequate.

The stimulus-response theories seem to apply when learning is thought of in terms of mastery of subject-matter regardless of individual interests and when trial-and-error is the primary method for learning. As learning accelerates, one learned item seems to become the basis for learning another. This contiguity has meaning to both groups of theorists although the cognitive theorists are better able to explain what happens by reference to motivation and understanding.

The importance of repetition is supported primarily by the stimulus-response theories. Forgetting is easier to explain by reference to cognitive theories which tend to emphasize that learning is permanent unless replaced by more recent learning. Transfer of learning is largely supported by cognitive theorists although it was also referred to by Thorndike and other stimulus-response advocates.

By combining aspects of both groups of theories, it may be seen that the learning process at its simplest is very complex. Perhaps the greatest outcome of a study of learning theories is the realization that each and every teacher must constantly endeavor to learn more about learning.

A review of the theories of the nature of intellect was made in a further attempt to give a better understanding of the learning process. The findings are reported next.

Theories of Nature of Intellect

Human intelligence has been discussed for centuries but most of the knowledge of its components has come about during the past thirty years. There is not yet agreement among authorities regarding a single definition of intelligence.

The twelfth volume of the Journal of Educational Psychology[18] indicated that in 1921 thirteen well-known psychologists each gave different views on the nature of intelligence. Binet and Simon[19] earlier emphasized that intelligence consisted of comprehension, reasoning, and judgment and

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[18] Thorndike, E. L., and others, "Intelligence and Its Measurement: A Symposium," The Journal of Educational Psychology 12:123-147, March, 1921, and 195-216, April, 1921.

[19] Harris, C. W., and Liba, M. R., editors, Encyclopedia of Educational Research, p. 715.

that of these, judgment was of major importance. Spearman[20] added to the information about intelligence by originating the idea of "g" as a general intelligence factor. He believed that "g" was characterized by the combination of noegenesis (the creation of knowledge) and abstractness.

Thorndike[21] held that there were three kinds of intelligence, mechanical, social, and abstract. Thoughts and actions concerned with physical objects required the use of mechanical and social intelligence. The creation of information about persons or objects required abstract intelligence.

Some researchers have given more specific definitions of intelligence. Stoddard specified in the following definition that intelligence was an ability consisting of several complementary factors.

> Intelligence is the ability to undertake activities that are characterized by (1) difficulty, (2) complexity, (3) abstractness, (4) economy, (5) adaptiveness to a goal, (6) social value, and (7) the emergence of originals, and to maintain such activities under conditions that demand a concentration of energy and a resistance to emotional forces.[22]

Good has considered the terms, intelligence and intellect, as being synonymous and meaning the ability to execute the learning process.

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[20] Spearman, C. E., and Jones, LL. W., Human Ability, pp. 68-69.

[21] Thorndike, E. L.,"Intelligence and Its Uses," Harper's Magazine 140:227-235, January, 1920.

[22] Stoddard, G. D., The Meaning of Intelligence, p. 4.

> Intelligence: (1) ability to make successful and rapid adaptation to new situations and to learn from experience; (2) capacity to integrate experience; (3) as commonly used in measurement and testing, a degree of ability represented by performance on a group of tests selected because they have proved their practical value in the prediction of success in academic work and in some vocations.
>
> Intellect: the so-called power to integrate experience; intelligence.[23]

Whether these definitions are clear seems to depend upon the background and experience of the reader. Piaget appeared concerned with such definitions as indicated by his statement: "If intelligence is adaptation, it is desirable before anything else to define the latter."[24] After giving such a definition to his liking, he also added to the literature a none-to-clear definition of intelligence. He said, ". . . intelligence constitutes the state of equilibrium towards which tend all the successive adaptations of a sensori-motor and cognitive nature, as well as all assimilatory and accommodatory interactions between the organism and the environment."[25]

Guilford holds that the definition of intelligence as learning ability is not defensible, ". . . for intellect is not a unity, nor is learning ability."[26]

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[23] Good, C. V., editor, Dictionary of Education, p. 222.

[24] Piaget, Jean, The Psychology of Intelligence, p. 7.

[25] Ibid, p. 11.

[26] Guilford, J. P., Personality, p. 406.

Literature reveals that several authorities[27] have the view that factor analysis yields systems of coordinates which facilitate making predictions about the efficiency of people and can be linked to studies of intellect. Some of the same authorities and others[28] believe that factors are genuine causal entities affecting intellect.

Some recent psychologists, following the idea that there are several types of intelligence and considering intelligence as dynamic, have reported interesting findings. Lorge[29] indicates that as a person's years of schooling increase, his intelligence test results do likewise. Hunt reports that Piaget's observations tend to support the idea of increasing intelligence with age.

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[27]Anastasi, Anne, "Faculties versus Factors: A Reply to Professor Thurstone," Psychological Bulletin 35:391-395, 1938; Burt, C. L., The Factors of the Mind, 509 pp.; Guilford, J. P., "The Structure of Intellect," Psychological Bulletin 53:267-293, July, 1956; Spearman, C. E., The Abilities of Man, 416 pp.; Thomson, G. H., The Factorial Analysis of Human Ability, 383 pp.; Thurstone, L. L., Primary Mental Abilities, 121 pp.

[28]Cattell, R. B., Factor Analysis: An Introduction and Manual for Psychologist and Social Scientist, 462 pp.; Guilford, J. P., "Human Abilities," Psychological Review 47:367-394, 1940; Kelley, T. L., Essential Traits of Mental Life, 145 pp.; Thurstone, L. L., The Nature of Intelligence, 167 pp.

[29]Lorge, Irving, "Schooling Makes a Difference," Teachers College Record 46:483-492, May, 1945.

> Piaget's observations and experiments indicate that the behavioral and thought structures comprising intelligence are continually changing as a consequence of the accommodation and assimilation involved in a person's encounters with his environment.[30]

Literature supplies evidence that there are many interpretations of the meaning of the term "intelligence" just as there are varied ideas about learning. Educators work with "measured intellect because this is the level at which the person has shown he can perform."[31]

Several interesting studies have been conducted on the relation of learning and intellect to aptitude. Of these studies, eight are noted as pertinent to this investigation.

Brolyer, Thorndike, and Woodyard[32] reported that academic, commercial, and shop curricula in high school seemed to aid in development of verbal, numerical, and spatial-visualization abilities respectively. Hartson[33] found that verbal and numerical abilities developed at different rates in various college courses.

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[30]Hunt, J. McV., Intelligence and Experience, p. 246.

[31]Townsend, E. A., and Burke, P. J., Learning for Teachers, p. 37.

[32]Brolyer, C. R., Thorndike, E. L., and Woodyard, Ella, "A Second Study of Mental Discipline in High School Studies," Journal of Educational Psychology 18:377-404, September, 1927.

[33]Hartson, L. D., "Does College Training Influence Test Intelligence?" Journal of Educational Psychology 27:481-491, October, 1936.

The effects of engineering courses on the factor of visualization was the object of three independent studies by (1) Faubian, Cleveland, and Harrell,[34] (2) Churchill and others,[35] and (3) Blade and Watson.[36] The first study indicated no change after a six-week course, the second showed a slight gain after a nine-week course, and the third reported a significant gain.

Picton[37] reported that final achievement in high school solid geometry was not improved by the use of models for training in spatial visualization. Further, he stated that "the use of models in developing spatial concepts does not affect achievement on topics involving these spatial concepts."[38]

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[34]Faubian, R. W.; Cleveland, E. A.; and Harrell, T. W., "The Influence of Training on Mechanical Aptitude Test Scores," Educational and Psychological Measurement 2:91-94, January, 1942.

[35]Churchill, R. D., and others, "Effect of Engineer School Training on the Surface Development Test," Educational and Psychological Measurement 2:279-280, July, 1942.

[36]Blade, M. F., and Watson, W. S., "Increase in Spatial Visualization Test Scores During Engineering Study," Psychological Monographs 69, Whole No. 397, 1955, 13 pp.

[37]Picton, J. O., The Effect on Final Achievement in Solid Geometry of an Introductory Unit Based Upon Developing Visualization and Understanding through the Use of Models, 140 pp.

[38]Ibid, p. viii.

Nunn[39] studied the impact of certain curricular patterns at the secondary level on spatial visualization ability. He reported that "a positive and meaningful correlation exists between basic intelligence and spatial visualization ability, . . ." but that curricular patterns at the secondary level have no apparent impact on spatial abilities.[40]

It appears from these and other reports that the gain in aptitude after limited amounts of training may be expected to be small if any. Still, over a long period of time, the primary abilities, particularly those of intellect, may be strengthened through informal learning and transfer of training. A theory, proposed by Ferguson,[41] is that we have families of habits with positive transfer more likely to occur within families than between them.

Other authorities have devoted much time to the study of learning and intellect. One in particular, Guilford, has attempted to state the dimensions of intellect. He indicates that "the discovery of the components of intelligence has been by means of the experimental application of the method of factor analysis."[42] He emphasizes that "the factors

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[39]Nunn, W. R., The Impact of Certain Secondary School Curricular Patterns on Spatial Visualization, 142 pp.

[40]Ibid, p. ix.

[41]Ferguson, G. A., "On Learning and Human Ability," Canadian Journal of Psychology 8:94-112, June, 1954.

[42]Guilford, J. P., "Three Faces of Intellect," The American Psychologist 14:470, August, 1959.

themselves can be classified because they resemble one another in certain ways."[43]

The structure of intellect may be classified in three ways: (1) the basic kind of process or operation performed, (2) the kind of material or content involved, and (3) the kind of product involved. These three kinds of classifications of the factors of intellect have been represented by means of the cubical model shown as Figure 1.[44]

The kinds of content are shown along one side of the cube, the operations along a second, and the products along the third side of the figure. Each of these major classifications of the factors of intellect have been divided by Guilford into several parts. The operations consist of five groups of intellectual abilities: (1) factors of cognition, (2) memory, (3) convergent thinking, (4) divergent thinking, and (5) evaluation. Guilford explained each of the groups when he stated:

> Cognition means discovery or rediscovery or recognition. Memory means retention of what is cognized. Two kinds of productive-thinking operations generate new information from known information and remembered information. In divergent-thinking operations we think in different directions, sometimes searching, sometimes seeking variety. In convergent thinking the information leads to one right answer or to a recognized best or conventional answer. In evaluation we reach decisions as to goodness, correctness, suitability, or adequacy

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[43] Ibid.

[44] Used by permission of J. P. Guilford, Director, Aptitudes Research Project, Department of Psychology, University of Southern California, Los Angeles.

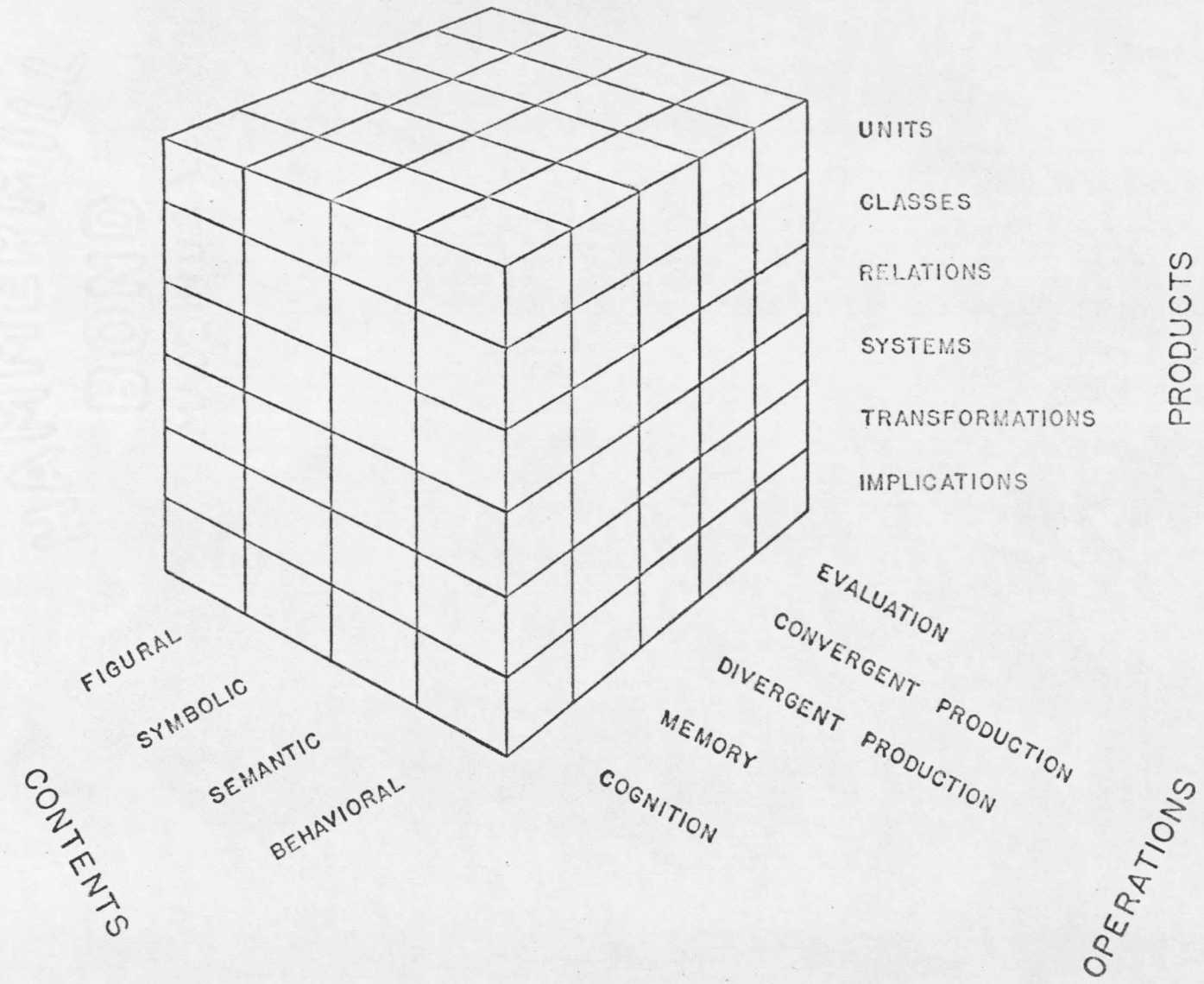

FIGURE I. THEORETICAL MODEL FOR THE COMPLETE "STRUCTURE OF INTELLECT"

of what we know, what we remember, and what we produce in productive thinking.[45]

The material involved in the factors of content of intellect may either be figural, symbolic, semantic, or behavioral. Only figural, symbolic, and semantic material are known.[46] Guilford has added the behavioral category on a purely theoretical basis to represent an area sometimes called "social intelligence." He explained the three known kinds of content as follows:

> Figural content is concrete material such as is perceived through the senses. It does not represent anything except itself. Visual material has properties such as size, form, color, location, or texture. Things we hear or feel provide other examples of figural material. Symbolic content is composed of letters, digits, and other conventional signs, usually organized in general systems, such as the alphabet or the number system. Semantic content is in the form of verbal meanings or ideas, for which no examples are necessary.[47]

There are as many as six kinds of products which can be obtained when the operations are applied to content. These are listed as units, classes, relations, systems, transformations, and implications. "So far as we have determined from factor analysis," stated Guilford, "these are the only fundamental kinds of products that we can know."[48]

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[45] Guilford, "Three Faces of Intellect," op. cit., p. 470.

[46] Ibid.

[47] Ibid.

[48] Ibid.

It needs to be emphasized that the model of the structure of intellect is purely theoretical and future research may indicate that some representative portions have been overlooked and others included which, in fact, are not important. However, the model gives a more concrete basis for research in learning and intellect than has been available previously.

Summary

The definitions that researchers have given for learning, intellect, and the related area--ability and aptitude--have also been ideas based upon particular theories. This accounts for the lack of agreement among authorities regarding definitions and emphasis placed on factors in the learning process.

The lack of agreement or, perhaps, systematic re-examination of existing concepts of learning has not been detrimental to education. Rather, it has led to increased interest in the entire educative process resulting in much fruitful research. Dewey considered theory practical and contended that:

> Theory is in the end . . . the most practical of all things, because the widening of the range of attention beyond merely purpose and desire eventually results in the creation of wider and farther-reaching purposes and enables us to make use of a much wider and deeper range of conditions and means than were expressed in the observation of primitive practical purposes.[49]

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[49] Dewey, John, Sources of a Science of Education, p. 17.

Any worthwhile educational situation involves a purpose and a content. Further, and most important, it involves a process of learning. Buswell[50] indicates that the purpose or objective is expressed as the theory of education, the content includes both subject-matter and behavior traits, and the process is expressed as the psychology of learning.

This chapter indicates the more agreed upon factors of the process of learning. Although the terms may not be acceptable to some authorities, there is agreement to varying degrees that similarity of content, contrast between content, contiguity of ideas, vividness of material, frequency of use, and recency of association are factors affecting learning.

Theories of intellect support the idea that intelligence is a variable factor in the learning process. Extensive research by Guilford indicates that the three known types of content which are related to the learning process through intellect may be classed as: (1) figural, (2) symbolic, and (3) semantic.[51] Other authorities generally appear to agree.

The review of literature further revealed that there is some agreement among authorities that the factors of intellect are very closely related to what is often termed mental processes operating in learning.

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[50] Buswell, G. T., "Educational Theory and the Psychology of Learning," Journal of Educational Psychology 47:177, March, 1956.

[51] Guilford, "Three Faces of Intellect," op. cit., p. 470.

Some of the most widely acknowledged mental processes, memory, discrimination, generalization, perception, cognition, and transfer, are discussed in the following chapter.

CHAPTER III

MENTAL PROCESSES ESSENTIAL FOR EFFECTIVE LEARNING

Each of the mental processes essential for effective learning has specific characteristics which separate it from the other processes yet make the others dependent upon it in some way. Memory is the first important process to be considered.

Memory--Remembering and Forgetting

Memory is the biological function which is necessary for consistent behavior.[1] It is through memory that the past and the present are united, yet memory is most important in learning because of its productive rather than reproductive quality.[2]

Attitudes may influence learning of current material either favorably or unfavorably[3] for they are a product of memory.[4] Material which is related to previous learning is most meaningful and is easiest to remember. Another important factor in remembering is the degree to which

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[1] Townsend, E. A., and Burke, P. J., Learning for Teachers, p. 116.

[2] Bartlett, F. C., Remembering: A Study in Experimental and Social Psychology, 317 pp.

[3] Garber, R. B., "Influence of Cognitive and Affective Factors in Learning and Retaining Attitudinal Materials," The Journal of Abnormal and Social Psychology 51:384-389, November, 1955.

[4] Townsend and Burke, op. cit., p. 119.

instructions identify what is to be learned and remembered.[5] There is general agreement among authorities on learning that persons learn in words and remember in words and that although practice is important in developing memory many variables affect its value.

Forgetting has been described by Townsend and Burke as "the inability to recall or recognize something which we could once recall or recognize."[6] It is explained by them in terms of inhibitions of three kinds, (1) reactive, (2) proactive, and (3) retroactive, which unite to cause the inability to remember.

Reactive inhibition, sometimes called primary negative drive,[7] is the negative reaction to a task which must be done and is independent of the effect of reward or reinforcement. It is essentially a need to lessen or cease activity and tends to slow learning. Planned rest periods lessen reactive inhibition and increase learning.

Proactive inhibition is associative in nature and is the interference with learning a new task caused by prior learning. According to Ausubel and Blake,[8] proactive inhibition may be minimized by the use of

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[5] Underwood, B. J., "Studies of Distributed Practice: IX. Learning and Retention of Paired Adjectives as a Function of Intralist Similarity," Journal of Experimental Psychology 45:143-149, March, 1953.

[6] Townsend and Burke, op. cit., p. 138.

[7] English, H. B., and English, A. C., A Comprehensive Dictionary of Psychological and Psychoanalytical Terms, p. 263.

[8] Ausubel, D. P., and Blake, Elias, Jr., "Proactive Inhibition in the Forgetting of Meaningful School Materials," Journal of Education Research 52:145-149, December, 1958.

meaningful concepts which increase the learner's ability to discriminate.

Retroactive inhibition is the interference with prior learning caused by present learning, especially when the learning activities are somewhat similar. Retroactive inhibition is, like proactive inhibition, associative in nature and work done to overcome it may produce inhibition in the opposite direction.

Forgetting can be lessened by the use of a planned amount of practice, although massed practice does not usually help. Instruction in classifying and organizing material to be remembered lessens forgetting as does the use of warmup, adequately-spaced complete reviews,[9] and recall shortly after learning.[10]

Memory appears to be related to all learning and the laws of efficient learning are useful guides in understanding and improving it. The association of ideas through a variety of experiences tends to improve memory and learning. James stated the importance of the association of ideas as:

> The more other facts a fact is associated with in the mind, the better possession of it our memory retains. Each of its associates becomes a hook to which it hangs, a means to fish it up by when sunk beneath the surface. Together they form a network of

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[9] Townsend and Burke, op. cit., pp. 147-154.

[10] Watson, Goodwin, "What Psychology Can We Feel Sure About?" Teachers' College Record 61:253-257, February, 1960.

> attachments by which it is woven into the entire tissue of our thought. The secret of a good memory is thus the secret of forming diverse and multiple associations with every fact we care to retain.[11]

The processes which support memory and allow learning to function in new contexts are discrimination and generalization. These processes are described next.

Discrimination and Generalization

Discrimination and generalization are considered as companion processes by a majority of authors in the field of learning. They make it possible for humans to apply learning to a wide range of situations.

Discrimination is the process through which likenesses and differences are perceived. When events are quite unlike, discrimination is relatively easy. When events are more alike, generalization is likely to occur. Discrimination is necessary for generalization because before one can generalize he has had to differentiate among similar items in context.

Generalization refers to the extension or diffusion of learning from one event or situation to another. When generalization is referred to as the result of the process of generalizing, the reference is

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[11]Weinland, J. D., How to Improve Your Memory, p. 18 (citing Psychology--Briefer Course, p. 294, by William James, Henry Holt and Co., New York, 1892).

essentially to the more extensive use in a subsequent learning situation of a conception, principle, or inference than was the case in the original situation.

According to Townsend and Burke, most generalizations result from the use of symbols which represent concepts.[12] As an example of this, one may consider the physical equivalence of the mountains of Colorado, Montana and Utah. This idea may be grasped by actually seeing the mountains in each of the states but is most frequently acquired through the use of maps, charts, or verbal descriptions. The learner grasps the meaning of ideas and attains mature knowledge only after reordering experience and getting satisfaction from his efforts. This is accomplished through perception and cognition.

Perception and Cognition

Perception and cognition are often considered together in the literature because it is usually very difficult to distinguish between that which constitutes a perception and a cognition. English and English have defined perception as an event while Good calls it an awareness.

> Perception: an event in the person or organism, primarily controlled by the excitation of sensory receptors, yet also influenced by other factors of a kind that can be shown to have originated in the life history of the organism.[13]

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[12] Townsend and Burke, op. cit., pp. 155-157.

[13] English and English, op. cit., p. 378.

> Perception: (1) in its most limited sense, awareness of external objects, conditions, relationships, etc., as a result of sensory stimulation; (2) more broadly, awareness of whatever sort, however brought about.[14]

In perception, the contact of a person with reality in the form of some object, event, or circumstance is immediate and there is considerable opportunity for a feedback from the stimulus. This feedback from the stimulus provides a check on the accuracy of the perception.

Cognition is a process in learning which is referred to in various ways by authorities. Townsend and Burke equate it with "understanding or comprehension."[15] Guilford says it means "discovery or rediscovery or recognition."[16] Cognition, according to Fearing, is "a structuring activity in which the organism seeks to establish a relatively stable environment in which to act."[17] There is a tendency for cognition to become more refined as a person's background of experience is enriched and he is aware of more relationships.[18]

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[14] Good, C. V., editor, Dictionary of Education, p. 291.

[15] Townsend and Burke, op. cit. p. 205.

[16] English and English, op. cit., p. 378.

[17] Townsend and Burke, op. cit., p. 202 (citing "An Examination of the Concepts of Benjamin Whorf in the Light of Theories of Perception and Cognition," by F. Fearing. From Language in Culture edited by H. Hoijer, Amer. Anthrop. Asso. Mem., No. 79, part 2, 56, No. 6, 41-81, December, 1954).

[18] Ibid, p. 205.

Klausmeier refers to cognition as the entire group of processes "whereby an individual obtains knowledge about anything--perceiving, remembering, discriminating, integrating, abstracting, generalizing, evaluating, imagining, thinking, problem-solving, and creating."[19] English and English appear to agree that it is a process which includes "perceiving, recognizing, conceiving, judging, reasoning."[20] These processes are linked and always occur in some context.

The relationship and application of the processes and conditions in learning is most evident in what has been called "transfer of learning." This is considered in the following section.

Transfer

It has been said that transfer is "a function of one's mastery of the situation and other similar situations."[21] Transfer is important in dissimilar situations where any part of the prior learning was mastered. Mastery of each new situation depends upon previous mastery and the degree to which the learner has been able to discriminate and generalize. Transfer reaches a maximum in a positive direction when a person is able to discriminate and generalize with a high degree of refinement. However, there are certain factors within the learner which aid him in

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[19] Klausmeier, H. J., Learning and Human Abilities: Educational Psychology, p. 7.

[20] English and English, op. cit., p. 92.

[21] Townsend and Burke, op. cit., p. 168.

achieving positive transfer. Some of the most important of these factors are intention to transfer, intellectual level, and understanding.[22]

Intention to transfer that which has been learned in one situation to a new learning situation can readily be seen to be important. Some authorities refer to this as attitude toward learning. A positive attitude tends to cause positive transfer and quicker learning.

The individual's intellectual level has consistently been linked to learning. As Guilford[23] has recently pointed out, there appear to be three or more faces of intellect. The important inference in his work is that intellect is a combination of major factors which, when working together, produce results. The degree to which the factors work together determines the quality of the product.

Understanding the process of grasping meanings is very important to transfer of learning. It was found by Hilgard and others that those who understood were more successful in transferring where either simple transposition or problem-solving was involved.[24] According to studies by

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[22] Ibid, p. 175.

[23] Guilford, J. P., "Three Faces of Intellect," The American Psychologist 14:469-479, August, 1959.

[24] Hilgard, E. R., Irvine, R. P., and Whipple, J. E., "Rote Memorization, Understanding, and Transfer: an Extension of Katona's Card-Trick Experiments," Journal of Experimental Psychology 46:288-292, October, 1953.

Talland[25] and by Vanderplas[26], a high quality of understanding provides the necessary sharp discriminations while also increasing the ability to generalize. In addition to the factor of understanding, habits of work, methods of attacking problems, and motivation to find transfer possibilities aid in the promotion of transfer.[27] Practice, particularly in discrimination and generalization, usually increases the transfer of learning. The primary conveyor of concepts from one learning situation to another are symbols in the form of words.[28]

The importance of transfer in learning seems to be based upon the idea that all learnings tend to merge. That which is learned is assimilated in relation to past experiences and affects new experiences. As each person has different experiences; so his learnings are likewise different.[29] Therefore, learnings should be considered in relation to one another whenever possible.

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[25] Talland, G. A., "Criteria in Conceptual Transposition," The American Journal of Psychology 70:263-267, June, 1957.

[26] Vanderplas, J. M., "Transfer of Training and Its Relation to Perceptual Learning and Recognition," Psychological Review 65:375-385, November, 1958.

[27] Seagoe, M. V., A Teacher's Guide to the Learning Process, p. 237.

[28] Townsend and Burke, op. cit., p. 176.

[29] Humphreys, L. G., "Transfer of Training in General Education," The Journal of General Education 5:213-214, April, 1951.

Summary

Most authorities in the field of learning indicate that there are specific mental processes which are of importance to the learning process. These processes are known as: (1) the process of memory, (2) the process of discrimination, (3) the process of generalization, (4) the process of perception, (5) the process of cognition, and (6) the process of transfer.

The processes of memory, discrimination, perception, and cognition operate in unison, whereas for effective learning, the processes of generalization and transfer operate only in dependence on the other four. The formation of meaningful major ideas rests in the ability to associate the images of other ideas already in the mind. This ability is dependent upon all six processes considered important in learning.

In the operation of these mental processes, graphical representation through figural, symbolic, and semantic content is an important tool which enables the learner to fix major ideas more permanently in the mind. The nature of graphical representation and its relationship to learning through the major processes of concept formation, communication, and creativity are indicated in the following chapter.

CHAPTER IV

NATURE OF GRAPHICAL REPRESENTATION AND ITS RELATIONSHIP TO LEARNING

The nature of graphical representation has been described mostly in connection with the fields of art and architecture. Only during the present century has it been used as a medium for translating statistics into visual forms.[1] Marshall stated that "up to the year 1910 there was not a book in the English language treating of the art of graphical representation."[2]

The importance of graphical representation in education has been emphasized primarily by those interested in audio-visual procedures although the military services focused attention on it through their training programs during and after World War II. More specifically, the importance of graphical representation in the learning process has been the subject of only a small amount of literature, most of which has been written during the last decade.

Definitions of important terms are given next so that the relationship of graphical representation to learning is clarified.

Definition of Terms

The original Greek word "graphikos" referred to drawing and painting

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[1]Lutz, R. R., Graphic Presentation Simplified, p. 1.

[2]Marshall, W. D., Graphical Methods, p. v.

and "graphein" means to write and represent by means of lines.[3] In mechanical drawing, to which "graphics" is often applied, drafting is credited with being a universal--a graphic--language in terms of which the industrial history of the United States has been written.[4] This language is a means of conveying thoughts and ideas in a technical world.[5]

Webster defines graphical as "well delineated; vividly described; . . ." and "of pertaining to the arts of painting, drawing, engraving, and any other arts which pertain to the expression of ideas by means of lines, marks, or characters impressed on a surface."[6] Representation is defined as "a likeness, picture, model, image, or other reproduction. . ."[7]

The term graphical representation is used by the writer to refer to well delineated, vividly described representations of ideas in the learning process. It is intended that the term refer to much more than that which is commonly called graphics, the art of science or drawing, and is intended to include the relationship to learning of other media in addition to that which can be referred to inclusively by the term graphic materials--charts, diagrams, graphs, posters, cartoons, comics, or maps and

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[3]Wittich, W. A., and Schuller, C. F., Audio-Visual Materials--Their Nature and Use, p. 91.

[4]Spencer, H. C., Basic Technical Drawing, p. 2.

[5]McCabe, F. T., Keith, C. W., and Farnham, W. E., Mechanical Drafting Essentials, p. 1.

[6]Bethel, J. P., general editor, Webster's New Collegiate Dictionary, p. 361.

[7]Ibid, p. 718.

globes. Specifically, for the purpose of this study, graphical representation is considered the vivid expression of ideas through the use of three general types of material for which authors use various names. In this study the types of material which are considered to be the tools of graphical representation are identified as: (1) concrete, (2) symbolic, and (3) verbal.

Concrete material is that which represents itself. It may present visual or auditory clues, or be perceived in terms of any of the other senses, but never represents anything other than itself. Pictorial representation is included in this category.

Symbolic material is composed of tokens, emblems, marks, badges, devices, characters, digits, letters, and other signs. Symbols have conventional meaning and are usually organized in general systems. Written ideas which create a picture in the mind are considered in this type of material.

Verbal material represents through spoken means. No examples are possible when referring to this type of representative material since it must remain wholly oral, unwritten, and word-for-word.

Since there appears to be general agreement, as revealed in pertinent literature, that the clear expression of ideas is important to learning, the following section is devoted to the relationship of graphical representation to concept formation.

Graphical Representation in Concept Formation

Concept formation is an important part of the thinking process. Thinking results, according to Dewey,[8] when ideas are considered in a step-by-step order aimed at a conclusion based on a belief. Apparently, questioning is inferred in thinking and concepts are developed through questioning. The process of concept formation leads to generalization, to economical intellectual efforts, to standardization of knowledge, and to a carry-over of ideas to new situations.[9]

Woodruff proposed that we have a concept "when through experience we get a mental picture in our minds of the objects or forces which make up our world."[10] A concept may also be thought of as an idea which, when associated with experience, results in a mental picture.

A study of concept formation conducted by Smoke showed that the process of concept formation is complex as it involves grouping, insight, and use of hypotheses. The study specifically noted the following:

> 1. The process of concept formation appears to involve grouping. The learner tends to envisage certain stimulus patterns as constituting a group to which any given stimulus pattern does or does not belong.
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> 2. Insightful behavior seems to be present in at least some instances of concept formation.

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[8] Dewey, John, How We Think, 301 pp.

[9] Franks, Milford, "Learning Through Concept Development: The Goal of Supervision and Instruction," Montana Education 39:9, April, 1963.

[10] Woodruff, A. D., Basic Concepts of Teaching, p. 64.

> 3. Concept formation, like most "thinking," appears to involve the formulation, testing, and acceptance or rejection of hypotheses. . .
>
> 4. One may have a concept and yet be quite unable to give an accurate verbal formulation of it. . .[11]

Early studies of concept formation cited by Vinacke[12] implied that concepts were an accumulation of experience "with some kind of resulting organization" and "the labeling, and manipulation, and application of aspects of this organization by means of symbols."[13] This process can make use of past experience by identification and classification of objects and by symbolic manipulation. A concept such as that of "cat" usually represents no particular cat but, rather, "cats" in general. By means of symbols, particularly words, gestures, or images, concepts can be manipulated in many complex ways.[14]

The early theories of concept formation leaned heavily on stimulus-response conditioning and generalization. This was brought out by Postman as follows:

> The greater the similarity between the conditioned stimulus and the test stimulus, the higher the probability that the response will occur. In studies of conditioning, similarity has usually been

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[11] Smoke, K. L., "An Objective Study of Concept Formation," in Harris, T. L., and Schwahn, W. E., Selected Readings on the Learning Process, p. 142.

[12] Vinacke, W. E., The Psychology of Thinking, pp. 97-135.

[13] Ibid, p. 105.

[14] Ibid, pp. 105-106.

> defined in terms of distances along a sensory continuum such as loudness or brightness. When the principle is applied to concept formation, the similarity responsible for evocation of the correct response resides in the common relevant feature. Thus concept formation can be treated as a special case of a general law of learning. An important implication of this analysis is that the successful formation of a concept is not dependent on an act of insight or the perception of a relationship by the learner. This is not to say that concept formation may not be accompanied by such perceptual events. Rather, the assertion is that the perception of relationships is not a necessary condition of concept formation.[15]

However, newer experimental analyses, largely the work of Kendler and Kendler,[16] have made it clear that a simple stimulus-response model cannot handle all the factors involved in concept formation. As indicated by Postman, they have developed a modified model which shows a more complex chain of events.

> According to a mediational model, the external stimulus and the overt response are terminal points of a more complex chain of events. The external stimulus (S) evokes an implicit response (r) which embodies the discrimination or classification of the stimulus by the learner. The occurrence of the implicit response changes, or adds to, the stimulation by providing an implicit cue (s) to which the overt response (R) is associated. Thus, the formula for the single-unit model is S-R, that for the mediational model is S-r-s-R.[17]

The mediational chains make it possible to assume that responses are associated both with specific physical stimuli and the "meanings"

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[15] Postman, Leo, "Recent Developments in the Experimental Analysis of Learning and Concept Formation," in Waetjen, W. B., editor, New Dimensions in Learning, pp. 56-57.

[16] Kendler, H. H., and Kendler, T. S., "Vertical and Horizontal Processes in Problem Solving," Psychological Review 69:1-16, January, 1962.

[17] Postman, op. cit., p. 58.

belonging to those stimuli. Also, mediational chains have the status of symbolic constructs.[18]

Other theoretical points of view regarding concept formation are under investigation. Several researchers are currently studying the quantitative relationships between the amounts and patterns of information communicated and the speed of concept formation. Four major conclusions related to past studies of this type, notably by Archer and Bourne,[19] have been reported by Postman:

> 1. The greater the amount of relevant information required for solution, the slower is the acquisition of concepts. . . . As the amount of material to be learned and recalled increases, so do the opportunities for interference among the units of the task.
>
> 2. The greater the amount of irrelevant information, . . . the lower is the identification of concepts. Irrelevant dimensions add to the informational load which the subject must process and enhance the opportunities for interference.
>
> 3. While the use of redundant (i.e., correlated) dimensions does not increase the amount of information, it increases the efficiency of concept formation when the redundant information is relevant. . . . The findings point to the role of perceptual factors in concept learning since redundancy may be assumed to enhance the perceptual saliency of the relevant or irrelevant dimensions.

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[18] Ibid.

[19] Archer, E. J., Bourne, L. E., Jr., and Brown, F. G., "Concept Identification as a Function of Irrelevant Information and Instructions," Journal of Experimental Psychology 49:153-164, March, 1955; Bourne, L. E., Jr., and Pendleton, R. B., "Concept Identification as a Function of Completeness and Probability of Information Feedback," Journal of Experimental Psychology 56:413-420, November, 1958; Bourne, L. E., Jr., and Haygood, R. C., "The Role of Stimulus Redundancy in Concept Identification," Journal of Experimental Psychology 58:232-238, March, 1959.

> 4. The specific conditions of "feedback" (information about the correctness or response to each instance) are important, . . . First, the longer the delay in the feedback, the slower is the progress to solution. . . . Secondly, the more complete the feedback, the faster is concept attainment. . . . Finally, the more frequently such feedback is given the more rapid will be the rate of concept attainment. . . . The specific conditions of feedback assume increasing importance as the complexity of the task becomes greater, i.e., as more relevant and irrelevant information must be discriminated and assimilated.[20]

Apparently the process of concept formation is not yet clearly understood and many studies are underway which may reveal important data for future use. Authorities seem to agree that concept formation is strongly related to past experience and that future studies need to be made in an attempt to determine relationships between ways of presenting material and the resulting performance of the learner. Each concept has many aspects which link sensory impressions through representational systems.

It is agreed that concepts have an important function in the learning process. This point was emphasized by Burtis and LeMay who stated: "We cannot and do not think in terms of symbols such as words. Rather, our minds usually conceive thoughts in terms of pictures--visualizations."[21] If it is true, as some individuals have emphasized, that meanings cannot be transmitted but meaningful sets of symbols can, the relationship of graphical representation to concept formation becomes more clear.[22]

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[20]Postman, op. cit., p. 64.

[21]Burtis, E. F., and LeMay, J. E., They SEE What You Mean, p. 11.

[22]Woodruff, op. cit., p. 65.

The review of literature indicated that concept formation was related to the process of transmitting ideas, commonly termed communication. The following section of this chapter deals with the ways in which communication takes place through graphical representation.

Graphical Representation and Communication

It is widely recognized that language is a social tool which must be mastered before an individual can participate in the culture of his land.[23] Lindesmith and Strauss stressed this relationship of language to society when they said, "It is clear that the language learned by the child is not primarily his language so much as it is his society's."[24] Yet, the importance of the manner of communicating thoughts is not fully understood. In advertising, as Muller-Brockmann[25] points out, the success of an exhibit depends largely on the designer's ability to organize and present the theme clearly and coherently. Unless the designer can visualize a finished product in its final setting, he cannot even guess how effective it will be in transmitting his ideas to the observer.

There is a parallel in education in the case of spelling. Toohy emphasized that confusion has resulted when great reliance was placed on rules in spelling, therefore we are now putting emphasis on "correct

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[23]Hullfish, H. G., and Smith, P. G., Reflective Thinking: The Method of Education, p. 137.

[24]Lindesmith, A. R., and Strauss, A. L., Social Psychology, p. 47.

[25]Muller-Brockmann, J., The Graphic Artist and His Design Problems, p. 96.

mental images."[26] Further indication of the receiver's role in the communication process is given by Anderson and Dearborn. They describe as follows an incident emphasizing that the language used in communicating an idea must be associated with the listener's way of expressing the idea.

> A boy in the first grade was reading aloud monotonously and without any show of interest or concern about the sentence: "Johnny does not have a dog." The situation suddenly took a turn for the better when the teacher explained that what the sentence meant was "Johnny done got no dog." Now that <u>was</u> too bad, he <u>should</u> have one, and there was plenty of overt expressions of sympathy and general agreement that under the circumstances Johnny should by all means have a dog.[27]

Still another indication of the importance of getting ideas transmitted to the learners on their own levels of understanding was the instructional training program of the armed forces during the last war. Authors of instructional materials were encouraged to get down to the level of the enlisted personnel. It is said that "the writer of a handbook on radar operation had included in his copy the sentence: 'On certain nights reception is awful.' The typist questioned whether the word "awful" was good usage. The author of this frightful blunder exclaimed, "You're right, change it to, ' On certain nights the reception is lousy.'"[28]

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[26]Toohy, Elizabeth, "Learning to Spell is Learning to See," <u>The Education Digest</u> 28:46, September, 1962.

[27]Anderson, I. H., and Dearborn, W. F., <u>The Psychology of Teaching Reading</u>, p. 145.

[28]<u>Ibid</u>, p. 146.

Before the meaning of a communication can be understood by the receiver, it must be seen by him in both its own dimensions and in its proper significance.[29] Verbal expressions are always converted by the receiving mind into a visualization which is dependent upon the receiver's understanding of the words used.[30]

One purpose of communication which depends upon the accurate transmittal of thought is the stimulation of motivation. Teachers, employers, government officials, and others depend greatly upon their ability to stimulate individuals for the success of their endeavors. Much of Sir Winston Churchill's influence upon the people of England during World War II was related to his ability to verbally communicate ideas simply, clearly, and forcefully.[31] For emphasis, the following is quoted from his address given in the House of Commons on June 4, 1940:

> We shall defend our Island, whatever the cost may be; we shall fight on the beaches, we shall fight on the landing grounds,

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[29] King, E. J., World Perspectives in Education, p. 23.

[30] Burtis and LeMay, op. cit., p. 11.

[31] In an earlier section of this chapter in which terms were defined, it was stated that verbal material represents through spoken means and that it must remain wholly oral, unwritten, and word-for-word. When the material is changed from the oral form to written it becomes symbolic. Therefore, it is impossible to give a written example of a verbal communication. The reader may from time-to-time, however, find that a written example is referred to in relation to the verbal. When such is the case, it is intended that the quotation be thought of in its original oral form including such attributes as pitch or tone of voice.

we shall fight in the fields and in the streets, we shall fight in the hills. We shall never surrender.[32]

Such alliterative style as the preceding illustrates the way in which thoughts can be communicated graphically to bring an image to the mind of the listener. Poets use language in ways which cause relatively similar perception among listeners who have had similar prior experiences. The poem, "Winds of Fate," by Wilcox is an outstanding example of the use of words in presenting a concept graphically.

One ship drives east and another drives west,
While the self-same breezes blow;
It's the set of the sails and not the gales,
That bids them where to go.[33]

Whether the poem is given orally (verbal representation) or in written form (symbolic representation), the receiving mind visualizes, in terms of past experiences, the component ideas which form the total concept. Dale[34] has suggested that experience can be represented by a "cone of experience." This cone is entirely symbolic as may be seen by looking at Figure 2.[35] However, it represents all three types of representational material, verbal, symbolic, and concrete, in an order from

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[32]Mercer, F. A., and Fraser, G. L., editors, Modern Publicity in War, p. 27.

[33]Wilcox, E. W., "Winds of Fate," in The World's Best-Loved Poems, pp. 150-151.

[34]Dale, Edgar, Audio-Visual Methods in Teaching, pp. 42-43.

[35]Ibid, p. 42. Used by permission of the publisher, Holt, Rinehart & Winston, Inc., New York.

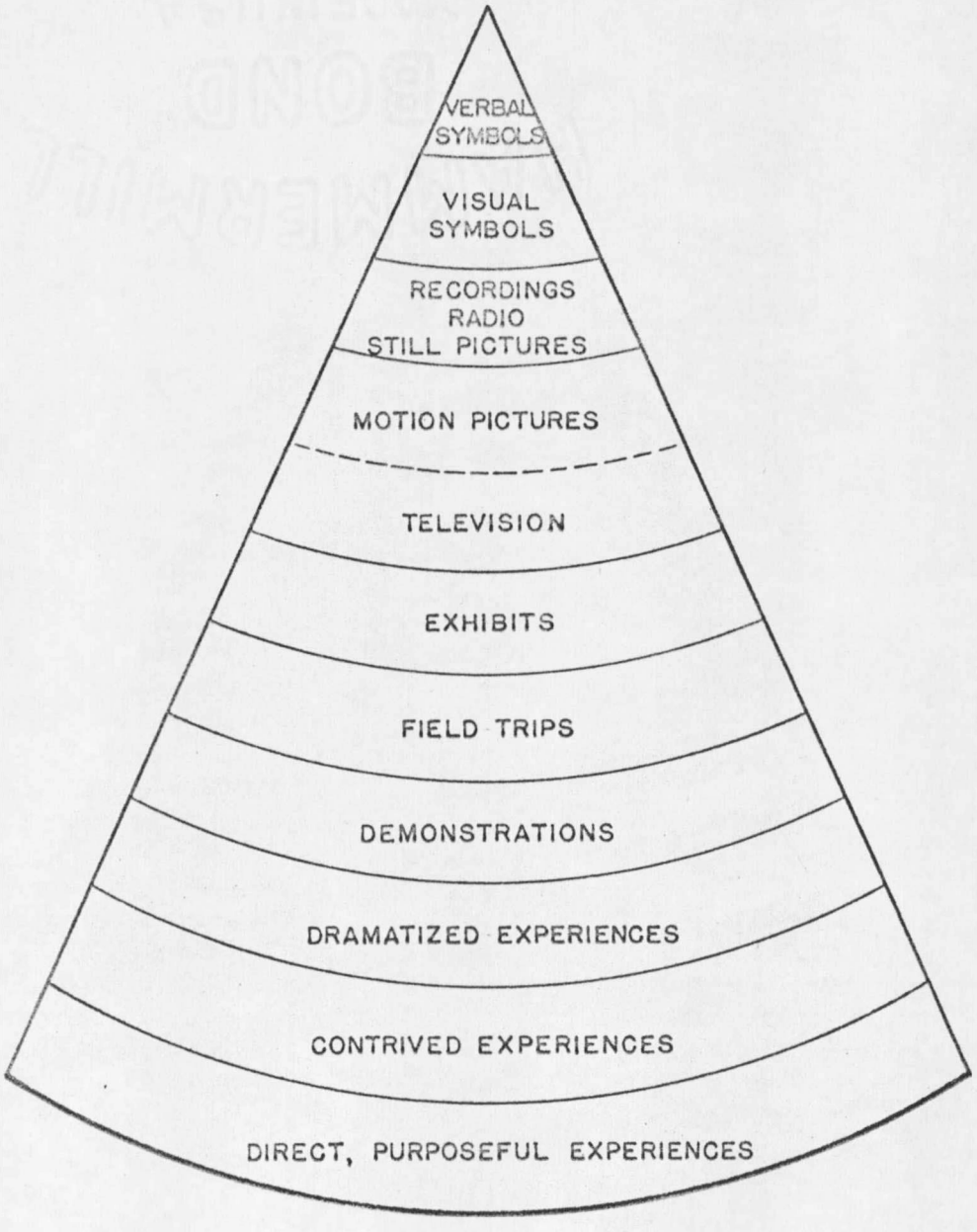

FIGURE 2. THE "CONE OF EXPERIENCE"

top to bottom which is from the most abstract to the most direct. In this instance, Dale has used a symbolic representation as an aid in communicating his idea of the inter-relationships of the types of audio-visual materials and their relative positions in the learning process.

The symbolic type of graphical representation far exceeds the verbal type in usage. Symbols, including letters, have conventional meaning and are usually organized in general systems or patterns. For example, when a reader encounters a strange word he responds to the general appearance of the word, not to its letters. If his vocabulary includes a word with a similar pattern and he can recall it, he may be able to read the word even though it has no meaning to him.[36] This seems to lend support to the idea that symbolic representation is important to communication. More important, it indicates that the symbols used in communication must be understood by the receiving mind in order that the communicator's thought can be interpreted meaningfully.

In everyday life symbols are used constantly. They very often have little resemblance to the thing they represent. In an abstract sense, a smile is a symbol for pleasure or a pin may symbolize membership in a club.[37] Comprehension or understanding of the message symbolized in such abstract instances must be complete or the receiver will not perceive

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[36] Cronbach, L. J., Educational Psychology, p. 278.

[37] Willerding, M. E., "What is the New Mathematics?" California Journal of Elementary Education 30:5, August, 1961.

and/or react appropriately. Bloom[38] associates comprehension and behavior and states that there are three types of comprehension behavior: (1) translation, (2) interpretation, and (3) extrapolation.

He interprets translation to mean "that an individual can put a communication into other language, into other terms, or into another form of communication."[39] Sometimes an abstract idea may need to be restated in more familiar terms. Occasionally, a long communication may have to be abbreviated or made more abstract to facilitate thinking.

The second type of comprehension behavior, interpretation, "involves dealing with a communication as a configuration of ideas whose comprehension may require a reordering of the ideas into a new configuration in the mind of the individual."[40] Inferences, generalizations, or summarizations may be based on interpretation behavior.

Extrapolation, the third type of comprehension behavior, concerns "the making of estimates or predictions based on understanding of the trends, tendencies, or conditions described in the communication."[41] Extrapolation, in almost all cases, must be regarded as an inference with some degree of probability but rarely a certainty.[42]

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[38]Bloom, B. S., Taxonomy of Educational Objectives, Handbook I, pp. 89-90.

[39]Ibid, p. 89.

[40]Ibid, p. 90.

[41]Ibid.

[42]Ibid, p. 95.

Another theory associating perception with behavior is that of McFee.[43] She has developed the "perception--delineation" theory which is useful in identifying the process in which a person perceives his visual world and communicates his responses. More specifically, McFee has stated her theory as being used to "identify the process in which a child or an adult (1) is prepared to perceive his visual world, (2) is affected by his psychological environment, (3) organizes the information he receives, and (4) creates or borrows symbols to communicate his responses."[44] The act of producing the symbols is defined as the delineation.

The four points stated in McFee's theory are not considered by her to be separate behaviors within the child, "but rather 'points' on which to focus our attention."[45] She illustrates that idea in the following quotation:

> A child who is drawing a puppy is not first "perceiving," then "delineating." He is instead perceiving--delineating, that is, performing a complex action involving what he has learned in the past, how he feels, and how he is organizing what he sees.[46]

It appears that studies in communication through graphical representation, as well as in learning, bear out the belief that prior learnings

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[43] McFee, J. K., Preparation for Art, pp. 38-45.

[44] Ibid, p. 38.

[45] Ibid.

[46] Ibid.

have an important bearing on current learning activities. An interesting study on the learned habit of assuming that a certain pattern of lines means a certain shape was done by Lawrence and is reported by McFee:

> At the Hanover Institute there is a wall with three peepholes. People who look through the holes see cubes, and all the cubes look alike. Yet when they go around to the back of the wall they see that they have been looking at (1) a wire cube-shape, (2) a drawing of a cube on a board, and (3) a construction of wires and strings that does not resemble a cube from any viewpoint except that of the peephole.[47]

This illustration reveals that visual perceptions are not always adequate by themselves and, unless associated with other types of communication, do not give us all the information that we need regarding the exact nature of our environment.[48]

In concluding this section on the relationship of graphical representation and communication, the writer believes it essential to emphasize that knowledge cannot be transmitted literally. Verbal, symbolic, or concrete graphical representations alone cannot convey an idea from one person to another, but memories and associations may be stimulated through the representations.[49] Thus, in the formation of ideas, which is the goal

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[47] Ibid, p. 45 (citing Studies in Human Behavior, pp. 67-69, by Merle Lawrence, Princeton University Press, Princeton, 1949).

[48] Ibid, p. 46.

[49] Townsend and Burke, op. cit., p. 236.

of instruction, use of the symbol system reaches its highest level.[50]

Just as an artist must have an idea of how he can best communicate a message through the various media available, an educator must have an idea of the most effective means available to him to help students achieve maximum learning.

Davis[51] predicts that there will be less emphasis on memory and more on creative thinking in future years in colleges. Other literature tends to support this prediction and broaden it to include all levels and areas of education. Even though it seems, as Parnes states, that "we still know little about what 'creativity' really is,"[52] it is reported to be important in general education and to be related to graphical representation. In the following section, the relationship of creativity and graphical representation is shown.

Graphical Representation and Creative Expression

Creativity, the creative process, and creative expression are terms which the literature reveals are becoming more frequently used in education. As in the case of other terms discussed, authorities do not agree on a specific definition of any of them. However, these authorities concur

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[50] Ibid, p. 248.

[51] Davis, P. H., "Changes are Coming in the Colleges," The Journal of Higher Education 33:143, March, 1962.

[52] Parnes, S. J., "Education and Creativity," Teachers College Record 64:338, January, 1963.

in the idea that creativity is important to society. Taylor, while emphasizing that much further study needs to be done on creativity, indicated that "the creative process in its greatest degree is one of the highest, if not the highest, activity to which man can aspire . . ."[53] A brief overview of ideas about the nature of creativity follows.

Nature of creativity. Torrance[54] drew from over five hundred research reports on creative thinking before concluding that creativity may be defined either as a process or a product, or in terms of an environmental condition or a personality. In his writings, he chose to define creativity as "the process of sensing problems or gaps in information, forming ideas or hypotheses, testing and modifying these hypotheses, and communicating the results."[55] Ghiselin appears to agree but has used a different wording to express his interpretation of the creative process. He says, "The creative process is the process of change, of development, of evolution, in the organization of subjective life."[56]

When creativity is defined as a process, thought must also be given to the many kinds of products--verbal, symbolic, and concrete. For those

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[53]Taylor, C. W., "A Tentative Description of the Creative Individual," in Human Variability & Learning, p. 69.

[54]Torrance, E. P., Creativity, 32 pp.

[55]Ibid, p. 4; almost the same definition appears in his "Conditions for Creative Learning," Childhood Education 39:367, April, 1963.

[56]Ghiselin, Brewster, The Creative Process, p. 2.

who define creativity as a product, the results of the process are, according to Torrance, "embodied in an invention, a scientific theory, an improved product, a literary work, . . . or the like."[57]

Hill, Mackintosh, and Randall favor the idea that creativity is "primarily a point of view, a way of feeling about things, situations, people, . . . and a way of responding to these things in one's environment."[58] Osborn believes that creativity is applied imagination; that although for example, science is "classified knowledge," it has come from men's hunches--"from their thinking up countless alternatives--from their dreaming up new ways and new devices by which to test their guesses."[59] Several other authorities[60] seem to indicate that creative activity may result incidentally in problem solving but that satisfaction of the internal needs of the creator is a most important product.

Traditionally, creativity has been associated with the graphic arts, music, literary masterpieces, and inventions. Today, the idea that everyone is creative, is becoming more widely accepted. As one watches youngsters in kindergarten it is apparent that they have eagerness, curiosity, capacity for wonder and puzzlement, spontaneity, spirit

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[57] Torrance, Creativity, op. cit., p. 4.

[58] Hill, Wilhelmina; Mackintosh, H. K.; and Randall, Arne, How Children Can Be Creative, p. 2.

[59] Osborn, A. F., Applied Imagination, p. 13.

[60] Dewey, John, How We Think, 301 pp.; Gotshalk, D. W., Art and the Social Order, 253 pp.; Vinacke, W. E., The Psychology of Thinking, pp. 238-261.

of adventure, imagination, and sensitivity to and fascination for the world in which they live.[61] Children receive many impressions from their environment which result in various thoughts and feelings. However, for the child to achieve "the totality of experience" it is necessary that he express those thoughts and feelings in some form.[62]

Creative expression has been discussed by Phillips and others[63] in terms of the areas or fields of social science, science, and art. The creative process was examined and discussed in 1958 by thirteen leading representatives from business and industry, education, the sciences, engineering and the arts and their expressions of its nature are given in Creativity, edited by Smith.[64] One of the authors, the noted social psychologist Dr. Irving A. Taylor, said that it was misleading to distinguish between types of creativity such as scientific or artistic but that it varies in depth and scope. Following are his descriptions of the five levels of creativity, expressive, productive, inventive, innovative, and emergentive:

> The first level can be called expressive creativity, the most fundamental form, involving independent expression where skills, originality, and the quality of the product are unimportant. The spontaneous drawings of children are examples of

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[61] Association for Supervision and Curriculum Development, Perceiving, Behaving, Becoming, pp. 142-143.

[62] Heffernan, Helen, "You Can Release Creativity in Children" California Journal of Elementary Education 29:184, February, 1961.

[63] Phillips, G. D., and others, "Education Through Creative Expression," Journal of Education 145:1-66, February, 1963.

[64] Smith, Paul, editor, Creativity, 210 pp.

> expressive creativity. The important characteristics are spontaneity and freedom which form the foundation upon which more creative talents develop. . . .
>
> Satisfaction in expressing may result in obtaining the necessary skills to produce objects showing mastery over some portion of the environment. This may be called the period or level of productive creativity. The artistic or scientific product is creative in that a new level of proficiency is achieved by an individual although such products may not be stylistically discernible from the products of others. . . . Heightened realism, objectivity and completeness characterize productive creativity, . . .
>
> When ingenuity is displayed with materials, techniques, and methods, inventive creativity is operative. Such inventive talent involves flexibility in perceiving new and unusual relationships between previously separated parts. It does not directly contribute to new basic ideas, however, which is a function of higher order creativity, but to new uses of old parts. The important characteristics are invention and discovery. . . .
>
> A fourth level, encompassing a number of definitions, can be called innovative creativity. When the basic assumptions of a field are sufficiently understood so that improvement through modification is possible, innovative creativity is involved. To penetrate to and understand basic foundation principles requires a great deal of abstract conceptualizing skills. . . .
>
> In rare instances, an entirely new principle or assumption, around which new schools flourish, emerges at a most fundamental and abstract level. Thus, this highest form of creative power we may call emergentive creativity. The scope of the formulations at this level are reflected in the works of Einstein and Freud in the scientific field, and Picasso and Wright in the field of art. . . . .[65]

Whether creativity is a process or a product, or is comprised of types or of levels, appears largely to be a matter of opinion. However, authorities agree that creativity is related to the learning process and is important to individuals and societies. It is also thought by many

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[65]Taylor, I. A., "The Nature of the Creative Process," in Creativity, pp. 55-60.

authorities that creativity has an important relationship to graphical representation.

Relation of creative expression to graphical representation. As life becomes more complex and routine tasks become more commonly turned over to machines, creative ability will become more important.[66] Since creative expression "grows out of experience"[67] or, in some instances, "depends upon inspiration. . . . from personal reaction to a vital experience,"[68] the importance of experience has been acknowledged.

Ghiselin has stated that "human experience is very persistently configurated."[69] He believes that to be creative a person must set aside from the mind to a point of insignificance all limiting usual configurations. Then the mind can create from "an indeterminate plenitude, elusive excitements and multitudinous shifting imitations of idea and imagery."[70]

The words he used in his statements, imagery (perception), idea (concept), and configuration (representation) are all related to the definition and explanation of graphical representation and are found

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[66] Whiting, C. S., Creative Thinking, p. 160.

[67] Hill, Mackintosh, and Randall, op. cit., p. 4.

[68] Boylston, E. R., Creative Expression with Crayons, pp. 41-42.

[69] Ghiselin, Brewster, "The Creative Process and Its Relation to the Identification of Creative Talent," in Scientific Creativity: Its Recognition and Development, p. 361.

[70] Ibid.

throughout other writings and studies on the creative process. Lowenfeld, noted for his many studies in creativity, says without qualification that "the artistic representation of visual impressions always starts from optical perception."[71] However, according to him, occasionally the importance of the optical sensation recedes and tactile sensations become more important. Finally, these tactile sensations synthesize with internal subjective experiences forming "haptic perception."[72] This haptic perception, being bound very closely to the self, is intensely subjective and results in formal representations distinguishable from representations of that which is visually perceived.[73]

At all times, creativity appears to follow perception, is related to experience, and is achieved through representation of a graphical nature. The original products of creativity, the ideas in the mind of the creator, can be transmitted to others only through the process of communication and, if they are to be understood clearly by the receiving mind, must be graphically represented.

Each term which is used in describing another must be clearly defined before understanding results. For example, how many persons have a graphic concept of the term knowledge? Webster defines knowledge as

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[71] Lowenfeld, Viktor, The Nature of Creative Activity, p. 82.

[72] Ibid.

[73] Ibid, p. 86.

"Acquaintance with fact; . . . clear perception of truth; . . . learning; . . ."[74] Thus it is possible that one person might refer to the outcome of learning as "knowledge," meaning "the clear perception of truth." Yet, another person hearing the statement, might not understand what was meant because to him "knowledge" means "learning." In the latter instance, the statement has been interpreted as: "The outcome of learning is learning." This communication, by being unclear, would not cause a new picture to be perceived in the mind of the receiver and hence, understanding would not result.

On the other hand, if the concept of the word, knowledge, is graphically communicated, the original meaning and the interpreted meaning will more closely resemble each other. In communicating all ideas, thinking must occur. The communicator must think in terms related to those known by the receiver; the receiver must think in the terms he knows, relating and associating, so that he may finally perceive the meaning of the communicator. Once the proper meaning is perceived, it is possible for the individual to generalize from the learned concepts in a way that will improve his ability to associate one idea with another.

Since learning is largely related to associations of ideas and since associational learning is "mainly verbal, abstract, and symbolic,"[75] it follows that the learner must be encouraged to think about the relationships

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[74] Bethel, op. cit., p. 466.

[75] Skinner, C. E., Essentials of Educational Psychology, p. 273.

among ideas. Robinson noted this need to emphasize thinking when he said, "the pupil who is given a vast body of facts or answers is sometimes kept too busy 'learning' to have any time for thinking."[76] Actually, it appears that learning does not take place until the learner has creatively processed the ideas (thought about them) and perceived the associations or relationships in terms of a mind picture which may be called a graphical representation.

Summary

When effective learning takes place, the behavior of the learner changes. The teacher's understanding of all the factors and processes involved in learning does not necessarily bring about desirable change. However, when the teacher understands the factors and processes involved in learning and, in addition, the basic principles of learning--that it should be an active process, meaningful, useful, interesting, individualized, satisfying, and unified[77] --a situation exists which is extremely favorable to learning.

Both learning and graphical representation involve the three major processes of concept formation, communication, and creativity. Concept formation is essential in order for a person to understand that which goes on about him. Mere exposure to information is not often meaningful and

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[76] Robinson, Don, "Scraps from a Teacher's Notebook, Phi Delta Kappan 45:54, October, 1963.

[77] Clement, S. L., "Seven Principles of Learning," The Clearing House, 36:23-26, September, 1961.

usually does not result in either permanent learning or the ability to transfer ideas from one situation to another. Until the ability to mentally transfer ideas has been developed, it is difficult for a person to effectively make use of the second major process, communication. In effect, a person must be capable of graphically organizing, associating, and representing his own thoughts before he can communicate his ideas to others. It is the creative process which makes possible a wide range of ways for effectively representing and communicating organized thoughts.

As a result of the review of literature described in the foregoing chapters, it appeared that the graphical representation of major ideas with emphasis on the factors essential for learning in a classroom situation would result in the students' achievement of a better general knowledge of the subject matter covered. A classroom experiment was designed and conducted to determine the importance of graphical representation in a classroom learning situation. This experimental study is reported in the next chapter.

CHAPTER V

THE EXPERIMENTAL STUDY

Since the review of literature clearly indicated that graphical representation was related to and important in learning, the experimental part of this investigation was designed to assess the importance of the use of graphical representation in teaching a college course.

Setting for the Study

The setting for the study was the course, Education 302, Educational Psychology, offered during winter quarter, 1965, by the Department of Education at Montana State College. This course is the first of the series of professional education courses required for all teacher education candidates at Montana State College. It is open to other students on an elective basis. Two professors from the Department of Education were assigned to teach the course.

Comparison of the Influence of the Professors on Learning in Educational Psychology

Because two professors were involved in teaching the educational psychology classes, it was necessary to determine the comparative influence on learning achievement of their personal characteristics and instruction. The task of gathering data for this comparison was done during spring and winter quarters, 1964.

One professor taught the course during spring quarter, 1964, to 131 undergraduate students designated as Group A. The other professor

taught the course during autumn quarter, 1964, to 95 undergraduate students known as Group B.

Both professors taught in their usual way, using procedures and materials commonly used in any college classroom situation. The classes met for three 50-minute periods each week during the quarter. The course was designed and taught with six major objectives in mind. The objectives were the development of (1) an understanding of how efficient learning takes place, (2) an understanding of the importance of learning in teacher planning, (3) the ability to apply learning principles in planning for important teaching-learning situations, (4) a sensitivity to the importance of transfer of learning in general education situations, (5) insights into improvement of the thinking ability of youth, and (6) a functional vocabulary in the fields of learning and planning.

The students who registered in Groups A and B were compared on the basis of the following criteria:

1. Credits passed as of the end of the quarter preceding their registration in the course in educational psychology.

2. Cumulative grade point average as of the end of the quarter preceding their registration in the course in educational psychology.

3. A. C. E. "Q" and "L" raw scores.[1] This refers to the American Council on Education Psychological Examination for College Freshmen, 1954

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[1]Raw score data was obtained from the Montana State College Testing and Counseling Service which administers the test to all students during their first quarter in residence at Montana State College.

edition. The "Q" raw score is based on "Arithmetic," 20 items, "Figure Analogies," 30 items, and "Number Series," 30 items. The "L" raw score is based on "Same-opposite," 50 items, "Completion," 30 items, and "Verbal Analogies," 40 items.

4. The Minnesota Scholastic Aptitude Test raw score.[2] This test (also referred to in this study as the MSAT) is a short form of The Ohio State University Psychological Test. It is composed of 15 same-as or opposite-of items, 30 word analogy items, and 32 reading comprehension items based on five paragraphs. Of the five paragraphs, three deal with natural science, one with social science, and one with physical science.

The data obtained were programmed for the IBM 1620 electronic computor and examined statistically to determine the similarity or difference between the groups of students. The usual parametric analysis of variance test (F-test)[3] and the test for analysis of difference between means (t-test)[4] were used since it was assumed that the observations were

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[2] Ibid.

[3] The F-test is defined as follows:

$$F = \frac{s_1^2}{s_2^2}$$

where s_1^2 is the larger of the two sample variances and s_2^2 is the smaller variance. (Downie, N. M., and Heath, R. W., Basic Statistical Methods, p. 134.)

[4] The t-test is defined as follows:

$$t = \frac{X_1 - X_2}{s_{d_x}}$$

where X_1 and X_2 are the means and s_{d_x} is the standard error of the difference between the two means. (Ibid, p. 135.)

independent, that the population was normally distributed and homogeneous in variance, and that the measurement was on an interval scale. A significance level of .01 was set for all statistical tests used in this study because a high confidence level was desired. That is, it was desired to set a level which would assure that hypotheses would be rejected in error not more than one time in a hundred.

As shown in Table 1, there was no significant difference between Groups A and B on the basis of cumulative grade point average, Minnesota Scholastic Aptitude Test raw scores, and the American Council on Education Psychological Examination "Q" and "L" raw scores. A significant difference of 10.41 credits was shown to exist between the groups on the basis of credits passed. (See Table 1.) A difference was expected because Group B students took the course in educational psychology one quarter later in their curriculum sequence than did students in Group A.

The importance of credits passed on final achievement was measured by a group of 30 objective test items[5] which both professors agreed to as a valid measure of learning in the course in educational psychology. In order to analyze the test results, students in Group A were paired and a

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[5]The objective test items were taken from the following source and used by permission of the publisher: Mouly, G. J., and Walton, L. E., Schaum's Outline of Test Items in Education, Schaum Publishing Co., New York. See Appendix A.

TABLE 1. ANALYSES OF VARIANCE AND DIFFERENCE BETWEEN CREDITS PASSED, CUMULATIVE GRADE POINT AVERAGE, MINNESOTA SCHOLASTIC APTITUDE TEST RAW SCORE, AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL EXAMINATION FOR COLLEGE FRESHMEN "Q" AND "L" RAW SCORES, AND "30 ITEM" EDUCATIONAL PSYCHOLOGY ACHIEVEMENT TEST RAW SCORE OF PROFESSOR COMPARISON GROUPS A AND B.

Group mean		"F" value*	Significance of "F" value at .01 level	"t" value**	Significance of "t" value at .01 level
A	B				
CREDITS PASSED					
87.08	97.48	1.43	not significant	-2.77	significant
GRADE POINT AVE.					
2.49	2.44	1.01	not significant	.89	not significant
M S A T					
45.86	43.88	1.23	not significant	1.20	not significant
A C E "Q"					
39.63	40.09	1.18	not significant	- .37	not significant
A C E "L"					
67.93	67.03	1.34	not significant	.56	not significant
"30 ITEM" ED PSY					
17.66	15.55	1.32	not significant	1.55	not significant

*Critical value of "F" at .01 level is 2.15.
**Critical value of "t" at .01 level is 2.63.

statistical test (the Wilcoxon matched-pairs signed-ranks test)[6] was applied. The basis for pairing was the difference in credits passed equal to the difference between the mean raw scores of Group A and Group B (10.41 credits) plus or minus one standard error of the mean of Group A (2.18 credits). (See Table 2.)

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[6]The steps in the use of the Wilcoxon matched-pairs signed-ranks test are as follows:

1. Determine the signed difference, d, between the scores for each matched pair.
2. Rank the d's without respect to sign, assigning the average of the tied ranks when d's are tied.
3. To each rank, affix the sign (+ or -) of the difference it represents.
4. Determine the value, T, of the smaller of the like-signed ranks.
5. Determine N by counting the total number of pairs having a non-zero difference.
6. Determine the significance of the observed value of T by one of the following methods:
   a. If N is 25 or less, refer to the table which shows the critical values of T for various sizes of N. If the observed value of T is equal to or less than that given in the table for a particular significance level and value of N, the null hypothesis may be rejected at that level of significance.
   b. If N is larger than 25, compute the value of z by the following formula:

$$z = \frac{T - \frac{N(N+1)}{4}}{\sqrt{\frac{N(N+1)(2N+1)}{24}}}$$

Determine the associated probability of the observed value of z by referring to the appropriate table of values. If the probability thus determined is equal to or less than the previously set significance level, reject the null hypothesis. (Siegel, Sidney, Nonparametric Statistics for the Behavioral Sciences, pp. 81, 83.)

TABLE 2. "30 ITEM" EDUCATIONAL PSYCHOLOGY ACHIEVEMENT TEST RAW SCORES FOR MATCHED PAIRS FROM PROFESSOR COMPARISON GROUP A PAIRED ON THE BASIS OF DIFFERENCES IN CREDITS PASSED*

Student code numbers		Credits passed		"30 Item" raw scores	
7	84	178	168	25	11
35	71	160	152	23	21
4	112	151	141	13	18
117	65	136	127	23	14
10	108	116	106	14	15
24	121	115	106	20	20
58	34	113	104	12	14
66	90	111	102	20	16
2	54	111	101	18	16
113	52	110	99	17	14
39	53	96	86	22	16
30	16	95	85	20	19
12	132	94	84	15	22
116	73	92	82	20	21
47	115	92	81	22	19
109	41	91	81	24	20
104	31	90	80	14	13
49	46	90	80	16	18
3	89	90	80	20	23
110	125	90	80	22	22
51	102	89	79	19	19
107	15	88	78	15	17
43	82	88	78	19	19
123	55	88	78	21	24
119	126	87	77	14	13
100	98	87	77	20	23
44	95	87	77	19	19
127	48	86	76	16	20
94	130	86	76	23	22
129	57	85	75	16	15
122	5	85	75	18	18
111	81	85	76	21	22
103	120	85	76	19	14
183	105	85	76	22	27
36	14	84	74	15	15
42	68	84	74	14	17
17	61	83	73	22	20
67	79	83	73	10	11
85	87	83	73	19	18
28	131	82	72	13	11
106	88	82	72	14	14
25	40	82	72	14	15
37	78	82	72	14	16
19	18	80	68	14	16
20	75	80	68	22	19
23	6	79	69	15	15
29	38	79	68	17	17
114	70	79	67	20	20
101	50	77	67	15	21
59	91	76	65	16	18
97	33	34	24	17	16

T = 405
N = 40
z = .067
p = .47

*Limits for differences in credits passed were set at the difference between the mean raw scores of Professor Comparison Group A and Professor Comparison Group B (10.41) plus or minus one standard error of the mean of Professor Comparison Group A (2.18).

The results of this test indicated that the value of z was .067 which had an associated probability, p, of .47. (See Table 2). Since p was greater than the previously set level of significance of .01, the null hypothesis, that 10.41 plus or minus 2.18 credits passed did not affect final achievement, was accepted.

Since the variations in credits passed did not affect the achievement of students within Group A, it was assumed that similar credit differences between Groups A and B would have no significant affect on final learning achievement by students in either of those groups. Therefore, since all the factors upon which the groups were compared were either not significantly different or the differences were unrelated to final achievement in the course, the next step in comparing the influence on learning of the teaching of the two professors was to analyze the final achievement of the two groups.

As Table 1 shows, the final achievement of Groups A and B in educational psychology as measured by the 30 objective test items was not significantly different at the selected significance level of .01. As a result of this determination, it was assumed that the influence on learning of the two educational psychology professors was not significantly different. Therefore, it was further assumed that any differences in final learning which might appear significant in the classroom experiment would be the result of changes in procedures and materials used. The experimental sample and controls were established next and are reported in the following section.

Experimental Sample and Controls

The experimental sample consisted of 91 undergraduate students who registered for educational psychology winter quarter, 1965. Three sections of the course were offered and no special procedure was used to assign students to the sections.

After registration was completed, the professors were assigned to the sections of the course. The professor who had taught Group A during spring quarter, 1964, was assigned to the experimental section of 34 students. This experimental group is referred to throughout the study as Group E. The professor who had taught Group B autumn quarter, 1964, was assigned to two sections with a combined enrollment of 57 students. This control group is referred to hereafter as Group C.

The students in Groups E and C were initially compared on the same basis as was used earlier to compare Groups A and B. These criteria were (1) credits passed, (2) cumulative grade point average, (3) A.C.E. "Q" and "L" raw scores, and (4) the MSAT raw score. Upon statistical examination using the F-test and t-test, it was determined as shown in Table 3 that there was no significant difference at the confidence level of .01 between Groups E and C on the basis of the comparative criteria.

Four additional tests were administered during evening sessions of the first week of the quarter to determine the comparability of the groups in terms of (1) general knowledge of educational psychology, (2) ability to think critically, (3) ability to reason abstractly, and (4) ability to

TABLE 3. ANALYSES OF VARIANCE AND DIFFERENCE BETWEEN CREDITS PASSED, CUMULATIVE GRADE POINT AVERAGE, MINNESOTA SCHOLASTIC APTITUDE TEST RAW SCORE, AND AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL EXAMINATION FOR COLLEGE FRESHMEN "Q" AND "L" RAW SCORES OF EXPERIMENTAL GROUP E AND CONTROL GROUP C.

Group mean		"F" value*	Significance of "F" value at .01 level	"t" value**	Significance of "t" value at .01 level
Exper.	Control				
CREDITS PASSED					
91.06	94.11	1.28	not significant	-.57	not significant
GRADE POINT AVE.					
2.30	2.36	1.42	not significant	-.82	not significant
M S A T					
45.38	40.47	1.02	not significant	.05	not significant
A C E "Q"					
41.71	38.32	1.45	not significant	.87	not significant
A C E "L"					
65.35	64.11	1.29	not significant	.60	not significant

* Minimum critical value of "F" at .01 level is 2.10.

**Critical value of "t" at .01 level is 2.63.

reason regarding mechanical applications. The four measuring instruments selected and used were (1) a comprehensive achievement test in educational psychology consisting of items selected from published sources in the field,[7] (2) the Watson-Glaser Critical Thinking Appraisal, Form YM, (3) the Differential Aptitude Test, "Abstract Reasoning," Form L, and (4) the Differential Aptitude Test, "Mechanical Reasoning," Form L.

The raw score data obtained from these tests were treated statistically. At the significance level of .01, there was no significant difference between the experimental group, E, and the control group, C, as shown in Table 4. Because the experimental and control groups appeared to be similar on the basis of the initial data obtained and analyzed, further controls which are stated next were used.

The professors of the two groups had available a complete list of books, booklets, and articles which were on reserve in the library for student use as reference works during the quarter.[8] The professors, working with the writer, developed a list of the more important chapters or

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[7]Test items were taken from the following sources and used by permission of the publishers: Blair, G. M., Jones, R. S., and Simpson, R. H., Instructor's Manual to Accompany Educational Psychology, Second Edition, The Macmillan Co., New York; Frandsen, A. N., Instructor's Manual for Educational Psychology: The Principles of Learning in Teaching, McGraw-Hill Book Co., New York; Jandron, E. L., Student Guide with Programmed Units to Accompany Sawrey and Telford's Educational Psychology, Second Edition, Allyn and Bacon, Inc., Boston; Klausmeier, H. J., with assistance of Richard Ripple, Instructor's Manual to Accompany Learning and Human Abilities: Educational Psychology, Harper & Brothers, New York; Mouly, G. J., and Walton, L. E., Schaum's Outline of Test Items in Education, Schaum Publishing Co., New York. See Appendix B.

[8]See Appendix C, Table 7.

TABLE 4. ANALYSES OF VARIANCE AND DIFFERENCE BETWEEN WATSON-GLASER CRITICAL THINKING APPRAISAL FORM YM, DIFFERENTIAL APTITUDE TEST ABSTRACT REASONING FORM L, DIFFERENTIAL APTITUDE TEST MECHANICAL REASONING FORM L, AND EDUCATIONAL PSYCHOLOGY ACHIEVEMENT PRE-TEST MEAN SCORES OF EXPERIMENTAL GROUP E AND CONTROL GROUP C.

Group mean		"F" value*	Significance of "F" value at .01 level	"t" value**	Significance of "t" value at .01 level
Exper.	Control				
WATSON-GLASER					
73.62	71.81	1.31	not significant	1.06	not significant
DAT ABSTRACT					
39.82	39.37	1.32	not significant	.32	not significant
DAT MECHANICAL					
49.82	51.68	1.58	not significant	-1.11	not significant
EDUC. PSYCH					
60.91	57.89	1.01	not significant	1.52	not significant

* Minimum critical value of "F" at .01 level is 2.10.

**Critical value of "t" at .01 level is 2.63.

sections in the reference works and the course text, Learning for Teachers by Townsend and Burke.

The selected readings were correlated with ten instructional areas of educational psychology which appeared to be considered important by writers in the field. The following areas of importance were determined after reviewing numerous current educational psychology textbooks: (1) introduction to educational psychology, (2) growth and development, (3) psychology of learning, (4) guidance of learning, (5) motivation, (6) memory, (7) transfer, (8) other mental processes--discrimination, generalization, perception, cognition, (9) individual differences, and (10) educational measurement.[9] A list of the correlated reference and text selections is given in Appendix C, Table 8.

During the classroom experiment, the professors passed handout sheets to the students which listed the instructional areas and the related readings. Thus, both professors and all the students were equally aware of the text and reference readings considered important and related to the instructional area under discussion at any particular time during the course.

The professor who taught the control group, C, lectured on the information within each of the ten instructional areas but used no concrete or symbolic means of representing the ideas talked about. The professor who taught the experimental group, E, lectured on the same informa-

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[9] These areas appear to include content similar to that reported as important by Nunney, D. N. in "Trends in the Content of Educational Psychology, 1948-63," The Journal of Teacher Education 15:372-376, December 1964.

tion and, in addition, used both concrete and symbolic representations which were selected and designed specifically to support a particular idea. Details of the nature of the experimental instructional method are described next.

Concept Development Through Graphical Representation: The Experimental Method

The nature of the instructional approach followed with the experimental group can best be summarized as concept development through graphical representation. Although in many respects lecturing and discussion in the class resembled any ordinary class, the constant use of concrete and symbolic materials, and their organization graphically to develop ideas made the approach vastly different. In applying graphical materials, constant use was made of ideas from various subject matter areas to illustrate the value of such materials in developing ideas and generalizations.

The basic thinking underlying the method was that, in all learning, ideas are represented by symbols, both verbal and non-verbal, and that in the development of major ideas the parts that make up the idea are best associated in a graphical sense relationship. This was clearly demonstrated early during the experiment as the approach was made to an assignment on class management in the textbook. The major idea the authors were trying to emphasize seemed to be that the approaches to class management tended to range from a permissive type to one entirely directive. The resulting effects on student disciplinary behavior extended from the classroom situation characterized as one of predominately self-disciplined

individuals to one of constantly disciplined pupils. Figure 3 illustrates the design of graphic flannel board materials used in developing the idea.

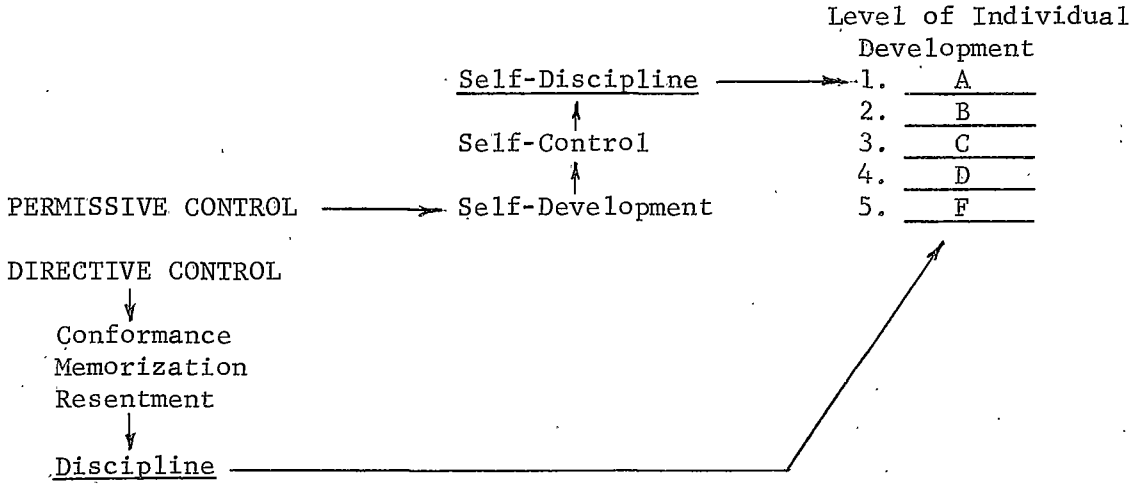

FIGURE 3. CLASS MANAGEMENT, THE INDIVIDUAL, AND LEARNING

The approach to the idea of the relationship of class management to the individual and learning was one of step-by-step development through the use of flannel board representations placed in order. The idea was developed that the highest level of individual achievement and the ultimate goal of self-discipline could be reached through the permissive approach. This was contrasted with development through the directive approach which usually results in the need for discipline and a low level of individual development. The usual verbalized comments, questions, and answers were developed to fix the ideas through illustrations of each of the steps in the design. With the design remaining on the flannel board, students then practiced verbalizing the concept they had formed.

In explaining the highest level of development, usually reached only by the self-disciplined individual, marks (A,B,C,D,F) were used as shown in Figure 3. This led to the characterization of high achievement as that in which important ideas or generalizations become the central focus for development. This same procedure was followed in developing understanding of the basic factors operating in motivation, readiness, classroom climate, level of aspiration, and conditions for learning.

Out of the many graphical designs used, certain ones have been selected for presentation in this section in order that the reader might get a feeling for the nature of the instructional method. To do this it was considered necessary to show the essential conditions for learning, the importance of readiness as a factor for effective learning, and the role of concept development. Each of these is treated in the following subsections under the titles: Fusion, Readiness, and Concept development.

Fusion. The concept of an effectively fused teaching-learning situation which encompasses the essential conditions for learning was one of the early lessons in the area of guidance of learning. The graphical flannel board materials used were patterned after illustrations of Gottesman who states that the organizational processes which are important and operational in a fused teaching-learning situation are: (1) workflow, (2) authority, (3) reward and penalty, (4) maintenance, (5) identification, (6) communication, and (7) evaluation.[10]

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[10]Gottesman, A. M., Fusion Concept in Classroom Teaching, pp. 5-6.

It was particularly emphasized that learning is often considered "acquiring new information, new or changed ways of responding, new understanding,"[11] and that the teacher's job is to aid the student in this development while the student must struggle for self-development. The common goal is learning and it is clear that this goal can only be achieved through fusion of the student's perceived needs and the classroom teacher's organizational processes. This idea of the single purpose of teaching and learning was shown in a flannel board representation similar to Figure 4.[12] The term "student" used throughout this section should be considered synonymous with "pupil" which was used in the figures.

An explanation of each of the organizational processes was given by the professor. The following ideas are essentially the same as those stressed.

The process by which learning is achieved is the workflow process. In the classroom, authority rests with the teacher but support for the workflow process may come from student-teacher cooperation in planning, in determining standards, and in maintaining classroom control.

The reward and penalty process includes all the forces by which students are induced to learn. Learning aids of both quality and quantity are supplied to the classroom through the maintenance process. The morale

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[11] Townsend, E. A., and Burke, P. J., Learning for Teachers, p. 9.

[12] Gottesman, op. cit., p. 7. Used by permission of the publisher, Department of Education, George Peabody College for Teachers.

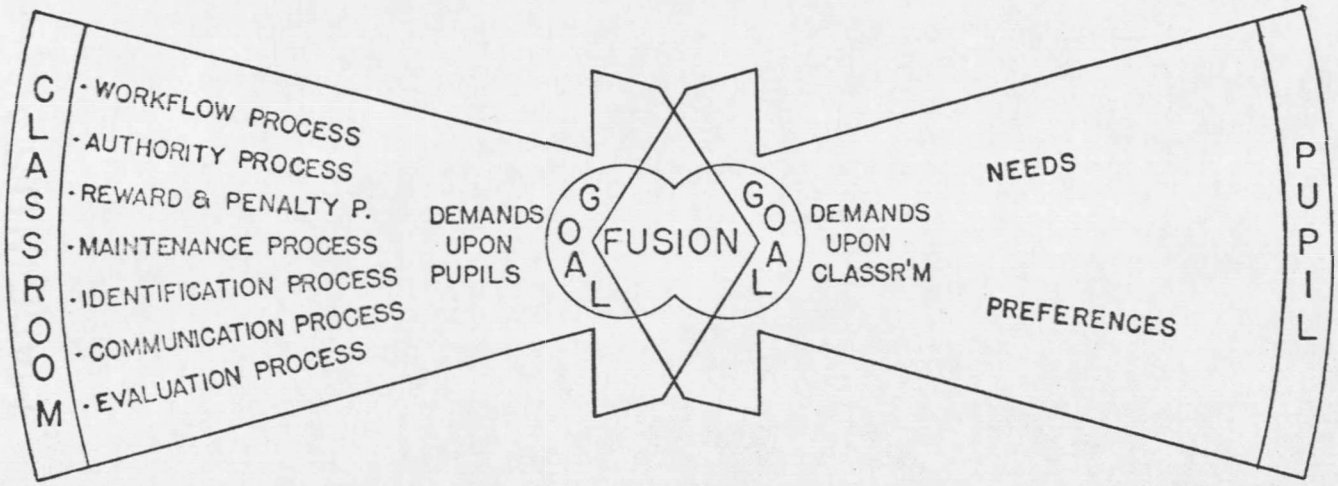

FIGURE 4. COMBINED ACTION OF THE CLASSROOM ORGANIZATIONAL PROCESSES AND PUPIL NEEDS AND PREFERENCES IN A FUSED TEACHING–LEARNING SITUATION

of the students depends upon their perceptions of the uniqueness and significance of the classroom. This identification of the student with the classroom is termed the identification process.

The adequacy of the communication process determines the extent of interaction and understanding in the classroom. Finally, an evaluation process which deals with the students, material, ideas, and behavior must be an ongoing part of the classroom situation.

All seven of these processes are largely dependent upon one another and must operate if maximum learning is to result in the classroom.[13] Such a fused organizational setting will provide the conditions required for the development of realistic levels of aspiration for both the students and the teacher.

Once the setting for, and importance of, the classroom conditions[14] for effective learning had been thoroughly discussed and viewed graphically by the experimental group, the professor proceeded to the next important condition--readiness. The way in which that area was handled in class is described next.

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[13] Ibid, pp. 5-6.

[14] Although there were numerous factors involved, the two essential conditions in the initial stages were considered to be basically the goal of the self-disciplined person--a high level of achievement--and the need for this goal resulting from what has been referred to as "fusion."

Readiness. Readiness was stressed throughout as being extremely important in effective learning and also in methodological approaches in instruction or in the direction of learning. But the stress was constantly on the symbolic representation of ideas both verbal and non-verbal. General discussion centered first on the readiness factors brought out by the authors of the textbook, Townsend and Burke, Learning for Teachers, and those brought out by the professor[15] in an article designed to focus attention of both teachers and supervisors on important factors to consider when planning for learning.

The readiness of the reader for what is to follow in this section and in succeeding sections can be brought about better by relating to the article first. It stated that youngsters in their learning develop key words and statements as symbols for ideas or processes, and that these symbols are basic to their readiness for new learning and problem solving. The emphasis in the article was on the consideration of ideas, or concepts, as three types: (1) Knowledge--Statements as concepts or generalizations, (2) Word--Words that are symbols for ideas, and (3) Ability--Words that are symbols of processes or relationships.

The illustrations that appear in this section should clearly show the importance of readiness. The term "Energy" is an example of what is

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[15]Franks, Milford, "Learning Through Concept Development: The Goal of Supervision and Instruction," Montana Education 39:8-10, April, 1963.

referred to as a word concept. The statement that "Water pressure is proportional to the height of the column" is an example of a knowledge concept. The word "inverse" was used in the article as an example of an ability concept. All three types of concepts are considered of great importance in the development of readiness for learning.

Figure 5 on the following page is a replica of the flannel board design that was used to present the various readiness factors brought out in the textbook, Learning for Teachers. Such items as "learning factors" with attention to "adequate symbols," "key ideas," "generalizations," and the graphic illustrative materials of the quadratic, octagon, and hexagon were used to supplement the textbook discussion. General factors such as age, intelligence, and attitude were discussed for the part they had to play as readiness factors in learning. Then knowledge, adjustment through ability to apply ideas, and readiness for exploring and discovering were explained. Again, special emphasis was placed on the importance of knowledge in readiness through adequacy of symbols, the availability of key ideas for quick recall, and the importance of having developed important generalizations and the ability to apply them.

The part of Figure 5 representing a "quadratic" is an example of how adjustment through the development of ability to apply ideas was stressed. The square was first placed on the flannel board and then labeled "x" on each side. The dimensions were then increased by one and the new area arrived at by visualizing the sum of the areas of the parts as $X^2+X+X+1$. Each of these parts was related to the concept "area."

GENERAL

AGE

LEARNING FACTORS

ADEQUATE SYMBOLS

KNOWLEDGE (TCHR-PUPIL)

KEY IDEAS

GENERALIZATIONS

INTELLIGENCE (TCHR–PUPIL)

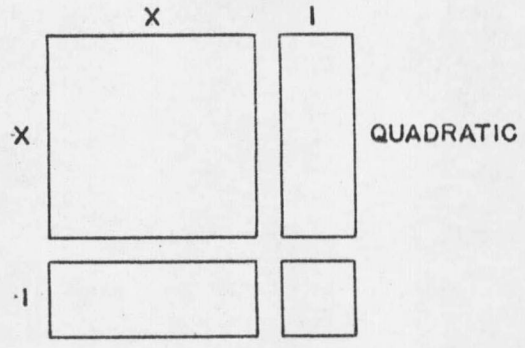
ADJUSTMENT

APPLICATION OF IDEAS

ATTITUDE

TIMING

PACING



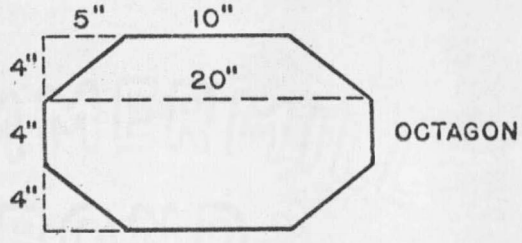
WILLINGNESS TO:

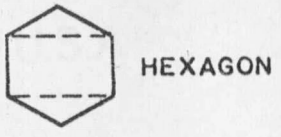
EXPLORE

DISCOVER

FOLLOW

BE DIRECTED





GUIDING PRINCIPLE FOR LEARNING: TEACHER OR DIRECTOR MUST ASSESS READINESS

FIGURE 5. THE QUADRATIC, OCTAGON AND HEXAGON – EXAMPLES USED IN TEACHING THE IMPORTANCE OF READINESS

Then the dimensions were increased by one more and verbalized again as $X^2+X+X+X+X+1+1+1+1+1$ or X^2+4X+4. These dimensions were again extended by one and the students were asked to give the area. This was extended to extrapolation of the third term of the trinomial with further increases in dimensions. Changes in the flannel board design were then made to arrive at a figure with dimensions of $2X+1$ and $X+1$ with the resulting area visualized. These were related to such common expressions in Algebra 9 as "expanding the binomial."

Throughout the demonstration student reactions were solicited for results, always with the intent to emphasize images of process that were basically visual and perceptually discriminating. Previously in the course the students had experienced another graphical presentation of the doubling of dimensions of similar, regular, plane figures and the subsequent discovery of what happened to the areas. They arrived at the generalization that "If dimensions are doubled under these conditions, areas are quadrupled." Since the example used in class in showing the quadratic was based on a value of three for X, the dimension became $X+3$, or doubled, and the area quadrupled, 9 to 36. Students were able to see this graphically as well as being able to apply the previously discovered generalization. Thus the value of knowledge in readiness was shown as well as the part played by discovery.

The octagon shown in Figure 5 was used to illustrate the part of exploration and discovery in readiness for problem-solving, and the effectiveness of perception in the process. The figure was placed on the

flannel board and the appropriate dimensions added one by one with the reading of the problem. The problem had been taken from a junior high school mathematics book and was essentially that a person had 250 octagonal pieces of metal costing a set price per square foot. The students were to find the total cost. Some of the students saw the octagon as two trapezoids and one rectangle 4" by 20". Some saw it incorrectly as a rectangle 10" by 20" and two trapezoids. Still others saw it differently. But it was quite evident that most of the students were not ready in a perceptual sense.

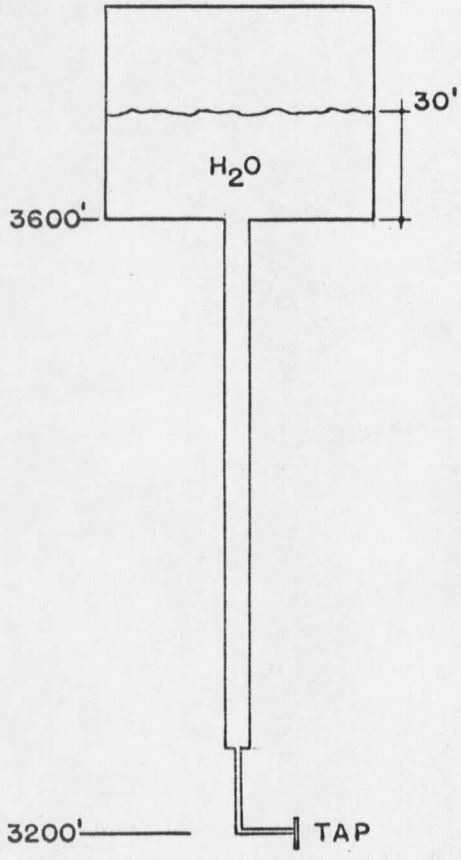
The final point noted in Figure 5 is that the teacher or director of the learning experiences must estimate the readiness of individuals and plan the kinds of exploratory exercises that make the different individuals ready. As an example, a hexagon was used on the flannel board. Students were asked to give the sum of the interior angles without doing any paper calculation. When they seemed unable to proceed, they were asked to imagine it in parts. They were shown a regular hexagon made up of parts. Once these were separated so that they could see two triangles and a rectangle, they saw the interior angles as being equal to eight right angles or 720 degrees. Then they were asked to imagine the original hexagon as being divided into triangles. They were finally able to see it as being made up of four triangles. It was evident that there were great differences in readiness for the problem and that all were in need of the visual experiences with graphical materials. The habit of exploration and discovery seemed secondary to the attempt to recall previous experiences.

A problem in determining the amount of pressure at a water tap in a community was used to reveal some of the problems of readiness. Following is the problem:

> A city reservoir is located on a hill so that the bottom of the reservoir is at an elevation of 3600' above sea level. If the water in the reservoir is 30' deep, what will be the pressure at a tap whose elevation is 3200'? (1 cu. ft. of water equals 62.4 lbs.)
>
> a. In pounds per sq. ft.?
> b. In pounds per sq. in.?

Again the flannel board was used to create a design, shown as Figure 6, that would reveal graphically the picture of the problem. The students were first told that the problem had been selected from several given to college students in a beginning course in physics, and then they were told that the basic ideas involved were very simple and could be identified and understood by almost any student at any level in the grades seven to twelve. The demonstration began with the illustration of a cube filled with water, one cubic foot in volume, and the estimation of the weight and resulting pressure caused by the addition of other similar size cubes. This was done to teach the idea that "Water pressure is directly proportional to the height of the column." Next, the following two generalizations were developed: "Pressure at a point in any fluid is the same in all directions," and "Pressure in an open fluid varies as depth and average density."

The movable outlet from the reservoir was changed to a slanting position and the first of the three generalizations was discussed. The



CONCEPTS TO BE DEVELOPED

KNOWLEDGE

WATER PRESSURE IS PROPORTIONAL TO THE HEIGHT OF THE COLUMN.
PRESSURE AT A POINT IN ANY FLUID IS THE SAME IN ALL DIRECTIONS.
PRESSURE IN AN OPEN FLUID VARIES AS DEPTH AND AVERAGE DENSITY.

WORD

MASS
WEIGHT
DENSITY

VOCABULARY

GRAVITY
PRESSURE

ABILITY

MORE THAN –
LESS THAN

SYMBOLS

CU. FT.
sq. FT.
H_2O
308'
360°
g

FACTS

62.4 LBS/CU. FT.

FIGURE 6. WATER PRESSURE

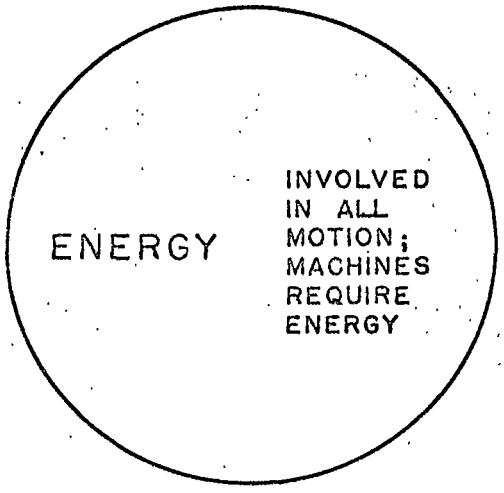
second of the generalizations was explained in relation to the points of outlet from the reservoir and from the water main. The third generalization was discussed in terms of the density of other fluids and their relation to water as a standard.

In Figure 6 are also shown the word and ability concepts that were stressed as important symbols necessary for reading the problem, and those which must be singled out by the teacher or director for assessment of the readiness of students. Weight, mass, and density were presented as word concepts for which there must be quick understanding of the ideas represented before true problem-solving could occur and before the ability to verbalize ideas could take place. It was stressed that these words were very important and that the readiness to proceed in related problem areas would not occur until these were a part of the student's vocabulary.

At this stage, words given under both word concepts and vocabulary were interchanged to emphasize the idea that if any one symbol did not bring quickly to mind the image of an idea or process the idea had to be taught before there was readiness to go on. The example of weight-weightlessness was used to show that the concept of gravity was essential to the understanding of weight and pressure and that both were essential to the understanding of weightlessness. Although words were treated as symbols for ideas, the often used symbols given in the figure were stressed as being important because they actually become a part of expression in reading. Without their use the reader does not understand.

In introducing this section on readiness, mention was made of "Energy" as an example of a word concept. This was presented to the group, as shown in Figure 7, as an idea that could be a unit of work over a period of four to six weeks. Words such as force, gravity, friction, inertia, potential, and kinetic were emphasized as supporting ideas that were essential to readiness for the major ideas and generalizations. The design as shown in the figure was in color so that the five major generalizations about energy stood out. The position of these and the indented position of subordinate ideas was stressed and related to outlining in English. These relationships were also extended to newspaper style of main and supporting headings organized by contrast in an effort to quickly give meaning to the major ideas. This was further extended to paragraph writing with first the topic sentence and then the supporting ideas.

Special charts and materials were brought into the class from time to time to develop the ability to clearly verbalize ideas. The Hydro-Electric Cycle shown in Figure 8 is an example. Although its primary purpose was to test the ability to verbalize, it was used also to assess readiness of the students with word concepts and symbols. They were asked to use previously developed concepts such as "potential energy" and "kinetic energy" in their verbalization. Students who faltered were stopped and asked again to explain each concept. Finally, there was satisfactory expression of the idea that "When the progress of a stream is stopped by a dam, the potential is concentrated because of the raised level of the water; and that by releasing this potential energy through the



SUN GIVES ALL ENERGY DIRECTLY OR INDIRECTLY
- ENERGY COMES FROM FOOD, FUELS, WIND, WATER, LIGHT AND NUCLEAR.

MOTION CHANGE IN AMOUNT–DIRECTION REQUIRES ENERGY
- WORK IS PRODUCT OF FORCE TIMES DISTANCE.
- FORCE EXERTED MUST OVERCOME GRAVITY, FRICTION OR INERTIA.
- POWER IS THE RATE OF DOING WORK.

ENERGY MAY BE POTENTIAL OR KINETIC
- KINETIC AND POTENTIAL ENERGY CHANGE FROM ONE TO THE OTHER.

ENERGY FORMS ARE ELECT., CHEM., MECH., HEAT, NUCLEAR, AND WAVE
- FORM OF ENERGY CHANGES, BUT TOTAL REMAINS THE SAME.
- MACHINES → MECH. ADV., MULTIPLY SPEED, OR CHANGE DIRECTION OF FORCE; TRANSFORM AND TRANSFER ENERGY.

ENERGY OPERATED MACHINES DO USEFUL WORK.

FIGURE 7. " ENERGY "

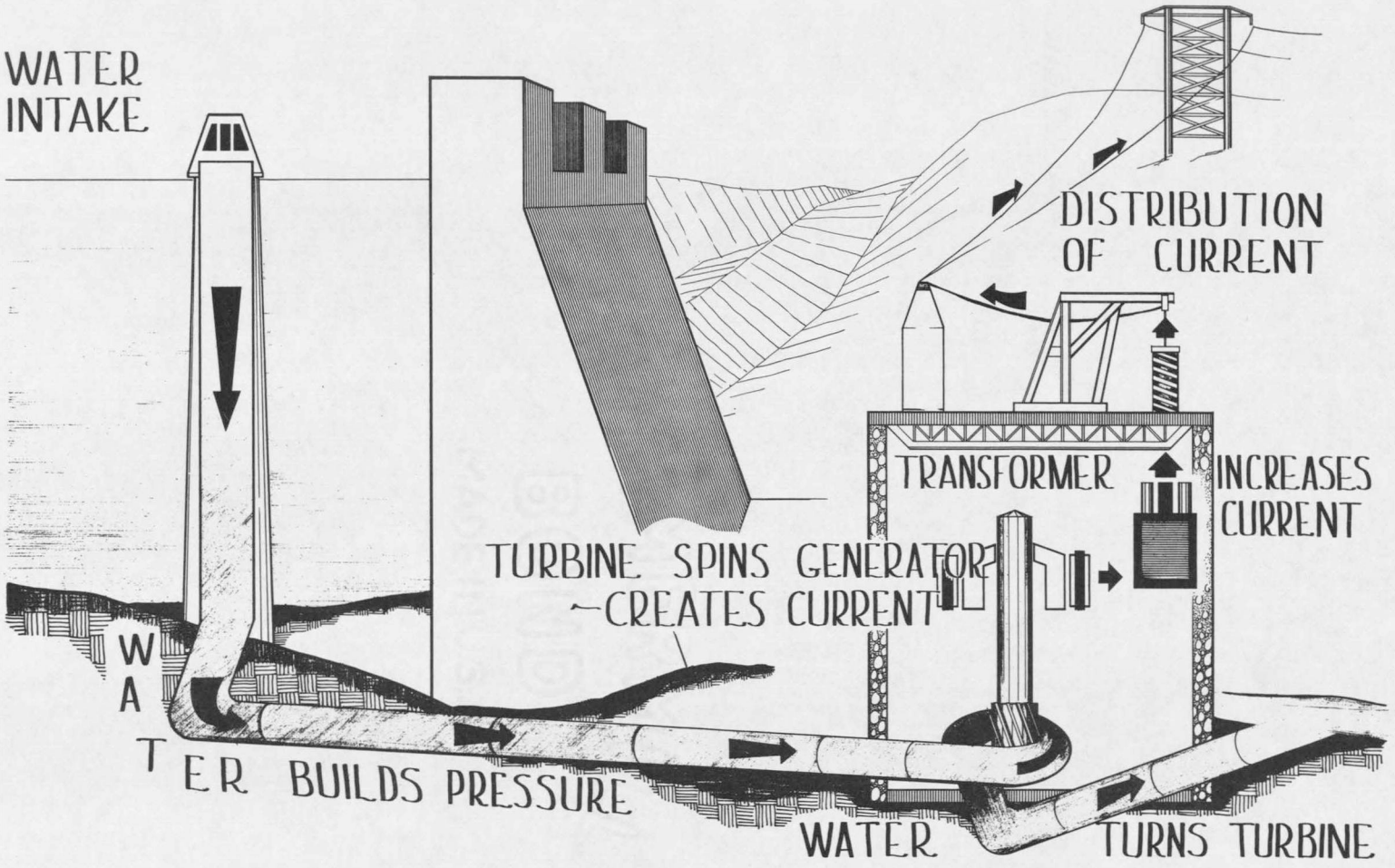


FIGURE 8. THE HYDRO-ELECTRIC CYCLE

turning of a turbine generator it is transformed to electrical energy and eventually passed on to consumers."

Only a few instances concerning readiness have been reported here. Throughout the course there were frequent references to readiness in all of the subject illustrations used. Also, there were numerous trials at expressing the ideas represented by symbols. That part of the experimental method will be discussed more fully in the following section.

Concept development. In the approach to concept development in the experimental group, much attention was given to planning materials so that students could see in a graphical way the step-by-step development of the idea. First, all examples that were used were selected from subject areas. These were then organized in a planned manner to develop understanding of a particular idea. The presentations involved primarily illustrations for the flannel board, the overhead projector, and prepared seatwork materials such as outline forms out of which the understanding of an idea or generalization could be developed. The nature of these presentations can be summarized by stating that five guide lines were followed in teaching the idea of concept development:

1. Use materials that start with the idea and develop supporting ideas.

2. Examine the supporting ideas and the resulting student verbalizations of the major idea involved.

3. Emphasize the logical step-by-step development of supporting

ideas and the often necessary grouping and regrouping of subordinate materials for the association of ideas.

4. Use numerous graphical type materials for ease of visualizing the ideas.

5. Stress student generalization of ideas and the importance of meaningful verbal expression in teaching these ideas to other persons.

These guide lines were followed primarily because it was the basic belief in this investigation that the quick understanding of ideas comes about more effectively through the use of learning materials that emphasize certain processes. The processes[16] treated in the experimental method as basic to effective learning were (1) perception, (2) cognition, (3) discrimination, and (4) generalization.

The following examples of concept development have been taken from actual lessons presented in order to show the graphical nature of the approach that was used. The reader should note that the subsections which follow point out different approaches to concept development.

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[16]The word processes is used here in much the same manner as that described by Townsend and Burke in Learning for Teachers, p. 10, where they refer to generalization and discrimination as "companion processes which support and allow learning to function in new contexts." Both perception and cognition are treated by Harriman, P. L. in his Handbook of Psychological Terms, pp. 32, 127, as intellective processes causing the organization of sensory data into experience patterns or knowledge. Klausmeier, H. J., in Learning and Human Abilities, p. 7, treats cognition as "the processes whereby an individual obtains knowledge about anything . . .", and Guilford, J. P., in "Three Faces of Intellect," The American Psychologist 14:469-479, August, 1959, treats it as an intellectual process.

Concept Formation[17]

In the preceding section on readiness, Figure 7 on "Energy" illustrates clearly the logical step-by-step development of an idea. First, the sun with the printed concept "Energy" and the two generalizations were discussed. Then each of the five important supporting ideas or generalizations was discussed in the order given in the design. With each idea, supporting ideas were discussed. For example, under the generalization "Motion change in amount or direction requires energy," the supporting concepts "work" and "force" were introduced as important ideas to be developed, understood, and associated in order for the generalization to be fully understood and ready for application to problem situations.

Various illustrations were used to bring out each of the ideas. As an example, letters in formula form were used to illustrate work, $W = f \times d$. Understanding the cycle of use of the sun's energy from evaporation of water from lakes to the depositing of snow on mountains as potential energy, and the change of this to its kinetic form, was developed. At stages and appropriate places, there was reassessment of the understanding of word concepts.

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[17]The reader should realize that in most cases in the use of subject matter examples of concept formation, time was not spent in developing an understanding of the idea but rather in the use of the major ideas and the supporting ideas to illustrate their importance in learning. In a few instances throughout the quarter, ideas were developed just as they would be when a student at any level is first introduced to a unit or idea.

The next example is of the type which starts with a group of supporting ideas and arrives at the major idea. Figure 9 shows the supporting ideas that were given to the students preceding a seatwork exercise on Brazil. The major idea shown in parentheses was not given.

Concept: (BRAZIL: GIANT OF SOUTH AMERICA)

Supporting ideas:

Half of the people of South America are Brazilians.
The United States of Brazil is larger than the United States of America and yet has only one-third the latter's population.
Its land area is as great as all other South American countries combined.
Its forests and great stores of iron ore and manganese are termed endless.
Its water power potential far surpasses the rest of South America.
It exports about one-half of the world's coffee supply.
Its harbors are among the greatest in the world.
Brazil has more potential land for agriculture than any other country of its size.

FIGURE 9. SUPPORTING IDEAS LEADING TO IDENTIFICATION OF A MAJOR CONCEPT

The students were asked to write the major idea revealed. In a few minutes a number of their answers were reviewed orally. These answers varied a great deal at first but eventually they narrowed to the one intended. As students listened to the ideas of each other, they appeared to re-examine their own ideas through a more critical examination of the supporting ideas. Through a series of questions, the professor of the experimental group caused the students to reflect on area, size, topography, effects of climate, and other factors involved in pulling together the relationships into one idea.

Next, a map of Brazil and part of South America, shown in Figure 10, was presented. This was kept before the students for reference. It was designed specifically for use in this lesson and used the contrast of color to make Brazil stand out. A circular insert appears in the lower left-hand corner of the map. This was used to replace one in the center of Argentina to give emphasis to the idea that the area of Brazil is equal to that of the rest of South America. Before the insert was used there was no way in which a comparison of areas could be made.

Numbers were used to show that the population of Brazil is equal to one-half that of all South America and comparisons were made with the United States of America. A second map, not shown in this report, was used to reveal mountain ranges, major stream flow, and general drainage areas by featuring highlands. On this map, the stream flow was indicated by stream width in much the same manner as that used by Helburn, Edie, and Lightfoot[18] in showing stream flow in Montana. Discussion centered around potential land use, water power, and the basic reasons for great harbors. This involved the significance of the two highland areas as outstanding coffee producing centers of the world, the potential of the Brazilian region for electric power, the industrial concentration in the Santos-Sao Paulo area, and the general relation of population concentrations

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[18] Helburn, Nicholas; Edie, M. J.; and Lightfoot, G. W., Montana in Maps, 85 pp. This booklet is an excellent example of the use of graphical representations in getting across ideas quickly and efficiently.

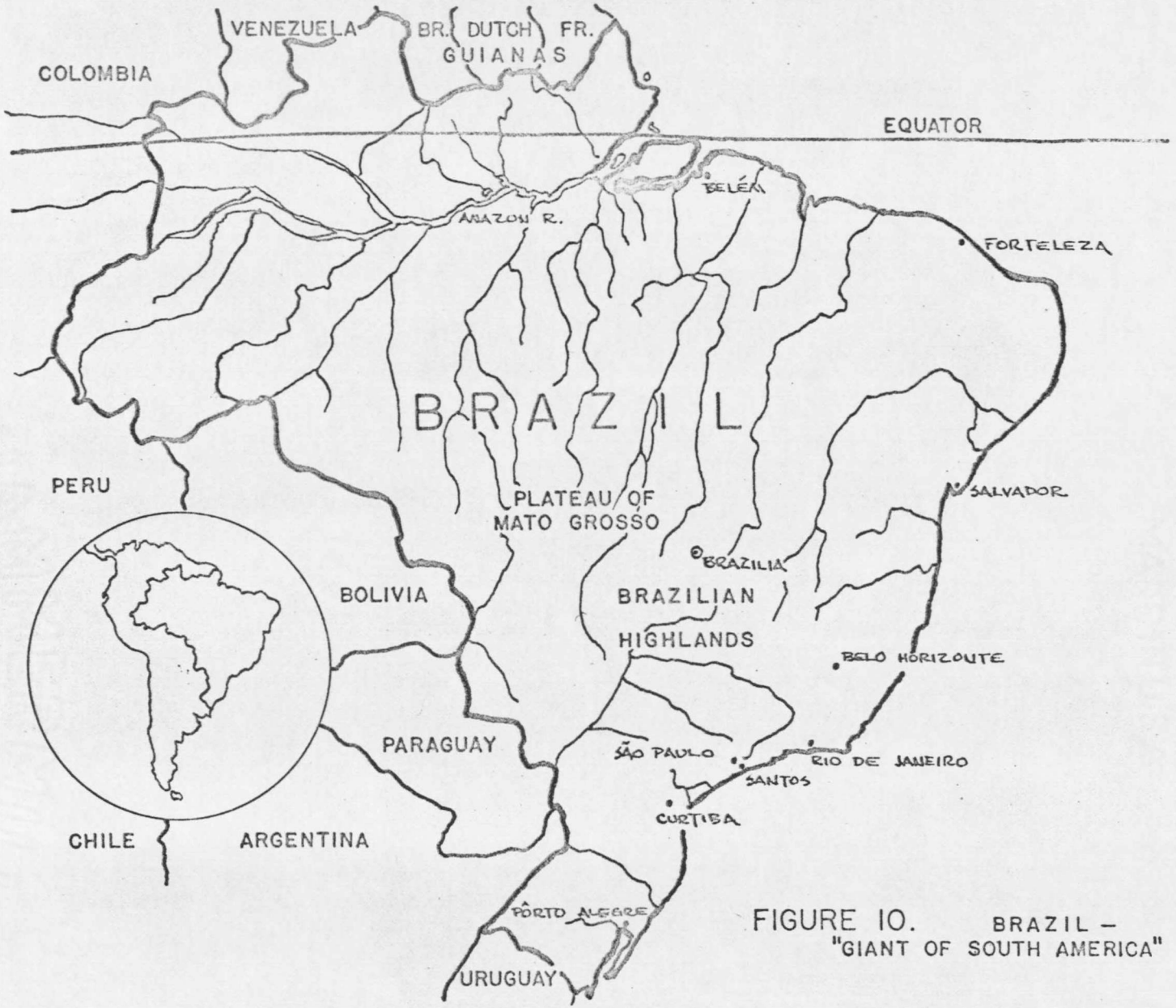

FIGURE 10. BRAZIL – "GIANT OF SOUTH AMERICA"

to undeveloped areas or resources. All of this was done without any previous study on the part of the students; just the in-class study of supporting ideas and the quick use of the maps.

In this example with Brazil it was interesting to note the thinking of the students. There was enough verbalization to indicate clearly that the four processes, perception, cognition, discrimination, and generalization were very much involved at all times.

Development of Generalizations[19]

In the previous section on concept formation, examples were given of step-by-step development of ideas and the identification of ideas from these steps. In this section, the step-by-step development is apparent in the ideas developed but the primary goal of the section is to show that through the development of ideas by the use of graphical materials, the learner is able to form mental images of relationships and ideas, and that these generalizations become important in solving problems and in meeting new situations.

One of the first presentations made in this area was in the development of the idea of the relationship of areas when the dimensions of similar, plane geometric figures are doubled. The figures used in the development

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[19]The previous section was concerned with the development of ideas as they occur from day to day and increase knowledge of a subject. This section singles out examples of basic generalizations for general education.

of the idea are shown in Figure 11.[20] The reader should visualize these pairs of similar figures of different dimensions as movable materials for flannel board use, as this is the way they were used.

The presentation was started with the placement of the four-inch square on the flannel board. Then the eight-inch square was placed at its side and the question asked, "What has happened to the dimensions?" This was followed by a similar inquiry, "What has happened to the area?" Some of the students were mentally calculating while others were contrasting sizes. The four-inch square was then moved over the eight-inch one so that all could see better the actual relationship of the areas. The four-inch square was next turned over so that the reverse side which was black was revealed. Some saw more quickly with the color contrast and the point was brought out that striking contrasts often aid in seeing relationships. It was stressed that individuals differ a great deal in their concepts of size, space, and relationships and that these types of materials cause greater discrimination. It was also at this stage that it was pointed out that the understanding of concepts such as parallelism or distance, could be improved just like any skill provided that the persons used meaningful experiences in their development.

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[20]These are similar, regular, plane geometric figures designed to develop understanding of the generalization that in these types of figures when the dimensions are doubled the area is quadrupled. The last pair of triangles was used to extend the generalization to what happens when the dimensions are tripled.

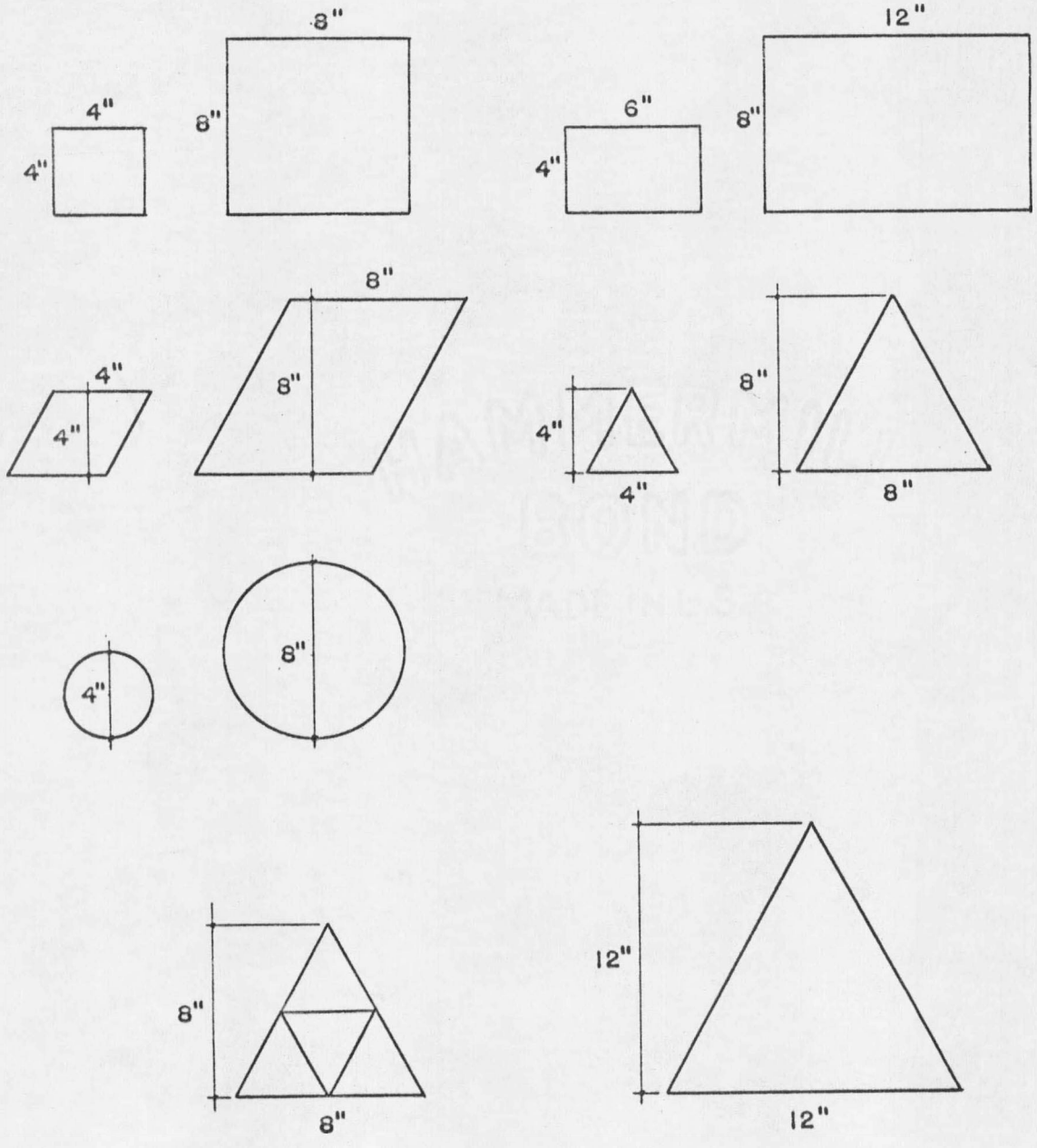


FIGURE 11. GEOMETRIC FIGURES

The rectangles, parallelograms, triangles, and circles were treated in a manner similar to the squares. At the end of these five discussions, students were asked what had taken place with regard to the dimensions and the areas. Then they were asked to draw a conclusion and to express it verbally. They concluded that in this type of figure the area was quadrupled when the dimensions were doubled.

It was interesting to note that as the demonstration proceeded from the square in which it was quite easy to see the relationship, to the circles, the students' abilities to visualize relationships were very much challenged. In fact, some of the students were not able to see the relationships even though they were similar. The triangles, which were the fourth set of figures to be shown, caused considerable difficulty. The four-inch one was placed in various positions on the eight-inch one. But it was not until it was turned over with the black side showing and its apex at the center of the base of the larger triangle that the smiles, "I see," appeared on all faces.

The circles caused even greater difficulty in visualizing. At this stage the chalkboard was used to show the two areas as a ratio. The students were quick to see that the relationship of 2^2 and 4^2 substantiated the generalization they had formed.

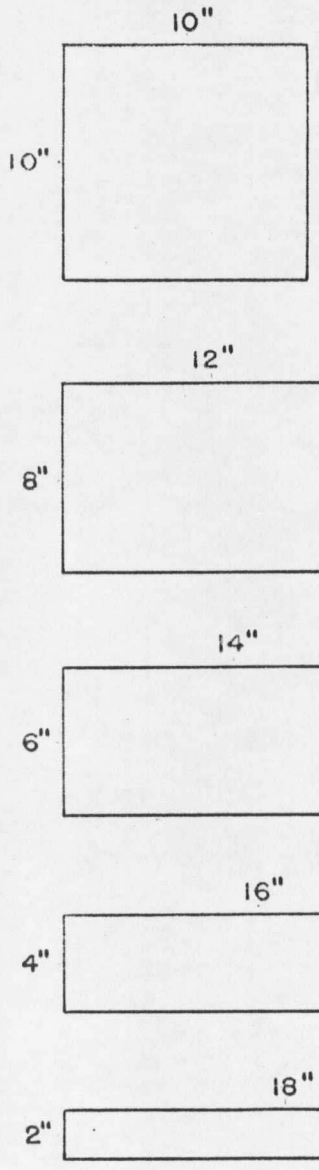
In Figure 11 there is a larger triangle with a base and altitude of 12". This was used to extend the generalization to the effect on areas when dimensions are tripled. Then, without the use of any form of representation, students were asked to give the result when dimensions were

increased four, five, and six times. They were asked to draw a conclusion about the relationship of area to what had been done to the dimensions. They concluded that if they squared the amount of increase in dimensions they would arrive at the number of times the area had been increased.

Another example was selected from mathematics to illustrate the importance of generalizations and the ease with which they can be developed from graphic materials. In this case it seemed important that students discover the relationship between the shape of a figure and its area. The materials used for the demonstration are shown in Figure 12.

The presentation was started by placing the ten-inch square on the flannel board. Students were asked to give the perimeter and then the area. These were recorded on the chalkboard. Then the rectangular piece 12" by 8" was placed on the flannel board and both the perimeter and area were recorded. This was also done for the two pieces 14" x 6" and 16" x 4". Students were asked to observe the data and to draw a conclusion from what was revealed. They first said that the perimeter remained the same but that the area became smaller. Then they were asked to make a generalized statement about the relationship of shape and size. There were various responses but finally it was concluded that with perimeter being constant in rectangular figures, the square yielded the greatest area.

The importance of this generalization was stressed for general education by means of questions and also the pursuit of where it might be of great value in life. The application of the generalizations to life situations was a common class procedure, usually designed for extending the students' abilities to apply them.



	PERIMETER	AREA
10" × 10"	40"	100 SQ IN
12" × 8"	40"	96 SQ IN
14" × 6"	40"	84 SQ IN
16" × 4"	40"	64 SQ IN
18" × 2"	40"	36 SQ IN

FIGURE 12. MAXIMA AND MINIMA

Throughout this section an attempt has been made to give an idea of the nature of the experimental instructional method. Examples of selected class presentations including reproductions of the graphical representations used have been given. Although there was never an objective test of the effectiveness of the use of the graphical materials during the course, it was believed that the students were being provided a better than usual opportunity for visualizing, thinking, and learning. At the end of the experiment, tests were given to both the experimental and control groups to determine the effects of the experimental method. The results are reported next.

Analysis of End-Test Data

The experimental and control groups were re-tested at the end of the quarter in which the classroom experiment was conducted. The measurement instruments used as end-tests were: (1) the same form of the comprehensive achievement test in educational psychology that was given as a pre-test, (2) the Watson-Glaser Critical Thinking Appraisal, Form ZM, (3) the Differential Aptitude Test, "Abstract Reasoning," Form B, and (4) the Differential Aptitude Test, "Mechanical Reasoning," Form B.

The raw score end-test data obtained were programmed for the IBM 1620 electronic computer after which the analysis of variance test (F-test)[10] and the test for analysis of difference between means (t-test)[11].

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[10] See footnote 3, page 80.

[11] See footnote 4, page 80.

were applied in the same manner as when analyzing the pre-test data. The same level of significance, .01, was also used in all data interpretations.

The data from the Watson-Glaser Critical Thinking Appraisal indicated that there was no significant difference between the experimental and control groups in the ability to think critically at the end of the experiment. This is shown in Table 5.

The analysis of variance test, F-test, of the results of the Differential Aptitude Test, "Abstract Reasoning" was significant. This indicated that the variance among the test results of the experimental and control groups was too great for the analysis of difference test, t-test, between the two means to be valid. See Table 5.

There was no significant difference between the mean achievement of the two groups in the ability to reason on mechanical problems as measured by the Differential Aptitude Test, "Mechanical Reasoning." The significance values are given in Table 5.

In contrast to the results pertaining to critical thinking and reasoning, the end-test results on the educational psychology achievement test indicated significantly greater final achievement in educational psychology by students in the experimental group. As shown in Table 5, the mean score of the experimental group was 70.53 whereas the mean of the control group was 64.72. This difference in mean scores gave a "t" value of 3.03, significantly above the critical value of 2.63 at the .01 level.

TABLE 5. ANALYSES OF VARIANCE AND DIFFERENCE BETWEEN WATSON-GLASER CRITICAL THINKING APPRAISAL FORM ZM, DIFFERENTIAL APTITUDE TEST ABSTRACT REASONING FORM B, DIFFERENTIAL APTITUDE TEST MECHANICAL REASONING FORM B, AND EDUCATIONAL PSYCHOLOGY ACHIEVEMENT END-TEST MEAN SCORES OF EXPERIMENTAL GROUP E AND CONTROL GROUP C.

Group mean		"F" value*	Significance of "F" value at .01 level	"t" value**	Significance of "t" value at .01 level
Exper.	Control				
WATSON-GLASER					
69.94	66.32	1.24	not significant	2.01	not significant
DAT ABSTRACT					
43.53	41.14	2.80	significant	2.15	not valid
DAT MECHANICAL					
50.71	52.53	1.07	not significant	-.99	not significant
EDUC. PSYCH.					
70.53	64.72	1.09	not significant	3.03	significant

*Minimum critical value of "F" at .01 level is 2.10.

**Critical value of "t" at .01 level is 2.63.

It would appear from the results of the classroom experiment in educational psychology that the graphical representation of major ideas in a course which is taught for one academic quarter, approximately 10 weeks of instruction, does not significantly improve students' abilities to think critically or to reason in terms of mechanical applications. No conclusion could be drawn regarding improvement of the ability to reason abstractly because the variance among the abstract reasoning test results was too great. However, the experiment indicated a significant improvement in the learning of important ideas in the content of the course. It was assumed that this improvement was related to the graphical representation of the ideas of the course content since the other factors which might have an influence on learning were determined to be equal among the student groups studied in the classroom experiment.

Summary

An experimental study was conducted during winter quarter, 1965, in educational psychology at Montana State College to determine the effects of the graphical representation of the major ideas of the course on (1) final learning, (2) critical thinking, and (3) reasoning. Professors were assigned whose personal characteristics and instructional abilities had previously been determined comparable on the basis of final learning achievement of students in educational psychology.

The experimental and control groups of students were determined to be equivalent on the basis of selected criteria. These criteria were: (1) credits passed, (2) cumulative grade point average, (3) Minnesota

Scholastic Aptitude Test raw score, (4) American Council on Education Psychological Examination for College Freshmen "Q" and "L" raw scores, (5) educational psychology achievement pre-test raw score, (6) Watson-Glaser Critical Thinking Appraisal, Form YM, raw score, (7) Differential Aptitude Test, "Abstract Reasoning," Form L, raw score, and (8) Differential Aptitude Test, "Mechanical Reasoning," Form L, raw score.

The course instruction for both groups was based upon the same textbook and reference assignments pertaining to ten selected instructional areas: (1) introduction to educational psychology, (2) growth and development, (3) psychology of learning, (4) guidance of learning, (5) motivation, (6) memory, (7) transfer, (8) other mental processes--discrimination, generalization, perception, cognition, (9) individual differences, and (10) educational measurement. The only difference in the instructional method was the use of graphical representations in teaching the experimental group.

The experimental and control groups were retested at the end of the classroom experiment using the same form of the educational psychology achievement test, the Watson-Glaser Critical Thinking Appraisal, Form ZM, the Differential Aptitude Test, "Abstract Reasoning," Form B, and the Differential Aptitude Test, "Mechanical Reasoning," Form B. The test results indicated that the use of graphical representations selected to emphasize the major ideas in a course such as educational psychology may cause a significant improvement in final achievement in the course but does not appear to improve students' abilities to think critically or to reason

in terms of mechanical applications. Because the variance among the results on the "Abstract Reasoning" test was large, no conclusion could be drawn relating to the improvement of abstract reasoning abilities through the use of graphical representations.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The role of graphical representation in learning in this age of great technological advancement and automation is worthy of concern. Literature pertaining to education in present times reveals that a sound general education is necessary as a foundation for specialized education.

Summary

The problem of the study was composed of three phases: (1) to determine what has been reported about the nature of learning, (2) to determine what has been said about the nature of graphical representation and its relationship to learning, and (3) to determine the importance of graphical representation in a classroom learning situation. The first two phases were handled through an extensive review of pertinent literature. The third phase was investigated through an examination of the effects of the graphical representation of the major ideas in a course in educational psychology on (1) final learning, (2) critical thinking, and (3) reasoning.

Conclusions

The following conclusions concerning the relationship to and importance of graphical representation in learning were made on the basis of the review of literature:

1. Learning theorists are not in agreement as to definitions of learning, intellect, and the related area of ability and aptitude.

2. Intelligence is considered a variable factor in the learning process.

3. Similarity of content, contrast between content, contiguity of ideas, vividness of material, frequency of use, and recency of association are factors important in learning.

4. There is agreement to varying degrees among authorities that memory, perception, cognition, discrimination, generalization, and transfer are mental processes which affect learning.

5. Learning involves at least three major processes, concept formation, communication, and creativity. The mental processes are involved in each of these major processes.

6. Three known types of content, figural, symbolic, and semantic, are related to the learning process through intellect although the exact relationship is not known because the structure of intellect is purely theoretical.

7. The graphical representation of ideas tends to make learning an active process, meaningful, interesting, transferable, individualized, satisfying, and unified.

8. The teaching of general educational concepts can be done more effectively with more permanent learning and transfer resulting when graphical representations are used.

Two conclusions were drawn as a result of the classroom experiment. These were:

1. The graphical representation of the major ideas in a course may cause a significant improvement in final achievement in the course.

2. The graphical representation of the major ideas of a course such as educational psychology does not tend to cause significant improvement in students' abilities to think critically or to reason effectively in terms of mechanical applications.

Recommendations

The following recommendations were considered appropriate in the light of information revealed by the investigation:

1. Studies of the human learning process should be intensified, especially through the use of experimental classroom teaching-learning situations.

2. Investigations should be made over a period of years under rigidly controlled circumstances to determine the impact that the use of graphical representations in teaching have upon the permanence of learning of basic concepts in each of the major subject-matter areas of general education.

3. There should be research in ways of teaching students how to think effectively in terms of transferring abilities learned in one subject-matter area to other areas.

4. Research should be implemented to ascertain the importance of transfer as a factor in the success of training and retraining persons for specialized occupations.

5. Studies should be conducted in an effort to determine any or all possible ways through which individuals' abilities to think critically and/or to reason effectively may be strengthened.

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APPENDIX

Appendix A

Thirty Test Items in Educational Psychology used to Compare the Effects on Final Learning Achievement of the Personal Characteristics of the Professors

THIRTY TEST ITEMS IN EDUCATIONAL PSYCHOLOGY USED TO COMPARE THE EFFECTS ON FINAL LEARNING ACHIEVEMENT OF THE PERSONAL CHARACTERISTICS OF THE PROFESSORS*

1. Insight may be defined as
   1. a set or orientation of the organism toward a given solution.
   2. a form of inspiration involved in creativity.
   3. a form of intuition closely related to instinct.
   4. a systematic application of the scientific method to the solution of a problem.
   5. a sudden reorganization of experience.

2. In most types of learnings, the final level of attainment is set primarily by
   1. the physical and physiological limitations within the learner.
   2. the learner's notion of what is adequate.
   3. the usefulness of the learning in the present and anticipated future.
   4. the time and opportunity available for practice.
   5. the limitations involved in the method or technique used.

3. The first step in the guidance of the learning of a complex skill is
   1. to make sure the learner has a clear understanding of the goal to be attained.
   2. to provide the learner with a good demonstration of what is expected.
   3. to give the learner confidence in his ability to do what is expected.
   4. to warn the learner against the possible mistakes he might make.
   5. to have the learner practice the subskills before attempting the total performance.

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*Test items were taken from Mouly, G. J., and Walton, L. E., Schaum's Outline of Test Items in Education, Schaum Publishing Co., New York and were used by permission of the publisher.

The mean correlation between achievement on this test and on the "Achievement Test in Educational Psychology" (see Appendix B) was .75. The correlation was determined after testing 277 students during five sessions.

4. Verbal guidance would be least effective in the learning of
   1. attitudes.
   2. concepts.
   3. facts.
   4. relationships.
   5. skills.

5. The form of guidance most appropriate in the development of meanings, concepts, and other complex ideas is:
   1. manual.
   2. kinesthetic.
   3. visual.
   4. verbal.
   5. a combination of the above in equal proportion.

6. Probably the most effective way of learning a complex and complicated skill is
   1. to practice the whole skill over and over.
   2. to practice each part of the skill separately.
   3. to practice the whole skill with separate attention to parts where indicated.
   4. to alternate between practice on the whole and on the parts.
   5. to integrate part by part into a continuous performance before proceeding to the next part.

7. Which of the following generalizations with respect to organization of learning material is safest in the light of our present knowledge?
   1. Any organization is preferable to chance order.
   2. Chance order arrangements are excellent because they require the pupil to do his own organizing.
   3. Logical organizations seem to promote more permanent learning.
   4. Psychological organization is most effective at all levels of instruction.
   5. Organization lies in the learner, not in the material.

8. The rules of mensuration in arithmetic are most effectively learned through
   1. systematic drill.
   2. incidental everyday experiences.
   3. specially selected meaningful experiences.
   4. a topic-by-topic approach to the study of arithmetic.
   5. a systematic procedure of laying out and measuring each geometric figure.

9. Perception can best be improved by
   1. concentrating on the differentiation of the total situation into its details.
   2. developing familiarity with the general framework into which the details of a given situation must fit.
   3. building resistance to distractions and irrelevant details.
   4. increasing one's sense of observation.
   4. developing interest in the situation.

10. A sensation that has attained awareness and some degree of meaning is known as
   1. a concept.
   2. a perception.
   3. a stimulus.
   4. an appreciation.
   5. an understanding.

11. When one pursues a year of French, then a year of German, and finds that his knowledge of German interferes with his recall of French, we call that interference
   1. associative inhibition.
   2. retroactive inhibition.
   3. synaptical inhibition.
   4. associative interference.
   5. experimental extinction.

12. Which of the following best explains the phenomenon of forgetting?
   1. the passage of time.
   2. the phenomenon of reminiscence.
   3. the phenomenon of interference.
   4. repression.
   5. negative transfer.

13. When facts are retained over unusually long periods of time, their permanence is probably best explained in terms of
   1. the absence of inhibition.
   2. the learner's intent to remember.
   3. the high intelligence of the learner.
   4. their recurrent use or application.
   5. thorough grasp by the learner.

14. In order to promote long-term retention, the teacher should
   1. carefully prevent the occurrence of mistakes.
   2. encourage cramming through periodic drill.
   3. encourage the memorization of material even if not thoroughly understood.
   4. reinforce the learning with the introduction of relatively similar material immediately after the learning.
   5. use the material in discussion and study of more advanced material.

15. To improve his ability to remember, one should
    1. cultivate efficient habits of acquiring.
    2. compose mnemonic devices.
    3. exercise mental discipline.
    4. practice memorizing difficult material.
    5. do none of the above; memory is a basic component of intelligence which is essentially unimprovable.

16. From the standpoint of the basic purpose for which the school exists, that learning is best which
    1. is based on habit formation.
    2. is greatly overlearned.
    3. is properly motivated.
    4. has maximum positive transfer value.
    5. results in maximum retention.

17. Transfer of training relies most heavily upon
    1. the intellectual status of the learner.
    2. the nature of the material.
    3. the method of presentation.
    4. the attitude of the learner.
    5. meaningfulness and generalization of experience.

18. With respect to the training of observational ability, modern psychologists hold that
    1. a faculty of observation can be trained.
    2. general skills and attitudes helpful in observation can be cultivated.
    3. only in the case of persons with very low level of observational ability can improvement be expected.
    4. such training is relatively impossible.
    5. most people have had ample opportunity to train whatever observational competence of which they are capable so that further improvement is rarely to be expected.

19. The general consensus on the inclusion of Latin in the high school curriculum is that
    1. Latin has been shown superior in transfer value to nearly all other high school subjects.
    2. the emphasis on Latin in the high school is based on a mistaken notion of the part of the lay public of its disciplinary value.
    3. the transfer value of Latin, like that of any subject, depends on the way it is taught.
    4. Latin should be made a requirement for college entrance since students who have taken Latin do better in college.
    5. Latin can be justified as a high school subject on the basis of its disciplinary value alone.

20. Transfer from a course in science is best promoted through
    1. emphasizing a thorough grasp of facts.
    2. illustrating the use of the scientific method.
    3. generalizing the findings of science.
    4. emphasizing the experimental approach.
    5. orienting the course to the nature of proof.

21. In a problem-solving approach to learning, the first step in the learning process would be
    1. to select the materials to be studied.
    2. to identify a problem to be attacked.
    3. to develop the hypotheses to be tested.
    4. to collect the evidence to be processed.
    5. to set forth certain tentative solutions.

22. In problem solving, it is generally wise to lay the problem aside temporarily when
    1. fatigue or frustration sets in.
    2. the learner has a clear idea of the problem.
    3. the problem is difficult.
    4. the learner is working on a fruitless lead as a result of the wrong mind-set.
    5. reasonable effort does not produce a solution.

23. The one essential condition for problem-solving to be effective is that
    1. the parts be presented in an organized way.
    2. some degree of trial and error take place.
    3. some degree of guidance be given.
    4. the parts be within the understanding and experience of the learner.
    5. the approach follow Dewey's steps of scientific reasoning.

24. One of the most important ways of fostering problem solving on the part of students is
    1. to refuse to give or to accept pat answers.
    2. to stimulate the formulation of a critical attitude.
    3. to emphasize problems that are real to them.
    4. to provide them with formal reasoning techniques.
    5. to enroll them in "stiff" academic courses.

25. A word is
    1. an abstraction.
    2. a concept.
    3. a generalization.
    4. an object.
    5. a symbol.

26. Which of the following teaching procedures is most conducive to the development of clear concepts?
    1. the presentation of as many details as possible.
    2. the presentation of clear-cut definitions to be memorized.
    3. the thorough analysis and study of separate parts.
    4. a systematic beginning-to-end presentation of the concepts.
    5. a varied presentation involving different sources and different approaches.

27. In what way does the curriculum maker contribute most to improving the degree of clarity of the concepts which the child has to develop?
    1. By simplifying the vocabulary through which the concepts are presented.
    2. By delaying the introduction of a given concept till the child has had more opportunity to develop readiness.
    3. By providing for repetition of the same concept at different levels of the curriculum.
    4. By providing systematic experiences designed to stimulate the intellectual growth of the child.
    5. By providing a systematic sequence of experiences graduated to build one concept upon another.

28. In the teaching of content subjects, the primary emphasis should probably be upon
    1. individual facts and skills.
    2. principles and generalizations.
    3. attitudes and values.
    4. recent developments.
    5. application to related fields.

29. Problem-solving differs from creative thinking in that
    1. creative thinking is original and independent of past experience.
    2. creativity is spontaneous and instantaneous.
    3. problem-solving involves trial-and-error.
    4. problem-solving requires a somewhat lower level of ingenuity, brilliance, scholarship, and flexibility.
    5. the "solution" in creative thinking is somewhat more novel and less defined by the problem.

30. Inspiration in creative thinking is similar to
    1. trial and error in learning.
    2. insight in problem solving.
    3. secondary conditioning in the learning of attitudes.
    4. concept formation in thinking.
    5. reinforcement in contiguous conditioning.

Appendix B

Achievement Test in Educational Psychology and Index of the Publisher, Author, Book Title, Chapter, Page, and Question Number for Each Item in the Test

ACHIEVEMENT TEST IN EDUCATIONAL PSYCHOLOGY

* * * * * * * * * * * * * * *

AREAS MEASURED BY TEST

Introduction to Educational Psychology

Growth and Development

Psychology of Learning

Guidance of Learning

Motivation

Memory

Transfer

Other Mental Processes

Individual Differences

Educational Measurement

* * * * * * * * * * * * * * *

Directions: All answers are to be marked on the separate answer sheet provided. Print your name and other information on the answer sheet only. Use only the pencils provided by the examiner when marking the answer sheet. Make neat, solid marks which completely fill in the spaces on the answer sheet. Erase cleanly if you wish to change an answer. Make sure your answers are in the proper space. The spaces are numbered from left to right across the sheet.

DO NOT MAKE ANY MARKS IN THIS BOOKLET

1. The major concern of educational psychology is
   1. growth and development.
   2. attitudes and ideals.
   3. learning.
   4. adjustment problems.

2. The emphasis upon psychology (the science of human behavior) in teacher education is best justified on the basis of the need
   1. to prevent abnormal behavior on the part of children.
   2. to promote intelligent behavior on the part of children.
   3. to understand human behavior (if one is to guide its development).
   4. to define what constitutes acceptable behavior.
   5. to promote greater philosophical and sociological insights into the nature of man.

3. General psychology and educational psychology are dissimilar in that educational psychology
   1. is concerned with the child and not with the adult.
   2. is concerned only with the various aspects of learning.
   3. selects and emphasizes certain data from the general field.
   4. is the more inclusive science.
   5. deals only with the applications and not with the theory.

4. Educational psychology is oriented toward
   1. the study of the peculiarities of individual children.
   2. the application of the principles and techniques of psychology to the solution of the problems of the classroom.
   3. the formulation of hypotheses and theories relative to educational practice.
   4. the development of pedagogical practices of maximum effectiveness.
   5. the development on the part of the child of realistic goals and effective plans for their attainment.

5. The primary task of the teacher is
   1. to teach the prescribed curriculum.
   2. to stimulate and guide student learning.
   3. to ensure that all students belong to socially acceptable peer groups.
   4. to promote habits of conformity to adult demands and expectations.
   5. to provide diagnostic and remedial aid wherever indicated.

6. In an experiment, the investigator attempts to have a control group which is
   1. identical in all respects to the experimental group.
   2. identical in all respects to the experimental group, except for the factor under study.
   3. different in all respects from the experimental group.
   4. opposite in all respects to the experimental group except for the factor under study.
   5. identical in all relevant respects to the experimental group except for the factor under investigation.

7. As the individual improves in a skilled performance, he uses
   1. fewer cues to guide each response.
   2. more cues to guide each response.
   3. more obvious cues to guide each response.
   4. no cues to guide his responses.

8. Active practice of a skill in itself
   1. guarantees eventual expertness.
   2. insures that some progress will be made continuously.
   3. provides opportunity for improving the performance.
   4. insures stability of performance under stress.

9. Developmental tasks pose difficulty for children because of the discrepancy between
   1. the expectancies of school and home.
   2. the abilities of boys and girls.
   3. the demands of different teachers.
   4. the child's readiness and society's expectations.

10. Maturation refers to
   1. the changes in behavior resulting from the effects of environmental forces upon inherited structure.
   2. the developmental level necessary for effective response to attempts at training.
   3. that phase of development which relates to the unfolding of whatever characteristics are incorporated in the genes.
   4. the attainment of final status in any one or more of the aspects of growth and development.
   5. those aspects of physical growth due to inherited potential.

11. The success of a learning experience from an overall modern educational point of view depends primarily upon:
   1. the readiness of the learner.
   2. the atmosphere of the learning situation.
   3. the personality of the teacher.
   4. the motivation of the learner.
   5. the degree of participation of the learner.

12. The reason effective teaching of a new topic calls for checking into what the class already knows about related material is
   1. to avoid unnecessary duplication.
   2. to use it as a starting point for further learning.
   3. to give the students a sense of accomplishment and progress.
   4. to increase their interest in the new material.
   5. to provide the necessary remedial work so that everyone starts at the same point.

13. On which of the following bases is play as part of the high school program best justified?
    1. the release of surplus energy.
    2. the release of tension.
    3. preparation for a career in sports.
    4. the promotion of pupil growth in areas not adequately met in the more academic program.
    5. need satisfaction for non-scholars.

14. Probably the greatest reason for the effectiveness of the democratic classroom atmosphere is that
    1. it puts the individual member on the spot to perform his best for the good of the group.
    2. it harmonizes with the favorable attitudes the student has already developed with respect to democracy.
    3. it permits mutual (inter-learner) support and reinforcement.
    4. it enables the stronger students to carry a greater share of the burden of class undertakings.
    5. it enables the learner to relate class activities to his particular motives and purposes.

15. The primary purpose of sociometric techniques is
    1. to appraise group structure.
    2. to appraise individual popularity.
    3. to appraise the personal and social adjustment of students.
    4. to identify potential leaders.
    5. to prevent the formation of cliques.

16. In practice the greatest contribution of intelligence tests is to give an index of the individual's
    1. vocabulary.
    2. specific aptitudes.
    3. educational potentiality.
    4. academic competence.
    5. intellectual curiosity.

17. Insight may be defined as
    1. a set or orientation of the organism toward a given solution.
    2. a form of inspiration involved in creativity.
    3. a form of intuition closely related to instinct.
    4. a systematic application of the scientific method to the solution of a problem.
    5. a sudden reorganization of experience.

18. In most types of learnings, the final level of attainment is set primarily by
    1. the physical and physiological limitations within the learner.
    2. the learner's notion of what is adequate.
    3. the usefulness of the learning in the present and anticipated future.
    4. the time and opportunity available for practice.
    5. the limitations involved in the method or technique used.

19. The bulk of man's response repertoire is
    1. instinctive.
    2. unlearned.
    3. acquired.
    4. similar to that of lower animals.

20. Which learning outcome is associated primarily with cognitive abilities?
    1. psychomotor skills.
    2. social skills.
    3. speech production.
    4. concepts.
    5. interests and attitudes.

21. Learning through conditioning can occur
    1. without understanding by the learner of the response being conditioned.
    2. only when the learner has a purpose for learning the response.
    3. without the use of reward or punishment.
    4. when the stimulus and response are widely separated in time.

22. A principle is
    1. an event, an actual state of affairs.
    2. the meanings an individual associates with words or other symbols.
    3. a generalization that implies action.
    4. knowledge about classifications and theories.

23. In finding new relationships, an individual usually
    1. modifies partially developed concepts.
    2. develops completely new concepts.
    3. does not utilize concepts.
    4. develops an explicit statement of principles.

24. A concept can be developed best by
    1. repeating the same experiences related to it.
    2. extending the range and variety of experiences related to it.
    3. verbalizing about it.
    4. thinking of appropriate illustrations of it.

25. Which of the following act primarily as sets or predeterminers of what will be learned in a new situation?
    1. facts and information.
    2. psychomotor skills.
    3. concepts and generalizations.
    4. attitudes and interests.
    5. methods of learning.

26. Which of the following types of activity is more characteristic of human learning than of learning in lower animals?
    1. symbolic.
    2. motor.
    3. sensory.
    4. motivated.

27. The reason attitudes may be more enduring than other forms of learning is that
    1. attitudes generally have an illogical basis.
    2. they are formed early in life.
    3. they are frequently learned through imitation.
    4. selective perception of what a person wants to see keeps them alive.

28. In memorizing poems, parts in plays, and musical selections, it is most efficient to study the selections
    1. as wholes.
    2. as series of small parts.
    3. in the largest meaningful units within the learner's capacity.
    4. in any of these ways.

29. Outlines, diagrams, pictures, models, and slow-motion films facilitate learning mainly by
    1. encouraging self-recitation.
    2. making response-guiding cues more identifiable.
    3. enhancing pupil interest.
    4. making abstract concepts concrete.

30. Modern educators are accepting more and more the notion that the time to learn a skill is
    1. in the early years when the mind is pliable.
    2. when the required readiness is attained.
    3. when it is needed by the individual.
    4. when other children are learning it.
    5. when opportunity for effective guidance and supervision becomes available.

31. The "sudden discovery of means-end relationships" in problem solving is generally known as
    1. perception.
    2. insight.
    3. intuition.
    4. hypothesis.
    5. inspiration.

32. Probably the most important of the following determinants of the effectiveness of learning is
    1. the method of presentation.
    2. the degree of meaningfulness and understanding.
    3. the concentration of the learning periods.
    4. the degree of overlearning.
    5. the atmosphere of the learning situation.

33. With which of the following aspects of learning are teachers and psychologists most directly concerned?
    1. the products of learning.
    2. the process of learning.
    3. the development of habits.
    4. the avoidance of errors.
    5. the accumulation of knowledge.

34. The real goal of the learning process is
    1. the acquisition of facts and skills
    2. the assimilation of knowledge.
    3. the development of attitudes.
    4. the application of knowledge and skills.
    5. the determination of future behavior.

35. The first step in the guidance of the learning of a complex skill is
    1. to make sure the learner has a clear understanding of the goal to be attained.
    2. to provide the learner with a good demonstration of what is expected.
    3. to give the learner confidence in his ability to do what is expected.
    4. to warn the learner against the possible mistakes he might make.
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    3. building resistance to distractions and irrelevant details.
    4. increasing one's sense of observation.
    5. developing interest in the situation.

42. A sensation that has attained awareness and some degree of meaning is known as
    1. a concept.
    2. a perception.
    3. a stimulus.
    4. an appreciation.
    5. an understanding.

43. Prompt and complete knowledge of one's progress
    1. facilitates learning.
    2. increases anxiety.
    3. impedes learning.
    4. interferes with motivation.

44. The teacher most effectively increases student efficiency in learning facts by
    1. delaying the reinforcement of a response until the learner is sure of himself.
    2. reinforcing a correct response immediately following the response.
    3. telling the learner when he has made an incorrect response.
    4. reinforcing all responses, correct and incorrect, thus giving the learner encouragement to continue trying.

45. The first job of the teacher in guiding purposeful learning is to
    1. demonstrate the correct performance of the task.
    2. help the learner set a realistic goal in connection with the task.
    3. help the learner assess the learning situation.
    4. help the learner apply previous learnings to the present task.
    5. reinforce the learner's correct responses and help him overcome inadequate ones.

46. The foremost reason why a teacher should try to discover the origin of specific interests is
    1. that he can thus determine whether or not interests fulfill a good purpose.
    2. to discover what in his teaching may have stimulated these interests.
    3. that he can then plan activities in terms of the basic needs behind these interests.
    4. to encourage the specificity of interests.

47. Recent studies of learning suggest that the following practice should be emphasized in schools
    1. mental discipline.
    2. teaching of relationships.
    3. drill.
    4. memorization.

48. The extent to which transfer of training occurs as a result of studying any school subject is most dependent upon the
    1. size of the class.
    2. age of the students.
    3. length of time the subject is studied.
    4. way the subject is taught.
    5. interests of the students.

49. The best learning procedure in teaching children is to have them
    1. read about the way an activity can be performed.
    2. write about the way an activity can be performed.
    3. see an activity as it is being performed.
    4. perform the activity themselves.
    5. discuss the way an activity can be or has been performed.

50. Whether or not practice leads to learning depends primarily on
    1. the intensity of the learner's motivation.
    2. the frequency and distribution of the practice periods.
    3. the learner's attention and concentration during practice.
    4. the success or failure of the responses from the standpoint of the attainment of the goal.
    5. the reinforcement of chance responses.

51. The most effective type of practice is that in which the learner
    1. is completely on his own.
    2. uses his learnings in the solution of more advanced problems.
    3. attains a high degree of perfection.
    4. is carefully prevented from making mistakes.
    5. is relatively unconcerned as to the outcome.

52. If a person's anxiety level becomes very high
    1. irrelevant and nonadaptive responses are likely to occur.
    2. he does better on intelligence tests requiring intense concentration.
    3. he improves in performance of a task when criticized.
    4. he develops considerable stress tolerance.

53. The studies on level of aspiration suggest that teachers should set tasks for children which are
    1. difficult to achieve.
    2. easily achieved.
    3. within the range of challenge.
    4. likely to overmotivate them.

54. School failure generally
    1. provides a challenge for a child to improve his performance.
    2. is an effective motivational technique for many children.
    3. results in a more realistic level of aspiration.
    4. produces negative attitudes toward school.

55. Which is the best guide for the teacher to follow in classroom motivation?
    1. Competitive activity is necessary in most classrooms.
    2. Firm but kindly discipline promotes zestful learning.
    3. Every classroom activity should lead to goals which students want to attain.
    4. Every classroom activity should be planned by the students to encourage realistic goal setting.

56. Teaching machines have their greatest motivational effect in that they provide
    1. an immediate sense of accomplishment.
    2. a good atmosphere for competition.
    3. closer relations between teacher and pupil.
    4. easy questions.

57. The end state which gives direction to motivated behavior is called.
    1. a purpose.
    2. an incentive.
    3. a motive.
    4. a goal.
    5. a need.

58. For learning to be effective, a goal must be meaningful in terms of
    1. the curricular objectives.
    2. the intellectual ideas involved.
    3. the learner's needs and purposes.
    4. the teacher's plans.
    5. the standards of the school.

59. Most differences in interests among individuals are the product of differences in
    1. age.
    2. sex.
    3. experiential background.
    4. opportunity.
    5. potentiality.

60. In developing a new topic or lesson, the teacher should begin with
    1. an overview of the subject.
    2. some interest already possessed by the student.
    3. the teacher's own interest.
    4. an explanation of the importance of the subject.
    5. a systematic step-by-step progress through the material.

61. The differences in the interests of boys and girls stem primarily from differences in
    1. instinctive predispositions.
    2. cultural pressures.
    3. endocrine balance.
    4. biological factors such as size, strength, etc.
    5. environmental opportunities.

62. Which of the following statements best describes the role of punishment as a tool in the hands of the teacher?
    1. It is effective in promoting good classroom discipline.
    2. It is most effective as a motivational device.
    3. Its overuse is likely to arouse anxieties which will reduce learning efficiency and cause the individual to cease trying.
    4. It is effective in developing in children desirable attitudes of respect for authority.
    5. It is effective only when it is impersonal, e.g., the child suffering the natural consequence of his misbehavior.

63. When one pursues a year of French, then a year of German, and finds that his knowledge of German interferes with his recall of French, we call that interference
    1. associative inhibition.
    2. retroactive inhibition.
    3. synaptical inhibition.
    4. associative interference.
    5. experimental extinction.

64. Which of the following best explains the phenomenon of forgetting?
    1. the passage of time.
    2. the phenomenon of reminiscence.
    3. the phenomenon of interference.
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65. When facts are retained over unusually long periods of time, their permanence is probably best explained in terms of
    1. the absence of inhibition.
    2. the learner's intent to remember.
    3. the high intelligence of the learner.
    4. their recurrent use or application.
    5. thorough grasp by the learner.

66. In order to promote long-term retention, the teacher should
    1. carefully prevent the occurrence of mistakes.
    2. encourage cramming through periodic drill.
    3. encourage the memorization of material even if not thoroughly understood.
    4. reinforce the learning with the introduction of relatively similar material immediately after the learning.
    5. use the material in discussion and study of more advanced material.

67. To improve his ability to remember, one should
    1. cultivate efficient habits of acquiring.
    2. compose mnemonic devices.
    3. exercise mental discipline.
    4. practice memorizing difficult material.
    5. do none of the above; memory is a basic component of intelligence which is essentially unimprovable.

68. The selection, elimination, and addition of certain aspects of one's experiences to memory is called
    1. retroactive inhibition.
    2. assimilation.
    3. proactive inhibition.
    4. repression.

69. When new learning interferes with the retention of old learning, we have
    1. evidence of the deterioration of the memory traces.
    2. retroactive inhibition.
    3. repression.
    4. assimilation.

70. Which of the following generalizations is, in the light of our present knowledge, the clearest statement of the relationship of the speed of learning to the permanence of learning?
    1. Fast learning is like cramming: "easy-come, easy-go."
    2. Slow learners remember material longer.
    3. Fast learners tend to remember best.
    4. There is little relationship between speed of learning and degree of retention.
    5. The relationship is so complex as to be incapable of generalization.

71. Retroactive inhibition refers to
    1. the forgetting which results from repression.
    2. the interference of a given learning by subsequent learnings.
    3. the gradual decline in learning ability and retention occurring in old age.
    4. the interfering effects of conflicting motives upon acquisition.
    5. the negative transfer of certain learnings upon the acquisition of subsequent learnings.

72. The basic reason why meaningful material is learned rapidly is that
    1. the learner is less likely to become bored.
    2. it is related to previous experiences of the learner.
    3. it has continuity and meaning inherent in itself.
    4. it is less susceptible to delayed forgetting.
    5. it permits more effective transfer.

73. From the standpoint of the basic purpose for which the school exists, that learning is best which
    1. is based on habit formation.
    2. is greatly overlearned.
    3. is properly motivated.
    4. has maximum positive transfer value.
    5. results in maximum retention.

74. Transfer of training relies most heavily upon
    1. the intellectual status of the learner.
    2. the nature of the material.
    3. the method of presentation.
    4. the attitude of the learner.
    5. meaningfulness and generalization of experience.

75. With respect to the training of observational ability, modern psychologists hold that
    1. a faculty of observation can be trained.
    2. general skills and attitudes helpful in observation can be cultivated.
    3. only in the case of persons with very low level of observational ability can improvement be expected.
    4. such training is relatively impossible.
    5. most people have had ample opportunity to train whatever observational competence of which they are capable so that further improvement is rarely to be expected.

76. The general consensus on the inclusion of Latin in the high school curriculum is that
    1. Latin has been shown superior in transfer value to nearly all other high school subjects.
    2. the emphasis on Latin in the high school is based on a mistaken notion of the part of the lay public of its disciplinary value.
    3. the transfer value of Latin, like that of any subject, depends on the way it is taught.
    4. Latin should be made a requirement for college entrance since students who have taken Latin do better in college.
    5. Latin can be justified as a high school subject on the basis of its disciplinary value alone.

77. Transfer from a course in science is best promoted through
    1. emphasizing a thorough grasp of facts.
    2. illustrating the use of the scientific method.
    3. generalizing the findings of science.
    4. emphasizing the experimental approach.
    5. orienting the course to the nature of proof.

78. When previous learning facilitates new learning, we speak of
    1. reproductive facilitation.
    2. positive transfer.
    3. negative transfer.
    4. retroactive facilitation.

79. Greater transfer from subject matter can be achieved by
    1. routine drill.
    2. memorization of facts and formulas.
    3. deliberate teaching for transfer.
    4. having subject matter extensively and logically organized.

80. The ability to generalize experience and to perceive relationships between two situations are in all probability functions of
    1. mental set.
    2. motivation.
    3. intelligence.
    4. proper attitudes.

81. When there is similarity or identity between two situations,
    1. transfer will be made from one situation to the other.
    2. the identity must be perceived and appreciated by students for transfer to occur.
    3. there is little need for practice or exercise in identifying similarities in various situations.
    4. the development of attitudes favorable to discovering becomes of less significance.

82. A major responsibility in teaching for transfer is to
    1. help students find applications of their present learning to new situations.
    2. point out elements in new situations that are similar to past situations.
    3. point out one common element in large number of activities.
    4. show that transfer will help develop good attitudes.

83. When a teacher directs his pupils to search their daily environment for new applications of a concept or skill they have learned, he facilitates transfer mainly by leading them to
    1. generalize.
    2. make varied applications.
    3. establish a set for transfer.
    4. review the concepts or skills.

84. Research on the subject of transfer of training suggests that
    1. transfer can be expected to occur in worthwhile amounts in nearly all learning situations.
    2. transfer, almost without exception, occurs in a positive direction.
    3. transfer does not occur automatically but must be deliberately provided for.
    4. the amount of transfer that takes place depends on the approach to the learning situation and is independent of the characteristics of the learner.
    5. the amount of transfer that takes place depends on the nature of the situations involved and is independent of the approach to the learning and the characteristics of the learner.

85. Unified or integrated social studies courses represent a more realistic approach to the understanding of today's complex problems since they permit the student
    1. to discriminate between meaningless facts and well-defined generalizations.
    2. to acquire knowledge that clearly differentiates between the contents of academic subjects.
    3. to see a problem in terms of other related problems, situations, or circumstances.
    4. to devote longer blocks of time to the subject without interruption.
    5. to get a more consistent viewpoint (from one single instructor).

86. In a problem-solving approach to learning, the first step in the learning process would be
    1. to select the materials to be studied.
    2. to identify a problem to be attacked.
    3. to develop the hypotheses to be tested.
    4. to collect the evidence to be processed.
    5. to set forth certain tentative solutions.

87. In problem solving, it is generally wise to lay the problem aside temporarily when
    1. fatigue or frustration sets in.
    2. the learner has a clear idea of the problem.
    3. the problem is difficult.
    4. the learner is working on a fruitless lead as a result of the wrong mind-set.
    5. reasonable effort does not produce a solution.

88. The one essential condition for problem-solving to be effective is that
    1. the parts be presented in an organized way.
    2. some degree of trial and error take place.
    3. some degree of guidance be given.
    4. the parts be within the understanding and experience of the learner.
    5. the approach follow Dewey's steps of scientific reasoning.

89. One of the most important ways of fostering problem solving on the part of students is
    1. to refuse to give or to accept pat answers.
    2. to stimulate the formulation of a critical attitude.
    3. to emphasize problems that are real to them.
    4. to provide them with formal reasoning techniques.
    5. to enroll them in "stiff" academic courses.

90. A word is
    1. an abstraction.
    2. a concept.
    3. a generalization.
    4. an object.
    5. a symbol.

91. Which of the following teaching procedures is most conducive to the development of clear concepts?
    1. the presentation of as many details as possible.
    2. the presentation of clear-cut definitions to be memorized.
    3. the thorough analysis and study of separate parts.
    4. a systematic beginning-to-end presentation of the concepts.
    5. a varied presentation involving different sources and different approaches.

92. In what way does the curriculum maker contribute most to improving the degree of clarity of the concepts which the child has to develop?
    1. By simplifying the vocabulary through which the concepts are presented.
    2. By delaying the introduction of a given concept till the child has had more opportunity to develop readiness.
    3. By providing for repetition of the same concept at different levels of the curriculum.
    4. By providing systematic experiences designed to stimulate the intellectual growth of the child.
    5. By providing a systematic sequence of experiences graduated to build one concept upon another.

93. In the teaching of content subjects, the primary emphasis should probably be upon
    1. individual facts and skills.
    2. principles and generalizations.
    3. attitudes and values.
    4. recent developments.
    5. application to related fields.

94. Problem-solving differs from creative thinking in that
    1. creative thinking is original and independent of past experience.
    2. creativity is spontaneous and instantaneous.
    3. problem-solving involves trial-and-error.
    4. problem-solving requires a somewhat lower level of ingenuity, brilliance, scholarship, and flexibility.
    5. the "solution" in creative thinking is somewhat more novel and less defined by the problem.

95. Inspiration in creative thinking is similar to
    1. trial and error in learning.
    2. insight in problem solving.
    3. secondary conditioning in the learning of attitudes.
    4. concept formation in thinking.
    5. reinforcement in contiguous conditioning.

96. Perceiving, remembering, recognizing, conceiving, judging, and reasoning are all processes included in
    1. instrumental conditioning.
    2. cognitive learning.
    3. trial and error learning.
    4. classical conditioning.

97. Convergent thinking differs from divergent thinking in that
    1. retention of what is cognized is essential.
    2. rediscovery or recognition is essential.
    3. the process leads to a right or conventional answer.
    4. the process leads to production.

98. Problem-solving and purposeful learning
    1. are fundamentally different.
    2. involve psychomotor abilities primarily.
    3. involve cognitive abilities primarily.
    4. involve a high level of divergent thinking.

99. The degree of meaningfulness of a problem to an individual depends primarily on
    1. the method in which the problem is presented to him.
    2. the amount of training and practice that he has had in problem-solving.
    3. his level of aspiration.
    4. his past experiences in relation to the problem.

100. In his approach to a difficult, unfamiliar problem, the child usually
1. generalizes as well as he can from his past experience, a probable solution.
2. avoids inventive extensions of previous generalizations.
3. structures the problem more complexly.
4. does all of the foregoing.

101. The most important single reason underlying the greater effectiveness of the reasoning of adults by contrast to that of adolescents is
1. their greater intellectual capacity.
2. their greater store of past experience which may be symbolized.
3. their greater objectivity in thought.
4. their more scientific approach.
5. their greater relative freedom from prejudice and other forms of emotional distortion.

102. It can safely be assumed that a student understands a principle when he can
1. repeat it verbally.
2. give examples of it.
3. use it in solving unfamiliar problems to which it applies.
4. recognize it as familiar when he encounters it again.
5. answer specific objective-type questions connected with it.

103. Research on the teaching of arithmetic has shown that
1. specific instruction on details produces superior results.
2. emphasis upon meaningful generalizations produces superior results.
3. all methods of teaching arithmetic are essentially equally effective.
4. repetitive drill combined with specific instruction produces superior results.
5. the only method found to be superior is that of informal arithmetic in the primary grades.

104. The greatest deterrent to creativity on the part of the child is:
1. adult insistence on perfection and conformity to adult standards.
2. failure on the part of adults to provide the needed inspiration.
3. his immaturity in appreciating the value of creativity.
4. his unwillingness to put in the effort required for perfection.
5. his easy discouragement and his short span of attention.

105. Regarding sex differences in relation to intelligence,
1. boys exceed girls in numerical ability from first grade on through college.
2. girls are superior to boys in linguistic ability from early childhood.
3. tests of general intelligence tend to yield average total scores for both sexes that are not significantly different.
4. all of the above are correct.

106. The combination of provisions for the gifted most applicable to a large variety of school situations is
1. enrichment and special schools.
2. enrichment and sectioning.
3. acceleration and special classes.
4. acceleration and enrichment.
5. sectioning and special classes.

107. As a result of schooling, individual differences in abilities and achievements will
1. increase with age.
2. decrease with age.
3. increase in range but not in kind.
4. decrease with age increase, but increase in specificity.

108. Individual differences are best taken care of in the classroom by
1. a sound acceleration and promotional policy.
2. a flexible program geared to individual needs.
3. an instructional program geared to the level of the lowest quarter of the class.
4. a systematic assignment of homework as a means of having the slower members keep up with the class.
5. an orientation of the curriculum toward the attainment of minimum essentials.

109. The extent to which a test measures what it purports to measure constitutes its
1. reliability.
2. validity.
3. standard deviation.
4. coefficient of correlation.

110. Which word is most synonymous in meaning to reliability?
1. intent
2. knowledge
3. consistency
4. difficulty

111. One distinct advantage of the essay examination is
1. it enables students to get practice in organizing their thoughts and presenting them logically.
2. it insures adequate sampling of the material.
3. its reliability is likely to be higher.
4. validity coefficients can more readily be derived.

112. The most obvious advantage of objective tests is that of
1. adequate sampling.
2. ease in preparing the test.
3. giving students practice in organizing their thoughts.
4. requiring critical thinking on the part of students.

113. The most frequently occurring value or score in a distribution of scores is designated the
1. mean.
2. median.
3. mode.
4. z-score.

114. The measure of central tendency to avoid if, for any reason, one wishes to avoid the influence of extreme scores is
1. the mean.
2. the median.
3. the mode.
4. the quartile.
5. the standard deviation.

115. The statistical concept of correlation expresses
1. a direct cause-effect relationship.
2. predictability in the individual case.
3. predictability as a group phenomenon.
4. the relative absence of extraneous factors.
5. the composite mathematical relationship among multiple variables.

TABLE 6. INDEX OF THE PUBLISHER, AUTHOR, BOOK TITLE, CHAPTER, PAGE, AND QUESTION NUMBER FOR EACH ITEM IN THE ACHIEVEMENT TEST IN EDUCATIONAL PSYCHOLOGY.

Achievement test item	Publisher	Author	Book title	Chapter	Page	Question
1	Allyn and Bacon, Inc.	Jandron, Earl L.	Student Guide with Programed Units to Accompany Sawrey and Telford's Educational Psychology, Second Ed.	1	10	2
19				4	47	2
43				6	70	9
52				9	104	20
53				10	114	20
54				11	125	10
68				7	82	16
69				7	83	19
78				8	92	10
79				8	93	14
80				8	93	17
81				8	93	19
96				5	59	3
105				14	163	15
109				13	150	1
110				13	150	4
111				13	151	9
112				13	151	11
7	Harper & Brothers	Klausmeier, Herbert J., with Richard Ripple	Instructor's Manual to Accompany Learning and Human Abilities	8	30	8
8				8	31	18
20				1	8	4
21				1	9	15
22				6	23	3
23				6	23	6
24				6	25	17
25				12	41	1
44				1	9	17
45				1	9	18
55				11	40	20
82				12	43	20

TABLE 6. (Continued)

Achievement test item	Publisher	Author	Book title	Chapter	Page	Question
97	Harper & Brothers (continued)	Klausmeier, Herbert J., with Richard Ripple	Instructor's Manual to Accompany Learning and Human Abilities	7	26	4
98				7	26	7
99				7	27	9
106				13	46	16
113				17	55	9
9	The Macmillan Co.	Blair, Glenn M.; Jones, R. Stewart; and Simpson, Ray H.	Instructor's Manual to Accompany Educational Psychology, Second Ed.	3	5	7
26				5	9	2
27				8	16	2
46				8	16	1
47				10	20	3
56				7	14	15
107				6	11	2
28	McGraw-Hill Book Company	Frandsen, Arden N.	Instructor's Manual for Educational Psychology: The Principles of Learning in Teaching	10	38	30
29				15	61	52
48				15	61	60
83				10	37	17
100				7	27	3
2	Schaum Publishing Company	Mouly, George J., and Walton, Lewis E.	Schaum's Outline of Test Items in Education	2	72	3
3				2	72	5
4				2	73	10
5				2	73	15
6				2	75	29
10				2	90	202
11				2	93	234
12				2	94	238
13				2	100	305
14				2	112	448
15				2	113	460
16				2	122	548

TABLE 6. (Continued)

Achievement test item	Publisher	Author	Book title	Chapter	Page	Question
17	Schaum Publishing Company (continued)	Mouly, George J., and Walton, Lewis E.	Schaum's Outline of Test Items in Education	2	136	719
18				2	139	746
30				2	135	699
31				2	136	720
32				2	137	721
33				2	137	724
34				2	192	1335
35				2	139	749
36				2	140	756
37				2	141	763
38				2	143	786
39				2	144	795
40				2	144	798
41				2	145	806
42				2	145	808
49				2	140	753
50				2	142	774
51				2	142	777
57				2	76	42
58				2	82	117
59				2	83	122
60				2	83	128
61				2	84	131
62				2	84	140
63				2	147	825
64				2	147	826
65				2	148	838
66				2	148	843
67				2	148	844
70				2	147	824
71				2	147	828
72				2	148	842

TABLE 6. (Continued)

Achievement test item	Publisher	Author	Book title	Chapter	Page	Question
73	Schaum Publishing Company (continued)	Mouly, George J., and Walton, Lewis E.	Schaum's Outline of Test Items in Education	2	150	855
74				2	151	868
75				2	152	882
76				2	153	890
77				2	153	892
84				2	152	880
85				2	153	896
86				2	154	906
87				2	154	908
88				2	155	917
89				2	155	918
90				2	156	925
91				2	156	932
92				2	156	933
93				2	157	941
94				2	158	951
95				2	158	956
101				2	154	904
102				2	155	920
103				2	157	942
104				2	158	949
108				2	166	1045
114				3	215	170
115				3	215	177

Appendix C

Tables

TABLE 7. LIBRARY REFERENCE LIST FOR EDUCATIONAL PSYCHOLOGY, WINTER, 1965

Author	Title
Association for Supervision and Curriculum Development	Human Variability and Learning
Association for Supervision and Curriculum Development	New Dimensions in Learning: A Multidimensional approach
Association for Supervision and Curriculum Development	Perceiving, Behaving, Becoming
Berelson, Bernard, and others	The Social Studies and the Social Sciences
Bloom, B. S.	Taxonomy of Educational Objectives, Handbook I, Cognitive Domain
Bruner, J. S.; Goodnow, J. J.; and Austin, G. A.	A Study of Thinking
Croft Educational Services (Publisher)	"The Teaching of Concepts and Attitudes," Professional Growth for Teachers
Cronbach, L. J.	Educational Psychology, Second edition
Crow, L. D., and Crow, Alice	Readings in Human Learning
DeCecco, J. P., editor	Human Learning in the School
DuBridge, L. A.	"Physics," NEA Journal
Frandsen, A. N.	Educational Psychology: The Principles of Learning in Teaching
Franks, Milford, editor	Creative Activities for Teachers and Supervisors
Franks, Milford	"Learning Through Concept Development: The Goal of Supervision and Instruction," Montana Education
Furman, D. W., editor	Guide to the Social Studies in the Elementary Grades
Harris, T. L., and Schwahn, W. E., editors	Selected Readings on the Learning Process

TABLE 7. (Continued)

Author	Title
Hullfish, H. G., and Smith, P. G.	Reflective Thinking: The Method of Education
Klausmeier, H. J.	Learning and Human Abilities: Educational Psychology
Michener, J. A.	Hawaii
Morse, W. C., and Wingo, G. M.	Psychology and Teaching, Second edition
Nunn, W. R.	"Nature of Spatial and Mental Abilities," (Excerpt from The Impact of Certain Secondary School Curricular Patterns on Spatial Visualization.)
Seagoe, M. V.	A Teacher's Guide to the Learning Process
Shapp, M. G., editor	Planning and Organizing Science Programs for Elementary Schools
Townsend, E. A., and Burke, P. J.	Learning for Teachers
Vinacke, W. E.	The Psychology of Thinking
Weinland, J. D.	How to Improve Your Memory
Wellington, C. B., and Wellington, Jean	Teaching for Critical Thinking
Wertheimer, Max	Productive Thinking

TABLE 8. AUTHORS AND TITLES OF CORRELATED READINGS FOR EACH OF THE TEN DESIGNATED INSTRUCTIONAL AREAS IN EDUCATIONAL PSYCHOLOGY

Instructional Area	Author	Correlated Reading
Introduction to Educational Psychology	Townsend, E. A., and Burke, P. J.	"Introduction," Chapter 1; "The Climate for Learning," Chapter 4
Growth and Development	Townsend, E. A., and Burke, P. J.	"Readiness," Chapter 3; "Motor Learning," Chapter 14
	Association for Supervision and Curriculum Development	Perceiving, Behaving, Becoming, Summaries on pp. 83, 99, 118, 141-142
	Klausmeier, H. J.	"Psychomotor Abilities and Skills," Chapter 8
Psychology of Learning	Townsend, E. A., and Burke, P. J.	"The Level of Aspiration," Chapter 6; "The Condition for Learning," Chapter 7; "Communications," Chapter 14
	DeCecco, J. P., editor	"A Review of Factors in Learning Efficiency," pp. 30-51
	Dubridge, L. A.	"Physics"
	Frandsen, A. N.	"Kinds of Learning Requiring Practice," pp. 291-295
	Franks, Milford, editor	Creative Activities for Teachers and Supervisors
	Hullfish, H. G., and Smith, P. G.	"A Theory of Learning for Teachers," pp. 169-191

TABLE 8. (Continued)

Instructional Area	Author	Correlated Reading
Psychology of Learning (Continued)	Klausmeier, H. J.	"Affective Outcomes I: Attitudes and Values," Chapter 9
	Michener, J. A.	"From the Boundless Deep," Chapter 1
Guidance of Learning	Townsend, E. A., and Burke, P. J.	"Managing the Classroom," Chapter 5; "Reinforcement," Chapter 12
	Association for Supervision and Curriculum Development	Human Variability and Learning, "Anxiety," pp. 14-23
	Association for Supervision and Curriculum Development	New Dimensions in Learning, "Reward and Punishment," pp. 46-55
	Frandsen, A. N.	"Efficient Modes of Attack in Learning," pp. 306-330
	Wellington, C. B., and Wellington, Jean	Summaries on teaching techniques on pp. 139, 158-159, 182-183, 200-201, 217-218, 235-236
Motivation	Townsend, E. A., and Burke, P. J.	"Motivation," Chapter 2
	Klausmeier, H. J.	"Motivation," Chapter 11

TABLE 8. (Continued)

Instructional Area	Author	Correlated Reading
Memory	Townsend, E. A., and Burke, P. J.	"Remembering," Chapter 8; "Forgetting," Chapter 9; "Serial Learning," Chapter 15
	Crow, L. D., and Crow, Alice	"The Three Faces of Intellect," pp. 270-287
	Frandsen, A. N.	"Causes of Forgetting," pp. 371-376; "Factors Facilitating Retention," pp. 377-389
	Seagoe, M. V.	"Material to be Learned," Chapter 7, pp. 121-150
	Weinland, J. D.	"Memory Improvement--General Principles," pp. 47-73
Transfer	Townsend, E. A., and Burke, P. J.	"Transfer," Chapter 11
Other Mental Processes--Discrimination, Generalization, Perception, Cognition	Townsend, E. A., and Burke, P. J.	"Generalization and Discrimination," Chapter 10; "Cognition," Chapter 13; "Problem Solving," Chapter 16
	Association for Supervision and Curriculum Development	New Dimensions in Learning, "Experimental Analysis of Concept Formation," pp. 55-65
	Berelson, Bernard, and others	"Geography," pp. 42-85

TABLE 8. (Continued)

Instructional Area	Author	Correlated Reading
Other Mental Processes--Discrimination, Generalization, Perception, Cognition (Continued)	Bloom, B. S.	"Knowledge," pp. 62-96
	Bruner, J. S.,; Goodnow, J. J.; and Austin, G.A.	"Disjunctive Concepts," pp. 156-162
	Croft Educational Services, publisher	"The Teaching of Concepts and Attitudes,"
	Cronbach, L. J.	"Improving Understanding and Thinking," pp. 349-396
	Crow, L. D., and Crow, Alice	"The Three Faces of Intellect," pp. 270-287
	Franks, Milford	"Learning Through Concept Development: The Goal of Supervision and Instruction"
	Furman, D. W., editor	"Concepts to be Developed" and "Things to Do" in each section of the book
	Harris, T. L., and Schwahn, W. E., editors	Summaries on "Problem Solving Processes of College Students," pp. 59-79; "Concept Development Simple to Complex," p. 124; "Evolution of Concepts," p. 132; "Objective Study of Concept Formation," p.142
	Hullfish, H. G., and Smith, P. G.	"The Conceptual Response," pp. 149-168

TABLE 8. (Continued)

Instructional Area	Author	Correlated Reading
Other Mental Processes--Discrimination, Generalization, Perception, Cognition (Continued)	Klausmeier, H. J.	"Cognitive Learning Outcomes I: Facts and Concepts," Chapter 6; "Cognitive Learning Outcomes II: Problem-Solving and Creativity," Chapter 7
	Morse, W. C., and Wingo, G. M.	"Ways of Learning," pp. 196-204
	Nunn, W. R.	"Nature of Spatial and Mental Abilities"
	Shapp, M. G., editor	"Concepts to be Developed" and "Things to Do" in each section of the book
	Vinacke, W. E.	"Concept Formation," Chapter 7, pp. 97-131; "Problem Solving," Chapter 9, pp. 160-192
	Wertheimer, Max	"Suggestions for Teaching About Area," pp. 269-285
Individual Differences	Klausmeier, H. J.	"Providing for Individual Differences," Chapter 13
Educational Measurement	Townsend, E. A., and Burke, P. J	"Measurement and Evaluation of Learning," Chapter 18
	Klausmeier, H. J.	"Evaluation and Measurement: Standardized Tests," Chapter 15, pp. 443-452

TABLE 9. SEX, CURRICULUM, CREDITS PASSED, CUMULATIVE GRADE POINT AVERAGE, MINNESOTA SCHOLASTIC APTITUDE TEST RAW SCORE, AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL EXAMINATION FOR COLLEGE FRESHMEN "Q" AND "L" RAW SCORES, AND "30 ITEM" EDUCATIONAL PSYCHOLOGY ACHIEVEMENT TEST RAW SCORE FOR EACH PARTICIPATING STUDENT IN PROFESSOR COMPARISON GROUP A.

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score		"30 Item" Educ. psych. raw score
						"Q"	"L"	
2	F	Elem. Educ.	111	2.48	56	36	60	18
3	M	Sec. Educ.	90	2.98	59	43	68	20
4	M	Engr. Sci.	151	1.94	46	42	61	13
5	F	Elem. Educ.	75	2.45	46	37	71	18
6	M	Sec. Educ.	69	2.43	50	35	61	15
7	M	Const. Tech.	178	2.25	18	32	65	25
8	F	Gen'l Stud.	110	2.45	67	34	78	18
9	F	Elem. Educ.	81	2.87	40	46	73	17
10	M	Sec. Educ.	116	2.09	33	40	62	14
11	F	Elem. Educ.	80	3.09	62	33	76	23
12	F	Elem. Educ.	94	2.11	46	38	79	15
13	F	Home Ec.	79	2.02	23	26	42	13
14	M	Phys. Educ.	74	2.01	26	27	57	15
15	M	Engr. Sci.	78	2.83	56	50	77	17
16	F	Elem. Educ.	85	2.68	39	40	56	19
17	F	Sec. Educ.	83	2.75	43	37	50	22
18	F	Sec. Educ.	68	2.29	45	35	62	16
19	F	Elem. Educ.	80	2.50	39	36	57	14
20	F	Elem. Educ.	80	3.40	54	41	63	22
21	M	Elec. Engr.	194	2.54	33	46	71	19
22	F	Gen'l.Stud.	35	2.89	40	41	66	18
23	M	Sec.Educ.	79	2.28	43	36	49	15
24	F	Elem.Educ.	115	2.04	54	37	83	20
25	F	Sec.Educ.	82	2.32	25	42	76	14
26	F	Home Ec.	81	2.51	28	36	38	15
27	F	Phys. Educ.	79	2.42	49	32	59	22
28	F	Elem.Educ.	82	2.65	45	38	47	13

TABLE 9. (Continued)

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score		"30 Item" Educ. psych. raw score
						"Q"	"L"	
29	F	Elem.Educ.	79	2.20	38	40	57	17
30	F	Sec.Educ.	95	3.46	72	62	99	20
31	M	Sec.Educ.	80	2.12	37	45	71	13
32	M	Phys.Educ.	63	2.07	32	35	51	16
33	F	Elem.Educ.	24	2.58	36	30	51	16
34	M	Gen'l.Stud.	104	1.55	31	46	77	14
35	F	Phys.Educ.	160	3.58	65	37	73	23
36	F	Home Ec.	84	2.69	44	59	65	15
37	F	Elem.Educ.	82	2.63	56	50	77	14
38	M	Pre-med.	68	1.84	42	49	66	17
39	F	Elem.Educ.	96	3.32	58	55	99	22
40	M	Sec.Educ.	72	2.29	50	44	69	15
41	F	Elem.Educ.	81	3.04	54	33	79	20
42	F	Home Ec.	84	2.51	56	45	81	14
43	F	Sec.Educ.	88	2.83	53	54	77	19
44	F	Sec.Educ.	87	3.68	64	37	75	19
45	F	Home Ec.	81	2.16	26	34	48	17
46	M	Sec.Educ.	80	2.49	51	29	71	18
47	F	Sec.Educ.	92	3.37	63	47	85	22
48	F	Elem.Educ.	76	2.39	64	47	87	20
49	F	Sec.Educ.	90	3.12	61	42	79	16
50	M	Sec.Educ.	67	1.74	39	42	49	21
51	F	Elem.Educ.	89	2.05	26	32	61	19
52	M	Phys.Educ.	99	1.86	32	42	50	14
53	F	Elem.Educ.	86	2.48	41	34	54	16
54	F	Phys.Educ.	101	2.08	43	40	67	16
55	F	Elem.Educ.	78	3.63	60	25	74	24
56	F	Home Ec.	84	2.25	45	40	76	18
57	M	Elem.Educ.	75	2.10	64	36	69	15
58	M	Sec.Educ.	113	1.96	45	47	62	12
59	F	Commerce	76	2.21	34	41	66	16

TABLE 9. (Continued)

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score		"30 Item" Educ. psych. raw score
						"Q"	"L"	
60	F	Elem.Educ.	81	2.56	66	44	84	15
61	F	Home Ec.	73	2.13	48	51	76	20
62	F	Gen'l.Stud.	34	2.47	49	43	74	20
63	M	Elem.Educ.	134	2.06	35	32	62	14
64	F	Gen'l.Stud.	81	2.35	61	36	87	14
65	F	Art	127	2.44	27	34	67	14
66	M	Const.Tech.	111	2.19	40	50	49	20
67	F	Elem.Educ.	83	2.46	37	46	67	10
68	F	Gen'l.Stud.	74	2.55	69	40	88	17
69	F	Elem.Educ.	79	2.49	72	39	92	17
70	F	Gen'l.Stud.	67	2.29	46	51	63	20
71	F	Home Ec.	152	3.57	67	66	99	21
72	F	Sec.Educ.	84	2.17	53	42	74	19
73	F	Home Ec.	82	3.01	42	59	73	21
74	F	Elem.Educ.	80	3.09	54	34	56	24
75	M	Sec.Educ.	68	2.06	57	43	73	19
76	M	Gen'l.Stud.	16	1.75	60	37	96	20
77	F	Commerce	79	2.10	44	34	60	21
78	M	Sec.Educ.	72	2.21	51	33	72	16
79	F	Elem.Educ.	73	2.00	33	31	51	11
80	F	Elem.Educ.	84	3.17	47	33	77	18
81	F	Elem.Educ.	76	2.78	47	38	77	22
82	F	Elem.Educ.	78	1.77	35	31	61	19
83	F	Elem.Educ.	85	3.08	49	46	69	22
84	M	Ag.Econ.	168	1.95	39	30	65	11
85	F	Gen'l.Stud.	83	3.05	63	41	82	19
86	F	Phys.Educ.	81	2.53	30	26	62	13
87	F	Home Ec.	73	2.39	47	36	64	18
88	F	Sec.Educ.	72	1.93	54	56	67	14
89	F	Elem.Educ.	80	2.44	35	36	64	23
90	F	Sec.Educ.	102	1.76	39	23	70	16

TABLE 9. (Continued)

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score		"30 Item" Educ. psych. raw score
						"Q"	"L"	
91	M	Sec.Educ.	65	2.19	34	42	56	18
92	F	Elem.Educ.	82	2.11	44	33	72	12
93	F	Elem.Educ.	83	2.16	39	36	76	15
94	F	Chem.	86	2.57	63	59	80	23
95	F	Elem.Educ.	77	2.18	29	28	50	19
96	F	Elem.Educ.	81	3.56	63	48	83	18
97	F	Elem.Educ.	34	2.24	38	29	58	17
98	M	Sec.Educ.	77	2.68	62	62	73	23
99	F	Elem.Educ.	83	2.48	37	26	53	14
100	F	Home Ec.	87	2.91	50	38	69	20
101	F	Commerce	77	2.42	58	41	63	15
102	F	Home Ec.	79	2.99	45	37	62	19
103	M	Ag.Econ.	85	1.56	29	30	46	19
104	F	Sec.Educ.	90	2.81	58	52	77	14
105	M	Gen'l.Stud.	76	2.14	61	45	76	27
106	F	Phys.Educ.	82	1.41	27	48	65	14
107	F	Elem.Educ.	88	2.49	30	50	60	15
108	M	Elec.Engr.	106	2.20	26	32	47	15
109	F	Home Ec.	91	3.33	43	40	82	24
110	M	Sec.Educ.	90	2.62	74	46	98	22
111	F	Elem.Educ.	85	2.87	55	37	84	21
112	F	Home Ec.	141	2.68	28	30	45	18
113	F	Home Ec.	110	2.38	60	40	75	17
114	F	Elem.Educ.	79	2.56	39	40	67	20
115	F	Elem.Educ.	81	2.32	37	29	59	19
116	M	Elec.Engr.	92	2.36	51	45	72	20
117	F	Home Ec.	136	3.53	44	39	67	23
118	F	Home Ec.	104	1.91	21	26	49	14
119	F	Phys.Educ.	87	2.65	38	17	45	14
120	F	Elem.Educ.	76	2.12	31	25	58	14
121	F	Elem.Educ.	106	2.48	52	47	76	20
122	F	Gen'l.Stud.	85	2.48	58	52	87	18

TABLE 9. (Continued)

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score		"30 Item" Educ. psych. raw score
						"Q"	"L"	
123	M	Math.	88	2.94	33	40	57	21
124	F	Phys.Educ.	83	3.35	40	50	63	15
125	F	Gen'l.Stud.	80	2.91	63	58	97	22
126	F	Elem.Educ.	77	2.12	41	37	68	13
127	F	Home Ec.	86	2.60	45	37	75	16
128	F	Elem.Educ.	80	2.61	21	35	50	19
129	F	Sec.Educ.	85	2.47	54	35	72	16
130	F	Sec.Educ.	76	2.70	59	18	76	22
131	F	Home Ec.	72	1.94	25	34	53	11
132	F	Home Ec.	84	3.29	60	42	67	22

TABLE 10. SEX, CURRICULUM, CREDITS PASSED, CUMULATIVE GRADE POINT AVERAGE, MINNESOTA SCHOLASTIC APTITUDE TEST RAW SCORE, AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL EXAMINATION FOR COLLEGE FRESHMEN "Q" AND "L" RAW SCORES, AND "30 ITEM" EDUCATIONAL PSYCHOLOGY ACHIEVEMENT TEST RAW SCORE FOR EACH PARTICIPATING STUDENT IN PROFESSOR COMPARISON GROUP B.

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score		"30 Item" Educ. psych. raw score
						"Q"	"L"	
201	F	Elem.Educ.	89	2.06	46	46	73	16
202	F	Gen'l.Stud.	49	2.61	46	53	83	16
203	M	Math	185	2.52	37	37	46	17
204	F	Elem.Educ.	95	2.13	49	46	66	13
205	M	Indus.Arts	113	2.03	23	44	54	11
206	F	Elem.Educ.	79	1.98	21	36	65	14
207	M	Commerce	118	1.65	32	32	65	14
208	F	Gen'l.Stud.	48	2.38	44	29	59	9
209	F	Commerce	110	2.33	34	49	72	12
210	M	Sec.Educ.	83	2.07	41	50	72	16
211	F	Commerce	147	1.87	40	48	74	15
212	M	Indus.Arts	141	2.76	46	34	65	13
213	M	Gen'l.Stud.	58	3.28	70	51	88	16
214	F	Elem.Educ.	97	2.48	40	53	69	19
215	F	Sec.Educ.	93	2.13	35	28	69	20
216	M	Phys.Educ.	98	1.81	33	33	57	17
217	M	Indus.Arts	150	1.88	17	19	33	12
218	F	Phys.Educ.	92	1.86	51	53	66	19
219	M	Sec.Educ.	102	2.57	45	59	55	15
220	F	Sec.Educ.	116	3.40	52	49	82	21
221	M	Sec.Educ.	85	1.64	47	45	65	17
222	F	Home Ec.	97	2.37	38	23	64	20
223	M	Phys.Educ.	90	2.24	27	34	66	12
224	M	Gen'l.Stud.	95	2.63	40	55	79	19
225	M	Sec.Educ.	117	2.08	53	33	70	17
226	M	History	97	2.11	39	36	60	14

TABLE 10. (Continued)

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score		"30 Item" Educ. psych. raw score
						"Q"	"L"	
227	M	Sec.Educ.	47	2.38	47	34	69	13
228	F	Sec.Educ.	106	2.49	35	52	62	9
229	F	Art	99	2.35	49	50	60	15
230	F	Gen'l.Stud.	103	2.18	64	54	86	19
231	M	Physics	81	1.83	59	34	77	19
232	F	Sec.Educ.	78	2.04	46	34	58	20
233	F	Sec.Educ.	99	2.41	65	39	87	15
234	F	Elem.Educ.	40	1.74	38	47	65	15
235	M	Gen'l.Stud.	144	2.44	46	52	72	15
236	F	Elem.Educ.	94	2.70	47	44	86	18
237	M	Art	176	1.99	29	34	65	13
238	M	Commerce	85	1.79	62	36	72	20
239	F	Commerce	51	2.29	33	48	68	14
240	F	Commerce	99	3.23	55	47	77	13
241	F	Commerce	93	2.31	37	33	67	14
242	F	Nursing	120	3.00	38	28	62	19
243	F	Home Ec.	73	2.54	57	37	68	22
244	M	Sec.Educ.	57	2.61	36	22	49	15
245	F	Home Ec.	102	2.57	36	45	56	14
246	F	Gen'l.Stud.	93	3.42	54	36	79	14
247	M	Sec.Educ.	91	2.77	47	37	66	16
248	F	Nursing	135	2.75	50	31	76	14
249	F	Home Ec.	106	2.81	55	57	86	16
250	F	Home Ec.	111	2.94	62	45	77	16
251	M	Commerce	102	1.52	29	37	60	13
252	F	Art	98	2.67	42	46	65	15
253	F	Sec.Educ.	115	2.57	42	42	69	15
254	F	Gen'l.Stud.	97	2.99	54	44	69	13
255	M	Commerce	115	2.34	36	46	56	18

TABLE 10. (Continued)

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score		"30 Item" Educ. psych. raw score
						"Q"	"L"	
256	M	Indus.Arts	103	2.41	28	43	48	16
257	F	Sec.Educ.	86	2.06	35	52	61	15
258	F	Commerce	72	1.74	25	34	59	13
259	F	Home Ec.	96	2.26	35	34	67	13
260	F	Nursing	98	3.08	45	25	73	20
261	M	Sec.Educ.	145	2.12	31	34	49	16
262	F	Home Ec.	95	2.55	51	57	74	14
263	F	Elem.Educ.	82	2.45	48	23	61	15
264	F	Phys.Educ.	154	2.36	50	40	65	12
265	F	Elem.Educ.	83	3.18	56	43	75	10
266	M	History	130	3.07	55	48	87	19
267	M	Sec.Educ.	102	2.60	61	53	78	17
268	M	Pre-med	98	2.68	51	64	68	14
269	F	Commerce	88	1.88	34	45	56	15
270	F	Art	101	2.59	46	34	67	11
271	F	Art	103	2.03	23	32	58	16
272	M	Gen'l.Stud.	192	2.48	26	15	56	12
273	F	Commerce	48	1.96	46	37	50	10
274	F	Home Ec.	106	3.58	62	49	65	22
275	F	Nursing	120	2.57	46	27	74	20
276	F	Sec.Educ.	101	2.34	66	41	81	18
277	M	History	28	1.43	41	37	48	17
278	F	Elem.Educ.	71	3.00	69	34	99	19
279	F	Elem.Educ.	107	2.34	39	28	70	12
280	F	Sec.Educ.	55	3.07	51	43	74	18
281	F	Home Ec.	97	2.23	40	48	57	16
282	F	Elem.Educ.	108	2.04	43	32	60	14
283	F	Art	103	2.64	43	31	74	17
284	F	Elem.Educ.	86	1.73	26	56	61	14
285	F	Elem.Educ.	62	2.75	66	31	81	20

TABLE 10. (Continued)

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score		"30 Item" Educ. psych. raw score
						"Q"	"L"	
286	F	Phys.Educ.	65	2.51	36	38	44	16
287	F	Home Ec.	103	3.17	36	31	54	17
288	M	Art	103	2.05	34	34	73	14
289	M	Sec.Educ.	33	2.44	46	41	53	9
290	F	Elem.Educ.	103	3.19	55	46	72	21
291	F	Sec.Educ.	92	3.51	54	43	79	19
292	M	Art	102	2.32	32	28	54	13
293	F	Nursing	129	2.71	47	30	70	19
294	F	Gen'l.Stud.	112	3.61	63	42	82	14
295	F	Elem.Educ.	45	2.13	32	40	65	14

TABLE 11. SEX, CURRICULUM, CREDITS PASSED, CUMULATIVE GRADE POINT AVERAGE, MINNESOTA SCHOLASTIC APTITUDE TEST RAW SCORE, AND AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL EXAMINATION FOR COLLEGE FRESHMEN "Q" AND "L" RAW SCORES FOR EACH PARTICIPATING STUDENT IN EXPERIMENTAL GROUP E.

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score	
						"Q"	"L"
301	F	Home Ec	47	1.78	39	39	67
302	F	Commerce	123	2.69	56	58	67
303	F	Gen'l.Stud.	104	2.29	57	33	71
304	F	Gen'l.Stud.	120	2.65	58	45	78
305	F	Phys.Educ.	51	1.65	41	28	61
306	M	Commerce	46	2.36	35	40	49
307	F	Commerce	116	2.56	44	49	54
308	M	Phys.Educ.	81	1.70	35	36	72
309	F	Elem.Educ.	78	2.53	62	45	69
310	M	Sec.Educ.	149	2.28	47	36	55
311	F	Gen'l.Stud.	66	2.26	60	49	87
312	F	Sec.Educ.	73	2.58	47	49	78
313	F	Elem.Educ.	107	1.99	21	38	43
314	F	Elem.Educ.	76	2.08	26	34	38
315	F	Elem.Educ.	79	2.68	44	32	52
316	M	Phys.Educ.	73	1.74	44	46	58
317	F	Phys.Educ.	114	2.33	36	40	62
318	M	Commerce	116	2.14	43	36	69
319	F	Sec.Educ.	134	2.07	47	44	66
320	F	Elem.Educ.	103	2.01	45	34	64
321	M	Phys.Educ.	114	2.32	53	35	64
322	F	Elem.Educ.	98	2.11	37	35	59
323	F	History	116	2.29	57	61	65
324	F	Elem.Educ.	76	3.03	52	51	81
325	F	Home Ec	64	2.38	45	37	57
326	M	Sec.Educ.	44	2.41	43	48	62
327	M	Phys.Educ.	53	1.79	42	34	57
328	F	Sec.Educ.	104	2.24	56	45	72
329	F	Elem.Educ.	64	2.31	43	40	68
330	F	Sec.Educ.	89	2.92	73	50	92
331	F	Gen'l.Stud.	182	3.27	66	52	99
332	M	Sec.Educ.	77	2.40	32	29	59
333	F	Elem.Educ.	56	2.07	48	38	54
334	M	Sec.Educ.	103	2.13	53	52	73

TABLE 12. SEX, CURRICULUM, CREDITS PASSED, CUMULATIVE GRADE POINT AVERAGE, MINNESOTA SCHOLASTIC APTITUDE TEST RAW SCORE, AND AMERICAN COUNCIL ON EDUCATION PSYCHOLOGICAL EXAMINATION FOR COLLEGE FRESHMEN "Q" AND "L" RAW SCORES FOR EACH PARTICIPATING STUDENT IN CONTROL GROUP C.

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score	
						"Q"	"L"
401	F	Gen'l.Stud.	48	1.69	41	34	75
402	M	Gen'l.Stud.	56	2.59	51	39	77
403	F	Gen'l.Stud.	110	2.12	52	38	63
404	M	Gen'l.Stud.	106	2.49	64	38	82
405	M	Commerce	77	1.87	22	18	52
406	F	Commerce	107	2.18	38	24	62
407	F	Elem.Educ.	118	2.93	53	34	72
408	M	Ag. Educ.	90	2.03	19	38	46
409	M	Gen'l.Stud.	168	2.44	53	63	77
410	F	Home Ec	67	2.81	25	28	50
411	M	Sec.Educ.	152	2.07	23	28	52
412	M	Pre-med	112	2.59	58	56	85
413	M	Phys.Educ.	52	1.89	23	34	53
414	F	Elem.Educ.	66	2.60	57	39	71
415	F	Commerce	66	2.89	45	41	70
416	M	Gen'l.Stud.	115	2.75	35	45	52
417	F	Elem.Educ.	48	1.70	44	33	68
418	M	Ag. Educ.	93	2.34	26	20	49
419	F	Elem.Educ.	70	2.59	71	46	93
420	M	Ag. Educ.	92	2.29	54	35	70
421	M	Sec.Educ.	96	2.20	41	30	60
422	M	Commerce	93	2.13	36	46	65
423	F	Sec.Educ.	64	2.59	29	46	61
424	M	Indus.Arts	109	2.69	54	49	71
425	M	Phys.Educ.	115	2.43	23	30	40
426	M	Gen'l.Stud.	164	3.13	58	60	81
427	F	English	107	2.64	41	35	74
428	F	Home Ec	116	2.75	54	42	67
429	F	English	78	3.17	59	20	93
430	M	Indus.Arts	85	1.81	21	17	44
431	F	Elem.Educ.	61	2.31	32	31	58
432	F	Sec.Educ.	90	3.31	51	42	78
433	M	Commerce	51	1.74	43	40	60
434	M	Commerce	101	2.51	31	31	68
435	F	Elem.Educ.	61	1.90	46	40	60
436	M	Phys.Educ.	44	1.40	17	38	78
437	M	Commerce	232	1.77	22	46	46
438	M	Indus.Arts	135	2.00	29	35	51

TABLE 12. (Continued)

Student code number	Sex	Curriculum	Credits passed	Cum. grade point ave. (A=4 points)	MSAT raw score	A C E raw score	
						"Q"	"L"
439	M	Indus.Arts	113	2.68	31	37	47
440	F	Home Ec	76	1.81	30	41	69
441	F	Elem.Educ.	79	2.67	56	36	75
442	F	Commerce	63	2.22	44	42	71
443	F	Commerce	128	2.92	58	47	70
444	F	Elem.Educ.	67	2.14	35	34	66
445	M	Gen'l.Stud.	83	2.09	37	39	45
446	F	Home Ec	69	2.22	53	40	87
447	F	Sec.Educ.	116	2.43	47	51	71
448	M	Ag.Educ.	110	2.60	48	40	72
449	F	Gen'l.Stud.	132	2.08	20	27	17
450	F	Commerce	121	2.54	49	63	73
451	M	Sec.Educ.	111	2.58	38	33	55
452	M	Ag. Educ.	104	1.98	31	40	49
453	M	Indus.Arts	108	2.25	20	44	61
454	M	Gen'l.Stud.	28	1.81	34	36	53
455	M	Commerce	50	1.84	28	37	57
456	M	History	120	3.17	59	50	89
457	M	Physics	71	3.07	48	38	53

TABLE 13. WATSON-GLASER CRITICAL THINKING APPRAISAL FORMS YM AND ZM RAW SCORES, DIFFERENTIAL APTITUDE TEST ABSTRACT REASONING FORMS L AND B RAW SCORES, DIFFERENTIAL APTITUDE TEST MECHANICAL REASONING FORMS L AND B RAW SCORES, AND EDUCATIONAL PSYCHOLOGY ACHIEVEMENT PRE-TEST AND END-TEST RAW SCORES FOR EACH PARTICIPATING STUDENT IN EXPERIMENTAL GROUP E.

Student code number	Watson-Glaser raw score		DAT AR raw score		DAT MR raw score		Educ. Psych raw score	
	YM	ZM	L	B	L	B	Pre	End
301	61	48	39	45	37	35	48	58
302	76	70	46	47	51	55	60	75
303	86	76	35	38	38	38	70	83
304	74	70	42	44	45	47	54	68
305	63	72	38	43	47	47	57	57
306	69	58	40	38	52	52	49	61
307	67	63	34	42	49	46	48	76
308	68	76	34	41	48	52	51	59
309	76	87	45	45	59	55	72	90
310	74	71	43	46	55	62	68	76
311	82	67	9	45	49	46	67	75
312	73	71	41	41	43	41	70	83
313	61	67	42	46	48	39	51	66
314	57	67	41	38	39	39	59	73
315	71	63	39	45	41	42	63	71
316	76	69	38	42	63	65	68	77
317	72	64	40	41	61	56	64	73
318	68	66	30	33	60	62	46	56
319	73	67	40	48	51	55	67	76
320	77	61	36	39	42	42	50	68
321	75	78	40	45	56	61	58	71
322	70	67	33	37	43	36	50	55
323	76	78	46	46	51	52	62	69
324	79	70	40	47	50	55	73	79
325	77	65	47	45	47	42	69	66
326	77	78	44	48	60	61	44	57
327	70	67	38	39	45	45	66	68
328	75	66	45	49	45	50	65	64
329	83	70	45	43	51	54	68	75
330	82	72	46	49	57	52	72	82
331	90	86	49	47	59	52	82	82
332	70	76	38	44	50	51	61	69
333	63	64	46	48	52	46	59	66
334	84	88	45	47	62	62	60	74

TABLE 14. WATSON-GLASER CRITICAL THINKING APPRAISAL FROMS YM AND ZM RAW SCORES, DIFFERENTIAL APTITUDE TEST ABSTRACT REASONING FORMS L AND B RAW SCORES, DIFFERENTIAL APTITUDE TEST MECHANICAL REASONING FORMS L AND B RAW SCORES, AND EDUCATIONAL PSYCHOLOGY ACHIEVEMENT PRE-TEST AND END-TEST RAW SCORES FOR EACH PARTICIPATING STUDENT IN CONTROL GROUP C.

Student code number	Watson-Glaser raw score		DAT AR raw score		DAT MR raw score		Educ. Psych. raw score	
	YM	ZM	L	B	L	B	Pre	End
401	77	66	32	38	48	44	55	64
402	77	73	46	46	66	61	57	61
403	82	69	47	39	51	50	60	70
404	62	76	40	45	64	66	74	78
405	67	68	19	19	35	44	63	58
406	72	56	35	34	42	39	58	69
407	76	68	38	42	52	46	72	71
408	71	68	39	44	57	62	61	57
409	82	77	44	47	61	59	65	76
410	65	67	35	34	53	42	49	53
411	71	60	36	34	61	63	56	59
412	83	82	43	42	58	64	60	77
413	69	67	44	40	55	54	47	45
414	80	76	40	37	38	37	63	75
415	69	55	37	43	45	47	63	70
416	65	64	49	44	65	66	57	74
417	61	52	38	44	39	52	58	56
418	71	68	36	37	44	45	47	61
419	89	77	42	43	59	53	65	72
420	80	73	36	39	60	59	65	74
421	72	61	42	38	58	48	55	67
422	67	66	32	35	64	59	55	60
423	54	58	40	43	46	49	51	63
424	80	68	43	47	58	62	72	65
425	65	61	33	38	34	36	52	50
426	92	82	45	49	64	66	72	73
427	67	67	43	43	48	52	60	70
428	75	66	47	43	47	52	64	71
429	77	69	35	41	52	42	66	77
430	62	34	37	39	61	63	44	49

TABLE 14. (Continued)

Student code number	Watson-Glaser raw score		DAT AR raw score		DAT MR raw score		Educ. Psych. raw score	
	YM	ZM	L	B	L	B	Pre	End
431	60	56	46	44	40	43	55	68
432	86	84	46	47	54	55	68	87
433	74	72	37	44	53	55	57	60
434	73	65	26	42	51	54	52	64
435	73	63	39	45	40	39	51	66
436	54	49	19	8	32	27	40	37
437	67	64	47	45	63	60	43	58
438	67	73	39	44	59	59	58	65
439	59	67	37	42	58	64	54	65
440	61	55	37	42	43	48	47	58
441	89	78	45	46	52	62	69	75
442	70	60	44	44	45	46	43	57
443	74	72	41	48	52	55	71	67
444	71	60	37	35	34	35	72	64
445	68	66	37	42	49	57	48	57
446	75	64	43	45	49	48	56	63
447	82	74	45	46	53	49	60	66
448	69	66	39	41	62	62	75	78
449	62	63	43	47	40	51	42	52
450	81	77	45	50	55	58	47	65
451	65	70	38	38	45	53	57	65
452	65	57	40	42	56	55	68	72
453	70	61	36	36	53	55	43	58
454	66	59	33	43	58	53	52	60
455	69	61	43	44	48	45	53	56
456	81	82	44	46	56	51	67	74
457	82	68	45	42	61	63	66	67