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INTERACTION OF COGNITIVE ORGANIZERS AND STUDENT PERSONALITY TYPES IN THE LEARNING AND RETENTION OF MATHEMATICS

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IBRAHIM D. ZAKKOUR

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INTERACTION OF COGNITIVE ORGANIZERS AND STUDENT PERSONALITY TYPES IN THE LEARNING AND RETENTION OF MATHEMATICS

APPROVED BY

Thomas J. Hill

[illegible]

Herbert R. Hengst

Harold Huneke

DISSERTATION COMMITTEE

DEDICATION

To my parents Diab Baracatt Zakkour and Fudha Zedan Zakkour.

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CHAPTER I

INTRODUCTION

Need for and Significance of the Study

In 1960 David Ausubel established his theory of subsumption and the use of cognitive organizers as a method of instruction. Since that time a considerable amount of research has been advocated relative to the facilitating effects of cognitive organizers on the reception of a new learning task. Several types of organizers have been identified, but research on what constitutes an organizer and on the effects of organizers has yielded conflicting and contradictory results. While the controversy over the facilitating effects of organizers continues unresolved, recent developments and trends in research in mathematics education seem to focus on learning styles, cognitive styles, and conceptual tempos of students. In light of this, different patterns of cognitive, affective, and psychomotor variables emerged. Recent research reports suggest that learning effectiveness is a function of the interaction of these variables with instructional treatments (Cronbach and Snow, 1969). Thus, in order to disentangle the complexity of these emerging patterns, a typological approach may very well be more useful in assessing cognitive preferences and learning styles of students. Such an approach, relative to student personality, might accurately predict the facilitating effects of organizers on learning and retention. Among all available typologies, that of Jung seems most comprehensive and appropriate as a "conceptual framework capable of representing the organization of cognitive, affective, and temperamental qualities within the individual" (Levy, 1972). Peterson (1973) suggested that research relative to student characteristics might accurately predict the success of organizers in facilitating learning. No research has yet investigated the interactive effects of cognitive organizers and student personality types on the meaningful reception of a new learning task. If it could be shown that relationships between student personality types and the success of organizers exist, then a new stream for research is discovered and a better understanding of the effectiveness of organizers is achieved. The outcomes of such research would benefit counselors, curriculum planners, and teachers in designing specific organizers for specific student personality types. Thus this research is designed to determine the relationship between student personality types and the effectiveness of organizers on learning and retention.

Theoretical Framework of the Problem

While educators argue over the classification of "teaching" as an art or a science, David Ausubel believes that teaching "is the art and science of presenting ideas and information meaningfully and effectively so that clear, stable, and unambiguous meanings emerge and are retained over a long period of time as an organized body of knowledge" (1963, p. 19). The process of presenting ideas and information meaningfully, however, is contingent upon the proper selection of an appropriate teaching technique. There are several teaching strategies available for the teaching of almost any concept, but the selection of the proper technique for use in a particular classroom situation is dictated by the content and objectives of the learning task. Ausubel suggests that "meaningful learning takes place if the learning task can be related in nonarbitrary, substantive fashion to what the learner already knows, and if the learner adopts a corresponding learning set" (1963, p. 18). The function of this corresponding learning set is that of relating substantive aspects of the new learning task to relevant components of the learner's existing cognitive structure--which includes the requisite intellectual capacities, ideational content, and experiential backgrounds--so that significant relationships will be developed and incorporated (Ausubel, 1963). This interaction between the learner's existing cognitive structure and the new learning task is a distinctive feature of meaningful learning. Ausubel elaborates further by stating that "meaningful reception learning occurs as potentially meaninful learning material enters the cognitive field and interacts with and is appropriately subsumed under a relevant and more inclusive conceptual system." This implies that Ausubel's model of cognitive organization for the learning and retention of meaningful material

> . . . assumes the existence of a cognitive structure that is hierarchically organized in terms of highly inclusive

> conceptual traces under which are subsumed traces of less inclusive subconcepts as well as traces of specific informational data. The major organizational principle, in other words, is that of progressive differentiation of trace systems of a given sphere of knowledge from regions of greater to lesser inclusiveness, each linkes to the next higher step in the hierarchy through a process of subsumption, (1963, pp. 24-25).

Adopting this hypothesis, then, it would be possible to facilitate the transmission of knowledge by showing how ideas and concepts are logically and hierarchically related. By employing the principle of progressive differentiation, the most general and inclusive ideas of a new learning task are introduced first. These general and inclusive ideas become part of the cognitive structure and serve as subsumers--advance organizers--for the reception of more detailed material, of the new learning task, to follow (Ausubel, 1963). That is to say, one can deliberately manipulate existing cognitive structure by using teaching strategies that include advance organizers prior to the presentation of the potentially meaningful material. The function of organizers, then, is that of facilitating the reception of new learning material by providing "ideational scaffolding for each unit of differentiated subject matter" (Ausubel, 1963). Several types of organizers have been identified, but the most common feature of organizers is that "organizers are introduced in advance of the learning material itself, and are also presented at a higher level of abstraction, generality, and inclusiveness" than the learning task itself. The instructional value of organizers obviously depends in part upon how well organized the learning material itself is. Also organizers must "delineate clearly, precisely, and explicitly the principal similarities and differences between the ideas in a new learning task" and the learner's existing cognitive structure (Ausubel, 1963). Even though Ausubel considered the cognitive structure to be the major factor influencing the meaningful reception of new material, meaningful reception leaning of potentially meaningful materials is contingent upon the cognitive, affective, and psychomotor variables within the individual. Thus learning effectiveness is a function of the interaction of these variables with the instructional treatment--type of organizer (Ausubel, 1963).

Recent research reports suggest that individuals may learn more easily from one method than another, that this "best method" differs from individual to individual, and that such differences are related to individual ability and personality (Cronbach, 1957; Cronbach & Snow, 1969). Relative to this trend of thought, then, it would be reasonable to believe that different student personality types interact differently with different organizers. The typology chosen for this study is based upon Jung's theory of personality which states that "much of the apparently random variation in human behavior is actually quite orderly and consistent, being due to certain basic differences in the way people prefer to use perception and judgement" (Myers, 1962). In other words, Jung's theory is based upon differences in the way a person perceives and the way he judges.

In light of this hypothesis, Myers and Briggs have developed an instrument called the Myers-Briggs-Type-Indicator, (MBTI). This instrument is designed to "ascertain, from self-report of easily reported reactions, people's bias preferences in regard to perception and judgement" (Myers, 1962). In other words, this instrument helps to assess how a person looks at the world and how he acts upon what he sees. Ausubel asserts that meaningful reception learning and retention occur if potentially meaningful material is perceived before it is learned.

> In fact, it would be more correct to say that individuals learn information they perceive rather than that they learn as such. During the perceptual phase, attitudes, motivation, expectations, and cultural frames of reference influence learning and retention . . . (1963, p. 50).

Translating this into Jung's theory, then, it would be reasonable to assume that students learn most effectively out of the kind of perception and kind of judgement they prefer. If this is correct, then the most effective organizer will be that which matches the student's preferred mode of perceiving and judging. Understanding the cognitive and perceptual processes of the student, however, is far from understanding the student, and the process of education involves his personality as a whole.

Statement of the Problem

This study deals with the question: "Are there any interactions between cognitive organizers and student personality types in learning and retention of mathematics?"

The purpose of the study is to examine the manner in which student personality types, as measured by the Myers-Briggs-Type-Indicator, affect the extent to which cognitive organizers facilitate the meaningful reception and retention of a new mathematical task.

Operational Definition of Variables and Terms

Meaningful learning occurs if the learning task can be related in nonarbitrary, substantive fashion to what the learner already knows, and if the learner adopts a corresponding learning set to do so.

Learning set refers to the learner's disposition to learn or perform in a particular way; in meaningful learning, the learner has a set to relate substantive aspects of new material to relevant components of the learner's existing cognitive structure so that significant relationships will be developed and incorporated.

Reception learning takes place when the entire content of what is to be learned is presented to the learner in a final form. The learner is only required to internalize the material that is presented to him so that it is available and reproducible at some future date.

Cognitive structure includes the requisite intellectual capacities, ideational content, and experiential background. It refers to an individual's organization, stability, and clarity of knowledge in a particular subject-matter field at any given time.

Cognitive organizer refers to introductory material utilized prior to or after the presentation of the new learning task itself. These organizers consist of learning materials which are presented to the learner at a higher level of abstraction, generality, and inclusiveness than the learning task itself. Their function is that of facilitating the reception of the new learning material by providing ideational scaffolding for each unit of differentiated subject matter.

Advance organizer refers to a cognitive organizer which is employed prior to the actual learning task itself.

Post organizer refers to a cognitive organizer which is employed after the actual presentation of the new learning task itself.

Expository organizer refers to a cognitive organizer which is used to provide proximate subsumers when the new task is completely unfamiliar to the learner. These proximate subsumers primarily furnish ideational anchorage in terms that are already familiar to the learner.

Comparative organizer refers to a cognitive organizer which is used when the new learning task is familiar to the learner, and is utilized to incorporate new concepts with similar concepts of the learner's existing cognitive structure.

Personality type is determined through measurement of differences in personality characteristics in four dimensions: (1) Extraversion-vs-Introverion (EI); (2) Sensing-vs-Intuition (SN); (3) Thinking-vs-Feeling (TF); and (4) Judging-vs-Perceiving (JP).

General Rationale for Research Hypotheses

This research is designed to test Ausubel's theory of organizers coupled with Jung's theory of psychological (personality) types. This theoretical merger leads to the conjecture that different student personality types benefit in varying ways from different organizers.

Theory suggests the following: (1) The extraversion-introversion dimension is concerned with the direction of interest. Extraverts prefer to direct their mental activity toward the external world of people and things, but introverts prefer the inner world of concepts and ideas. (2) The sensing-intuitive dimension is concerned with perception. Perception is understood to include the processes of becoming aware of things, people, occurrences, or ideas. Sensing types, who value the factual, realistic soundness of precept, prefer teaching strategies that relate to experiential background and build methodically step by step. But intuitive types, who value imaginative possibilities and quickness of perception, prefer teaching techniques that allow them to learn in their own way and at their own rate. (3) The thinking-feeling dimension is concerned with judgement. Judgement refers to the processes of drawing conclusions about what has been perceived. Thinking types prefer to arrive at decisions by impersonal logical analysis, but feeling types would rather rely on personal and inter-personal (emotional) subjective values. (4) The judging-perceiving dimension reflects one's attitude for dealing with one's environment. Judging types organize their world in their own orderly manners, but perceptive types are more understanding and open to suggestions from within their environment.

In terms of the theory, there are valuable differences in personality that result from the way we perceive and the way we judge. We become aware of things either through the senses or through intuition, and we judge things by either thinking or feeling. We all use these processes, but not equally. Each of us tends to like one process best in each dimension, grow most expert at it, acquire the traits that result from it, and use it in the areas where we prefer to use it either extravertly or introvertly. Therefore, it would be reasonable to assume that different cognitive organizers would have different effects on learning and retention of students of different personality types. Table 1 shows sixteen different possible combinations that can occur when a person shows his/her type preference.

Specific Hypotheses

H_{01}: There are no significant interactions between the three treatments and the four personality dimensions as measured by mean learning test scores.

Table 1

TYPE TABLE

		SENSING TYPES WITH THINKING	SENSING TYPES WITH FEELING	INTUITIVES WITH FEELING	INTUITIVES WITH THINKING		
INTROVERTS	JUDGING	ISTJ Introverted Sensing with thinking	ISFJ Introverted Sensing with feeling	INFJ Introverted Intuition with feeling	INTJ Introverted Intuition with thinking	JUDGING	INTROVERTS
INTROVERTS	PERCEPTIVE	ISTP Introverted Thinking with sensing	ISFP Introverted Feeling with sensing	INFP Introverted Feeling with intuition	INTP Introverted Thinking with intuition	PERCEPTIVE	INTROVERTS
EXTRAVERTS	PERCEPTIVE	ESTP Extraverted Sensing with thinking	ESFP Extraverted Sensing with feeling	ENFP Extraverted Intuition with feeling	ENTP Extraverted Intuition with thinking	PERCEPTIVE	EXTRAVERTS
EXTRAVERTS	JUDGING	ESTJ Extraverted Thinking with sensing	ESFJ Extraverted Feeling with sensing	ENFJ Extraverted Feeling with intuition	ENTJ Extraverted Thinking with intuition	JUDGING	EXTRAVERTS

H_{02}: There are no significant differences in mean learning test scores among the three treatments on each of the four personality dimensions.

H_{03}: There are no significant differences in mean learning test scores between the two preferences on each of the four personality dimensions.

If H_{01} is rejected, then H_{02} and H_{03} will be tested for simple main effects; otherwise, H_{02} and H_{03} will be tested as main effects.

H_{04}: There are no significant interactions between the three treatments and the four personality dimensions as measured by mean retention test scores.

H_{05}: There are no significant differences in mean retention test scores among the three treatments on each of the four personality dimensions.

H_{06}: There are no significant differences in mean retention test scores between the two preferences on each of the four personality dimensions.

If H_{04} is rejected, then H_{05} and H_{06} will be tested for simple main effects; otherwise, H_{05} and H_{06} will be tested as main effects.

H_{07}: There are no significant differences among the three groups with respect to simultaneous measures on all and each of the four personality dimensions.

Assumptions and Limitations

In conducting this research, it was assumed that: (1) the MBTI is a valid and stable instrument for measuring student personality type; and (2) a student's score on each of the four personality dimensions reflects his/her preferred mode of perceiving and judging.

The discriminant analysis relies upon the assumption that the discriminating variables have a multivariate normal distribution and that they have equal variance-covariance matrices. In practice, the technique is very robust and these assumptions need not be adhered to. The MBTI, however, violates the normality assumption, but such violation does not constitute a serious limitation.

This study is limited to the student population of Mathematics 1444 at the University of Oklahoma. It is delimited by the small number of classes--six--participating in this study; such a small number allows little latitude when using class means for units of statistical analysis. It is also delimited by the fact that no attempt was made to control teacher variation in the classroom.

CHAPTER II

REVIEW OF RELATED LITERATURE

Interest in cognitive organizers is evidenced by the considerable amount of research articles reported in a recent review of literature by Barnes and Clawson (1975). The moving force behind this trend is that organizers facilitate the meaningful reception of a new learning task by providing "ideational scaffolding" which will allow for the incorporation and retention of the more detailed learning material to follow (Ausubel, 1963).

In 1960 Ausubel investigated the effects of an expository organizer and an historical organizer on learning, using 500-word passages on the properties of carbon steel. He found that expository organizers facilitate learning. His subjects, however, were inadequately matched and some possessed relevant and stable subsuming concepts. In a subsequent study, Ausubel and Fitzgerald (1961) conducted a study in which expository and comparative organizers were studied in light of conceptual discriminability theory. The comparative organizers pointed out major similarities and differences between Buddhism and Christianity, while the expository organizer presented major facts about both religions. A control group was used; the historical introductory passage contained information related to human learning interests. Duration of treatments lasted three days, at the end of which a posttest was administered. A retention test was given ten days after the treatments ended. It was found that the comparative organizer was not significantly higher than the expository organizer, but both were significantly superior to the control group in facilitating learning. It was suggested that the organizers facilitated learning by providing ideational anchorage for those students who had relatively little verbal ability.

Ausubel and Fitzgerald (1962) compared the effectiveness of an expository organizer and an introductory passage in a study of the endocrinology of pubescence. Undergraduate students studied two unfamiliar passages about endocrinology. The results of the total experiment showed no significant differences. When ability scores on the SCAT were used as a basis for ability grouping, significant results were found for the low ability group, favoring the expository organizer.

Ausubel and Youssef (1963) compared the effects of an advance organizer and a nonideational passage of historical and biographical nature. The subjects were senior college students, and the learning material dealt with Christianity and Buddhism. The experiment lasted four days, followed by a posttest when treatment ended. A delayed retention test was given 10 days after the completion of the experiment. It was found that organizers facilitated learning when verbal ability was held constant. When knowledge of Christianity was held constant, the significant difference was also in favor of the advance organizers.

Wittrock (1965) believed that cognitive sets influenced the learning material developed by Ausubel and Fitzgerald (1961). In his findings, Wittrock suggested that some types of cognitive sets facilitate learning and retention.

Scandura and Wells (1967) compared the effects of achievement between a historical introductory organizer and a mathematical game organizer. Contents of both organizers were based upon group theory and combinatorial topology. The subjects were undergraduate elementary education majors. Results of a criterion posttest showed that students who employed the game organizers performed significantly higher than students in the control group. The difference due to materials was also significant but interaction between type of introduction and material was not, even though the organizer effect seemed to be stronger with the topology material. They reasoned, however, that the effectiveness of an advance organizer may decrease with increasing familiarity with similar models; this is due to the possibility that the subjects were more familiar with materials related to groups than with materials related to topology.

Balckhurst (1966) studied the effects of an oral expository organizer on learning and retention. The subjects were educable mentally retarded adolescents. He found no differences among the organizer, introductory, and control groups on learning and twelve-day retention.

Shultz (1966) compared a group that received two advance organizers with a group that did not receive any organizer but studied the same unit of instruction as that of the experimental group. The subjects were sixth-grade students enrolled in a science course. The experimental group received the first organizer at the beginning of the study. Twelve weeks later, the second organizer was given. No statistically significant differences were found on the posttest and delayed retention test. It was suggested, however, that students who lacked in analytic ability to reorganize information independently benefited from the facilitating effects of organizers.

Woodward (1966) compared the facilitating effects of pre-organizer and post organizer and discovery learning and verbal learning. Subjects were college students majoring in elementary education. The learning material was written in programmed form and was mediated by a computer. He found no significant difference between groups (no control group was used).

Jerrolds (1967) investigated the relative effects of advance and modified advance organizers on delayed retention of specific concepts at the ninth-grade level. No statistically significant differences were found between the two types of organizers and control groups. Students of above average I.Q. scores using the modified advance organizer benefited most from the use of organizers.

Kuhn (1967), using college students in an elementary biology course, found some evidence to suggest that organizers are effective to a certain extent with students of low analytic ability. He also suggested that when carefully sequenced material is presented to students, organizers might have facilitative effects on learning and retention.

Neisworth (1967), using educable mentally retarded adolescents, found no significant difference on achievement between an experimental group using an advance organizer and a control group using no organizer.

Harrington (1968) and Bauman, Glass, and Harrington (1969) reported that post organizers were superior to advance organizers. In fact they stated that advance organizers do not facilitate learning, but post organizers do facilitate learning significantly.

Grotelueschen and Sjogren (1968) compared three experimental groups and one control group. They manipulated the structure and sequencing of a learning task in mathematics. The subjects were 24 adults and 48 graduate education students. They found that advance organizers facilitated learning and transfer of complex tasks when the learning material was presented in a partially sequenced manner for adults of superior intellectual ability. This contradicts Ausubel's and Fitzgerald's (1962) findings which limited the facilitating effects of organizers to low-ability subjects only.

Farman (1968) studied the effects of a comparative organizer on retention of two parallel tasks from descriptive statistics. In one treatment, the comparative organizer was interpolated between the parallel tasks. In a second treatment, the comparative organizer was presented subsequent to the parallel tasks. No significant difference was found relative to one of the tasks. On the second task, students of average and low quantitative aptitude benefited most from the comparative advance organizer.

Allen (1969) compared the effects of an advance organizer on learning and retention in social studies. The subjects were ninth-grade students. His findings suggest that advance organizers facilitated learning and retention for students of above average ability, but had no facilitative effects with students of below average ability. This again contradicts the Ausubel and Fitzgerald (1962) findings.

Bravey (1969) studied the effects of advance organizers on the acquisition and retention of geological material. No significant difference was found between the experimental group and a control group.

Davis (1969), using eighth-grade students, compared the effects of three levels of advance organizers that were presented either prior to instruction or after the learning session. No control group was used. No significant differences were found.

Hustuft (1969) examined the effect of advance organizers on college students' decision making in a simulated situation. The organizers were in the form of video-taped classroom incidents. Significant differences were found in favor of the organizers, as evidenced by posttest scores of the experimental and control groups.

Townsend (1969) attempted to examine the effects of an advance organizer on learning to graphically analyze straight-line kinematics. The subjects were college students enrolled in a physics course. The learning material was presented in two modes of instruction: Programmed instruction and classroom presentation by the instructor. No significant main effect was found. The advance organizer interacted positively with programmed instruction. No significant treatment and ability level interaction was found.

Proger, et. al. (1970) compared four different advance organizers. His subjects were twelfth grade students. He found no significant difference between groups. He found significant interaction (treatment by ability level) that acted in the same way as that found in Ausubel and Fitzgerald (1961, 1962).

Kuhn and Novak (1970) had significant differences in favor of the advance organizer for immediate, but not for delayed, retention.

Pella and Trienzenburg (1969) and Weisberg (1970) compared the effects of different types of organizers. Their findings suggested that advance organizers with pictorial, graphic, and manipulative materials were more effective than verbal, expository advance organizers.

Livingston (1970), using eighth-grade and high school students, conducted three experiments with advance organizers. He used simulation games as advance organizers, and the learning materials dealt with economic geography. The control groups did not use simulation games as advance organizers. One experiment lasted one class session; the other two experiments lasted one week. The content of the first experiment was presented in a filmstrip; the content of the other two experiments was presented in a textbook. No significant differences were found, although the control groups scored higher in each of the experiments.

Gubrud (1970) compared the effects on learning of an advance organizer and a concrete experience. The subjects were junior and senior high school students. The material dealt with the concept of vectors. His findings suggested that organizers facilitated learning for students of relatively high abstraction ability.

Kirkwood (1970) investigated the use of advance organizers and "typical" introductions in a classroom presentation. The organizers were defined as overviews, and the introductions were defined as motivational passages. The subjects were elementary education undergraduates enrolled in an industrial arts class. A control group was employed. No significant difference was found on a posttest. Students of high ability (measured by SCAT scores) outperformed students of low ability students. No treatment and ability interaction was found.

Malone (1970) compared the effects of an advance organizer and a historical introduction on learning and retention of biology material. The subjects were community college students. Two experiments were performed. In the first experiment, a posttest was given three weeks after instruction ended; in the second experiment a posttest was given one week after completion of instruction. No significant main and interaction effects (treatment by sex) were found.

Ratzlaff (1970) compared the relative effects of advance organization, concurrent organization, and minimal organization on learning, retention, and transfer of mathematical concepts. The subjects were seventh grade students. The mathematics material dealt with the "base five" numeration system. Three groups were employed, and posttest scores revealed no significant differences on any of the criteria variables.

Ryder (1970) found that (an orally presented organizer and a control group) treatment, sex and grade significantly affected pupil understanding of two science concepts, and that experience background (good or poor) had no significant effects. He concluded that the advance organizer benefited students of rich experiencial background.

Steinbrink (1970) found that black students (elementary) who were taught a unit on geography using an advance organizer scored significanlty higher on a posttest than students in the control group with no advance organizer.

Thelen (1970), using four experimental and one control group of ninth grade students, compared the effects of advance organizers and guide material in viewing science motion pictures. No significant differences were found between treatments. Students not using advance organizers showed a negative change in attitudes toward motion pictures as instructional tools.

Barron (1971) compared a graphic organizer (defined as a visual and verbal presentation of the key vocabulary in a new learning task in relation to subsuming and/or parallel terms that presumably were part of the cognitive structure of the learners), a prose organizer (defined as a written expository), and no organizer. All sixth through twelfth grade levels received the same types of treatments. The statistical analysis did not indicate any differences favoring the organizers.

Yawkey (1971) studied differential performance effects in two groups of children (ages 3-7). Children in the experimental groups received a "number organizer" (based on set theory); students in the control groups received no such organizers. No significant main effects were found, but significant interaction effects were found between age and group. Advance organizers facilitated learning more as the age of children increased.

Bertou (1971) examined the effect of advance and post organizers and interspersed questions and all combinations thereof on learning and retention. The subjects were ninth grade students. The mode of instruction employed was in the form of a televised lecture. Posttest scores showed that advance organizers did not significantly affect learning and retention, but interspersed questions did affect learning and retention. No significant interaction was found between treatment factors.

Munford (1971) examined the effect of an organizer when it was positioned before and after the learning passage. His subjects were college students. A control group read an historical passage before the learning passage. No significant difference was found favoring the organizers.

Dvergsten (1971) employed one experimental group and a control group to study the effect of the use of an advance organizer combined with guided discovery on achievement and retention. The subjects were tenth grade science students. The learning task dealt with biology material. No significant differences were found between the experimental and control group.

Ethirveerasingam (1971) found that organizers, overviews and summary statements were equally effective in learning and retaining complex verbal material by eleventh grade vocational agriculture students.

Hershman (1971) compared the efficacy of advance organizers to that of behavioral objectives for improving achievement in a physics course. The subjects were college students. A control group was employed. No significant difference was found between treatments. The behavioral objectives were more effective in enhancing learning for low ability students.

Graber _et_. _al_. (1972), examined the effects of pre- and post-organizers with college undergraduate chemistry classes. A control group was utilized. The learning passage (which dealt with metalurgy), the two introductions, and the criterion tests used were those of Ausubel's 1960 study. He found no significant differences among groups.

Barnes (1972) and Clawson (1972) conducted a study of the effects of advance organizers. Barnes employed 12 sixth grade classes, and Clawson employed 20 third grade classes. The learning material was related to a topic in anthropology. The treatments were randomly assigned to classes. The statistical units of analysis were the classroom means. Both investigators found no signficant differences in favor of the groups using advance organizers.

Lucus (1972) studied the effects of written, visual, and audio advance organizers. His subjects were seventh grade science students, and the learning material dealt with a unit in biology. A control group was employed. He found no signficant difference between groups, nor did he find any significant interaction between treatment and either I.Q., abstract reasoning or sex.

Nixt (1972) examined the effects of frequent use of advance organizers and structured reviews in a college mathematics course. His sample did not include any mathematics, science, or engineering students. The learning materials dealt with analytic geometry, vectors, and matrix algebra. The method of instruction utilized televised lectures and supplementary recitation. Four advance organizers and four structured reviews were read by two experimental groups; one group read the organizers, the second group read the reviews, before and after the televised lecture. A control group was utilized. No significant differences were found favoring either treatment.

Schnell (1972) examined the effects of an organizer on the reading comprehension of prose material in psychology. The subjects were community college students. An advance, a post, and advance and post organizers were employed in the study. A control group was utilized. His findings suggested that regardless of the positioning of the organizer, students who received the organizers scored higher on a posttest than those students who did not receive any organizer. The preorganizer was more effective than the post and the pre- and post organizers. No significant interaction (treatment x intelligence x reading ability) effects were found.

Dapra (1972), using 96 college students of high and low verbal ability (as measured by verbal Scholastic Aptitude Test), compared four treatment groups: (a) advance organizer; (b) post questions; (c) repetition; and (d) control. The learning material was related to laws and concepts of Buddhism. The statistical analysis revealed no significant main or interaction effects. On a retention test, it was suggested that the groups that received advance organizers were more resistant to forgetting than other groups.

Lewis (1972) studied the effects of advance organizers (syntax as an advance organizer) on the acquisition of a foreign language. Experimental and control groups were utilized. The results showed that the groups using the advance organizers performed significantly better than the groups receiving no organizers.

Romberg and Wilson (1973) attempted to study the effect of an advance organizer, cognitive set, and post organizer on the learning and retention of written materials. "Advance organizer" was defined as information given to students prior to instruction that relates the unfamiliar new material to some general background the students are assumed to have. "Cognitive set" was used to denote information given to students prior to instruction that informs them of anticipated associations they can be expected to acquire in the instruction. "Post organizer" was used to refer to additional information that is given to students after instruction and that relates what has just been learned to the student' general background knowledge. Self-instructional booklets were designed so that the booklets contained a variety of combinations of organizers. No significant main effects were found on the learning test. A significant interaction betwen advance and post organizers, and a significant main effect for the cognitive set were found on the retention test. Examination of cell means indicated facilitating effects for the cognitive set; and either an advance or a post organizer was facilitating, but used together they were not facilitating.

Peterson, et al., (1973) studied the effect of an advance organizer, knowledge of a behavioral objective, and a post organizer on the learning and retention of a mathematical concept. Self-instructional booklets on network tracing were used, and each booklet contained a combination of these organizers. The subjects were eighth-grade students and preservice elementary education students. No significant main effect was found on posttest scores, but there was a significant interaction between advance and post organizers. No significant main effects or interactions were found on a retention test given one week after instruction. The interaction between advance and post organizers supports the findings of Romberg and Wilson (1973).

Yawkey and Dashiell (1973) found that the post organizer is more effective than the advance organizer when utilized as conceptual prestructuring in teacher training for early childhood education.

Price (1973) investigated the possibility of main and interaction effects among advance organizers, cognitive styles, and ability on acquisition and retention of meaningful verbal information. Cognitive styles were those of particularizer and generalizer, as identified by Ausubel's cognitive style instrument. Statistical analysis revealed no significant main or interaction effects.

Feller (1973) compared the effects of two types of advance organizers (advance and historical organizers) with the effects of two types of space questions (factual recall questions) on the reading comprehension of a selected group of tenth-grade students. Six classes were randomly assigned to treatment groups, and control groups read the assignment with no organizer. He reported that neither the advance organizer nor the historical organizer facilitated learning. He found no treatment and I.Q. scores interaction when three levels of I.Q. scores were analyzed. A question of independence might be raised concerning the statistical unit of analysis used in this study.

Johnson (1973) merged the theory of advance organizers with two concepts of Piaget's theory of cognitive development. He studied the effects of advance organizers on the child's ability to decenter and circumvent his egocentric thinking in learning selected mathematical concepts. Advance organizers were presented in forms of games, manipulatives, and applications. Using experimental and control groups, he found that students receiving the advance organizers scored significantly higher than students in the control group. He also found that students given several concrete models (or applications) were superior to students given one model on the decentering subexamination.

Anderson (1973) attempted to determine the facilitating effects of advance and post organizers on retention. The subjects were economics college students enrolled in macroeconomics. He tested for: (1) recognition and understanding, (2) simple application, and (3) complex application. The study lasted five class periods. A retention posttest was given three weeks after the unit of study ended. Advance organizers were found to facilitate retention better than post organizers.

Felker (1973) investigated the effects of adjunct post-questions and advance organizers and the combinations thereof on problem solving from prose text. A control and three experimental groups were employed in the study. His findings showed that there were no significant performance differences between having and not having advance organizers, and adjunct post-questions resulted in significantly superior problem solving behavior compared to no adjunct post-questions.

Caponecchi (1973) compared the effects of an advance organizer, an introductory overview, and an historical passage. The subjects were 91 undergraduate college students in a mathematics class. The learning material dealt with matrices. The experiment lasted eight class sessions (2 weeks) followed by a posttest and a three weeks retention test after the experiment ended. He found no significant differences among groups. When students were classified according to ability levels (based on ACT English and mathematics scores) there was found significant interaction between the treatments and ability levels on the achievement test. He found that low ability students benefited from the use of advance organizers and introductory overview more than the historical passage. There was no statistical difference between the organizer and the introductory overview, although the difference in the means favored the organizer.

Tyrell (1973), using 135 undergraduates enrolled in a basic introductory biology course, investigated the effects of cognitive organizer format and position on learning. His findings revealed that students receiving cognitive organizers achieved significantly better than students receiving nonorganizers. No overall advantage in one sequencing position of organizer over another was found.

Barrow (1973) compared the effects of an advance organizer with an historical introduction on learning science materials. The subjects were seventh grade students. His findings nullified the claim of facilitating effects of advance organizers. In fact, students having low I.Q. benefited more from the historical introduction than from the advance organizers.

Shmurak (1974) conducted a study to determine if advance organizers designed to match student cognitive style would produce greater learning and retention of expository science material than unmatched organizers. Students were classified into either categorical-inferential, descriptive-part-whole, or relational style. Learning styles were determined by means of the Sigel Cognitive Style Test. Three experimental and one control group were used. No significant differences were found.

Montano (1974) investigated the effects of an audio-visual advance organizer upon the learning of permutations. Three different levels of advance organizers were used: (1) audio-visual organizer, (2) a written advance organizer, and (3) no organizer. The subjects were lower division college students. The materials for instruction were contained in special instructional booklets. Audio-visual organizers were presented to one group on two projectors. A written eqivalent version of the advance organizer was read by a second group. Statistical analysis of posttest scores failed to yield any significant main or interaction effects between levels of advance organizer and ability levels. A complementary study was conducted to act as a control to measure the possibility of significant learning being produced by the audio-visual organizer alone. The audio-visual advance organizer, however, did not have any additional effect on learning without the instructional booklet.

Caille (1974) investigated the relative effectiveness of group interaction, individualized instruction, advance organizers, and reading and listening on student performance. Sixth grade students were used in the study. The findings showed no significant difference among experimental and control groups.

Frisch (1974) examined the possibility of main effect and interaction of organizers (intentional or unintentional), sex, instruction (target passage organized by name or attribute), and item type (posttest items which varied according to the kind of cues provided and to the number of text sentences in which information appeared). Statistical analysis revealed no significant differences. Small interactions were found between sex and other variables.

Brower (1974), using 84 adults, attempted to determine the effect of a series of four learning organizers. Experimental and control groups were used. His findings revealed no significant difference between groups with organizers and groups receiving no organizer instruction.

Slock (1974) attempted to determine if an advance organizer would cause both a long term and a short term increase in student performance. An experimental group and a control group were employed. The subjects were freshmen medical students. On two occasions prior to the instructional unit, the experimental group read an advance organizer while the control group read a non-conceptual passage. Following instruction, an achievement posttest was administered; six months later a retention test was also given. Results of both tests showed that the experimental group performed significantly better than the control group. This yields support to Ausubel's theory of advance organizers.

Laster (1974) studied the effects of an advance organizer with dental students. Three hours of advance organization in lecture form preceded twenty hours of classroom lecture material. No control was used. Results of achievement test scores revealed that a good measure of success was found in relation to the amount of material covered in a short period of time.

Jones (1974) studied the comparative effects of level specific advance organizers on the achievement of students of differing ability levels. A relatively abstract organizer was prepared for high school students enrolled in college preparatory courses (abstract subjects), and a relatively concrete organizer on the same topic was prepared for these high school students who were enrolled in a basic curriculum (concrete subjects). Abstract subjects were divided into three treatment groups: one group received the abstract organizer, the second group received the concrete organizer, and the third group received nonorganizer. Concrete subjects were likewise divided and treated. Following the introductory experience, subjects received four days of associated classroom instruction followed by a performance test. A retention test was given three weeks later. Test results revealed that abstract subjects receiving the abstract organizer scored significantly higher than abstract subjects receiving the concrete organizer or the nonorganizer. Concrete subjects receiving concrete organizer scored significantly higher than subjects receiving the abstract organizer, but not significantly higher than those receiving the nonorganizer. Interaction effects on performance test scores were significant. Retention test scores showed no significant difference, but interaction effects were still significant. It was concluded that organizers facilitate learning and short-term retention.

Zuck (1974) investigated the use of advance organizers in the learning of English as a second language. The subjects were 36 adults from 15 foreign countries. The study involved a pretest-posttest control group design. Subjects in the experimental group received the advance organizer in the form of general statements about abstract relationships in English syntax. While students in the experimental group were being administered the advance organizers, students in the control group had already started working on the assigned syllabus. Statistical analysis revealed no significant difference between the experimental and control group. It was reasoned that the extra time available for the control group may have influenced the results.

Kennedy (1974) investigated the possibility of main effects and interactions among organizers, student abilities (measured by students' grade-point average), and cognitive structure (the number of high school and college courses in math and science completed), on the acquisition and retention of metric system concepts. His subjects were undergraduate elementary education majors. The author found that the comparative organizer was superior to the historical introductory passage in facilitating the learning and retention of the metric system concepts. Also the historical introductory passage was more effective than the control treatment. The authro found no significant interaction except that for high ability students on both learning and retention.

Kahle and Norlan (1975) investigated the effect of an advance organizer when utilized with carefully sequenced audio-tutorial units (individualized instruction) on learning biology materials. The subjects were elementary education majors. An experimental and a control group were employed. Students in the experimental group spent ten minutes on the advance organizer every session for the duration of the experiment (four weeks). No significant differences were found between experimental and control groups on the achievement posttest.

Hartje (1975) investigated the effects of using advance organizers on the learning and retention of specific mathematical concepts taken from elementary group theory. The subjects were twelfth grade students who had completed only mathematics courses required for high school graduation. Self-instructional booklets were used. One experimental group received two advance organizers: (1) a discussion of axiomatic systems and (2) a discussion of mathematical systems before each of three lessions in the self-instructional booklets. A second experimental group received only one advance organizer, the discussion of mathematical systems. The control group received only the instructional booklets. Statistical analysis showed significant main effects for multiple organizer treatment. The multiple and single organizers were both significantly higher than the control treatment for the retention test.

Swaney (1975) investigated the relative effects on achievement of three summarizations (organizers) techniques differing only by degree of abstraction. In order of decreasing levels of abstraction, these techniques were: A summarizer in behavioral objective format, a summarizer with problem format, and a summary with problem format. The subjects were enrolled in a first year college course in calculus. Having completed the course, the subjects were given one week on these written study guides in three treatment groups. Statistical analysis of the achievement test scores revealed no differences among the three groups. It was reasoned that the "homeostasis of human learning may be too tenacious to accept new learning patterns in so short a time."

Andreozzi (1975) attempted to determine the effectiveness of advance organizers and written verbalizations and the various combinations thereof on the learning and retention of selected algebraic concepts. The subjects were ninth grade students. Each day of instruction included treatment introduction (advance organizer or historical passage), a unit of instruction for all subjects, and treatment conclusions (written verbalizations defined as written responses to a series of questions for all treatments). The statistical analysis revealed that learning and retention were not affected by the advance organizers or written verbalizations. Written verbalizations in conjunction with advance organizers were more effective than when used with historical passages. This could be interpreted as consistent with the findings of Romberg and Wilson (1973) and Peterson, et al. (1973).

Maher (1975) studied the effects of organizers on the interpretive level of reading comprehension of selected fourth and sixth grade students. Two experimental and two control groups were utilized. The findings revealed that the use of advance organizers in the form of interpretive objectives, and questions aimed at these objectives, following the reading assignment, provided for significant improvement on the interpretive section on the California Reading Test. It was also found that low and average achievement students benefited most from the interpretive objectives and questions. The results of this study support the effectiveness of organizers.

Young (1975) studied the effects of post organizer and organizing repetition upon the learning of mathematics at the college level. The target group was all students in a college algebra course. Students were divided into groups of mathematical ability levels (as measured by mathematics scores of the ACT). Treatments were administered in the form of various combinations of organizers (PO, PO and RO, RO), and a control group. No significant differences were found on achievement among the four groups. No significant interaction was found between treatment and mathematical ability levels.

Graber (1975) studied the effects of advance organizers and teacher questions on student learning in undergraduate pre-calculus mathematics. Three different organizers and three rates of questions (number of questions) were employed. The various combinations provided nine treatments. No control group was used. Posttest results showed no significant difference among the nine groups. It was found, however, that of the students receiving organizers, those presented with four questions scored slightly higher than those presented with twelve questions.

Toth (1975) investigated the effects of prior knowledge and critical thinking on the interpretation of an advance organizer in the learning of a biology unit. The possibility of main and interaction effects between treatments (organizers and control) and prior knowledge and initial thinking (aptitude) was nullified by the finding of no difference in achievement among all groups. The results seem to dispute the claim of facilitating effects of organizers on learning.

Farr (1975) investigated the effects of three thematic organizers, in a seriesof three experiments, on reading comprehension. The first experiment tested the effects of one thematic organizer, the second experiment ested the effect of three thematic organizers, and the third experiment investigated the effect of three different types of thematic organizers. The results showed the presentation of thematic organizers facilitates reading comprehension.

As a result of three research projects, Lesh (1976) reported that advance organizers facilitate learning in instructional situations where "structural integration" is a problem; the advance organizer has a greater facilitating effect for a hierarchy unit than for a spiral unit; advance organizers are superior to post organizers, a contradiction to findings by Harrington (1968) and Bauman, Glass, and Harrington

(1969) and others; and advance organizers that consist of counter examples facilitate learning better than advance organizers with examples.

Bright (1976), using elementary education majors, reported that there was no significant difference in the effects of advance organizers, written at different levels of abstraction, in the learning of mathematical concepts. He did, however, find that advance organizers interacted significantly with the number of instances of recall of an advance organizer during instruction.

Summary

Several types of organizers have been identified, and the use of organizers as an instructional technique has been studied in various fields. Research findings, however, have been contradictory and inconclusive. No one pattern or trend seems to emerge regarding the facilitating effects of organizers on learning and retention.

Personality, Achievement and the MBTI

That a relationship between student personality and achievement exists is well established. Kemawitz *et al*. (1960), Hager (1961), Cleveland (1961), Cattel *et al*. (1966), and Swafford (1969) have reported that certain personality characteristics correlate highly with achievement.

Ridding (1967), using Cattel's High School Personality Questionnaire, observed that extraversion correlated positively with overachievement and introversion with under-achievement in both English and mathematics.

Hendly (1968), using the Minnesota Multiphase Personality Inventory, reported that students with high computational ability in mathematics tend to be more introverted and compulsive. She also suggested that certain personality characteristics are related to certain mathematical factors.

In a substantial amount of data, collected from different groups, Myers and Briggs have shown that students of different personality types exhibit differences in academic apptitude and achievement (Myers, 1962).

Conary (1965) investigated the variability of behavioral reponses of Jungian psychological types to select educational variables, and Grant (1965) investigated the behavior of MBTI types; their findings substantiated those of Myers and Briggs (1962).

Barberouse (1965), using eighth grade subjects, found that certain personality types (MBTI types) correlate with creative thinking, and intuitive types had higher I.Q. than sensing types.

May (1971), working with eighth grade subjects, investigated the relationship between the sensing and intuitive personality characteristics and mathematics student achievement in computation, concepts, and application, and sensing and intuitive personality characteristics and mathematics attitudes and intelligence. Statistically significant differences were found in achievement, computation, concepts, application, and intelligence between sensing and intuitive types, favoring the intuitive types.

In a series of research reports and papers, McCaulley (1971, 1973, 1974) concluded that in the general population extraverts out-number introverts, and sensing types out number intuitive types; the higher the educational background, the higher the proportion of intuitive types; intuitive types score higher than sensing types on most aptitude test which are designed to test verbal skill, speed of comprehension, and ability to draw conclusions and inferences; introverts with intuition are the most academically inclined; more males than females are thinking types, but more females than males are feeling types; judging types are better achievers (academically) than perceiving types.

CHAPTER III

RESEARCH DESIGN

Experimental Design

The experimental design of this study is illustrated in Table 2. This abstract representation is a 3 x 2 (treatment by personality dimension) factorial design which was used for the purpose of analysis of variance, utilizing statistical data from learning and retention test scores.

The subjects in this study were classified into two experimental groups and one control group with the following order of instruction:

Treatment I	Class 1	T_1	MBTI	AO	LA		T_2		T_3
	Class 2	T_1		AO	LA		T_2	MBTI	T_3
Treatment II	Class 1	T_1	MBTI		LA	PO	T_2		T_3
	Class 2	T_1			LA	PO	T_2	MBTI	T_3
Treatment III	Class 1	T_1	MBTI		LA	C	T_2		T_3
	Class 2	T_1			LA	C	T_2	MBTI	T_3

where "T_1", represents the pretest, "MBTI" refers to the Myers-Briggs-Type-Indicator, "AO" represents the advance organizer, "LA" refers to the classroom learning activities, "PO" represents the post organizer, "C" represents the control treatment, "T_2" represents the learning posttest, and "T_3" represents the retention test.

The Sample

The sample chosen for this study consisted of six intact classes of Mathematics 1444, Mathematics for Management, Social, and Life Sciences, at the University of Oklahoma. Class selection was based on the class instructor's willingness to participate in the study. Of 11 sections of Mathematics 1444, 6 class instructors volunteered to participate in the study. The final sample consisted of 88 students, all of whom participated in all phases of the study. Of the 88 subjects, 45 were males, 43 were females, 41 were freshmen, 37 were sophomores, 6 were juniors, and 4 were seniors. Table 3 shows the student type distribution of the final sample of this study.

Material and Instruction

The mathematical learning material used for this study was Chapter 8 (Matrices and the Solution of Linear Systems) from the book Foundations of Mathematics with Application to the Social and Management Sciences, 2nd edition, by Grace A. Bush and John E. Young, McGraw-Hill, Inc., 1973. This was the adopted text for the course Mathematics 1444 at the time of the study.

The topic of matrices was selected because it is a relatively advanced topic for many students in the social and life sciences, and few students have prior experience with it.

The instructional mode for this study was that of the classroom lecture-discussion type for the duration of the study.

Table 2

Multiple Classification Analysis of Variance for the Experimental Design

Treatment / Personality Dimensions	Advance Organizer	Post Organizer	Control	N = 88
Extraversion vs	cell #1 $n_{11} = 12$	cell #2 $n_{12} = 16$	cell #3 $n_{13} = 20$	$n_{1.} = 48$
Introversion	cell #4 $n_{21} = 16$	cell #5 $n_{21} = 13$	cell #6 $n_{23} = 11$	$n_{2.} = 40$
Sensing vs	cell #7 $n_{31} = 16$	cell #8 $n_{32} = 18$	cell #9 $n_{33} = 20$	$n_{3.} = 54$
Intuition	cell #10 $n_{41} = 12$	cell #11 $n_{42} = 11$	cell #12 $n_{43} = 11$	$n_{4.} = 34$
Thinking vs	cell #13 $n_{51} = 8$	cell # 14 $n_{52} = 9$	cell #15 $n_{53} = 11$	$n_{5.} = 28$
Feeling	cell #16 $n_{61} = 20$	cell #17 $n_{62} = 20$	cell #18 $n_{63} = 20$	$n_{6.} = 60$
Judging vs	cell #19 $n_{71} = 17$	cell #20 $n_{72} = 15$	cell #21 $n_{73} = 17$	$n_7 = 49$
Perceiving	cell #22 $n_{81} = 11$	cell #23 $n_{82} = 14$	cell #24 $n_{83} = 14$	$n_8 = 39$

Table 3

Sample Type Table

ISTJ 6	ISFJ 13	INFJ 4	INTJ 2	
ISTP	ISFP 5	INFP 8	INTP 2	
ESTP 2	ESFP 10	ENFP 7	ENTP 5	
ESTJ 9	ESFJ 9	ENFJ 4	ENTJ 2	
17	37	23	11	N = 88

E = 48 (55%)	I = 40 (45%)
S = 54 (61%)	N = 34 (39%)
T = 28 (32%)	F = 60 (68%)
J = 49 (56%)	P = 39 (44%)

Development of the Organizer

Ausubel did not set forth any outlines for the construction of operationally defined organizers. Yet he suggested that organizers must be of a higher level of abstraction, generality, and inclusiveness than the actual learning task. He also suggested that the organizer should use familiar terms and appropriate illustrations (Ausubel, 1963; pp. 81-83).

The organizer focused on the concept of "operation" in a mathematical system, and a mathematical system was defined as a set of elements together with a set of operations defined on the elements. It was indicated that certain properties govern the behavior of the elements in the set.

The set of real numbers was considered as a mathematical system and four properties of an "operation" were identified, namely, the commutative, associative, identity, and inverse properties. Various examples and counter examples were included in the organizer to illustrate the concept of operation and four properties of operation. A test for mastery was attached to the organizer to ensure incorporation of the organizer material in the existing cognitive structure of students.

The post organizer was the same as the advance organizer as shown in Appendix A.

The Myers-Briggs-Type-Indicator

This instrument was designed to implement Jung's theory of psychological types which states that "much of the apparently random variation in human behavior is actually quite orderly and consistent, being due to certain basic differences in the way people prefer to use perception and judgement" (Myers, 1962).

The MBTI is a 166-item, self-administering, forced-choice questionnaire published by the Educational Testing Service in 1962. The four basic preferences used in the MBTI are:

Index	Preference as Between
EI	Extraversion or Introversion
SN	Sensing or Intuitive
TF	Thinking or Feeling
JP	Judgement or Perception

The EI index is designed to reflect whether the person is an extravert or an introvert in the sense intended by Jung, who coined the terms. The extravert is oriented primarily to the outer world, and thus tends to focus his perception and judgement upon people and things. The introvert is oriented primarily to the inner world postulated in Jungian theory, and thus tends to focus his perception and judgement upon concepts and ideas.

The SN index is designed to reflect the person's preferences as between two opposite ways of perceiving, i.e., whether he relies primarily on the familiar process of sensing, by which he is made aware of things direclty through one or another of his five senses, or primarily on the less obvious process of intuition, which is understood as indirect perception by way of the unconscious, with the emphasis on ideas or associations which the unconscious task on to the outside things perceived.

The TF index is designed to reflect the person's preference as between two opposite ways of judging, i.e., whether he relies primarily upon thinking, which discriminates impersonally between true and false, or primarily upon feeling, which discriminates between valued and not-valued.

The JP index is designed to reflect whether the person relies primarily upon a judging process (T or F) or upon a perceptive process (S or N) in his dealings with the outer world, that is, in the extraverted part of his life (Myers, 1962).

According to Myers' theory, then, a person creates his/her own "type" by using the processes he/she prefers to use and in the areas where he/she prefers to use them. Myers emphasizes, however, that these basic preferences simply identify different kinds of people who are interested in different things, and are proficient in different fields.

Scoring the MBTI. There are two separate keys for each index (dimension), and different keys must be used for males and females on the T-F index. Each item on the test carries a weight of either 0, 1, or 2 points, and the scorer simply tabulates the total points for each of the eight preferences. For example, to determine the preference score on the E-I index the points for E and the points for I are obtained; the greater number indicates the direction and clarity of preference and the letter part of the score. The numerical score for the E-I group is obtained by doubling the difference between the E and I points and adding or subtracting one. This last operation is performed to eliminate all "troublesome" zero scores. A scoring sample is shown aside.

Points		Score
E 10	I 18	17
S 12	N 12	01
T 21	F 7	29
J 16	P 8	15
TYPE: INTJ		

Sample Scoring Box

For statistical purposes, preference scores can be changed to continuous scores. For an I, N, F or P score, the continuous score is the preference score plus 100. For an E, S, T or J, the continuous score is 100 minus the preference score.

Reliability of the MBTI. The reliability of the MBTI has already been established. By using the split-half procedure, and applying the Spearman-Brown Prophecy Formula to the MBTI, Myers reported that the reliabilities on each of the four indices vary from .75 to .94. Myers stated "the reliabilities appear creditable for an instrument of this sort."

Stricker and Ross (1962) correlated the MBTI with the Gray-Wheelwright Psychological Type Questionnaire, which is a personality scale with the same purpose as the MBTI. They found that the correlations of E-I, S-N, and T-F on the MBTI with the corresponding Gary-Wheelwright scales were .79, .58 and .60, respectively.

The Achievement Test

The achievement test consisted of two parts as shown in Appendix B. The first part consisted of twelve statements to be assessed as "true", "sometimes true", or "false". The second part consisted of thirteen multiple choice problems.

The total set of twenty-five items in the achievement test was written by the investigator, and the items were judged for content validity by an expert in the field of mathematics education who was the coordinator for Mathematics 1444 at the University of Oklahoma. The reliability of the achievement test was .72. This was established by applying the Kuder-Richardson Formula 14 to all scores on the achievement test. The retention test was basically the same as the achievement test; it followed the same format, but the matrices were changed.

Procedure for Collecting Data. A five-minute pre-test was administered in all six classes during the fith week of the fall semester of 1976-77. The purpose of the pre-test was to eliminate from the study those students with previous knowledge of matrices and to ensure relative equality of groups.

One week before the beginning of the experiment, the six classes were randomly assigned to three groups, with two classes in each group. Then the three treatments were randomly assigned to these groups. No attempt was made to control teacher variation in the classroom. All six class instructors participating in this study were graduate assistants in the Department of Mathematics at the University of Oklahoma, and each instructor taught one and only one class.

The introduction of the topic of matrices was scheduled for Tuesday, October 12, in all six classes. Three classes, however, needed an extra day to finish some assignments from previous topics, thus delaying the start of the experiment by one day. In order to delay the progress of the other three classes for one day, the MBTI was administered in the other three classes. On Wednesday, October 13, classes did not meet. On Thursday, October 14, the experiment began and the topic of matrices was introduced in all six classes.

On Thursday, October 14, the A-O group received the reading passage (advance organizer) prior to the introduction of the topic of matrices. Attached to the organizer was a list of questions that constituted a test for mastery of the organizer. The students read and studied the reading passage and responded to the questions. While responding to the questions, the students were allowed to refer to the reading passage they had read. Thirty minutes were allowed for reading the organizer and responding to the questions. The reading passage and questions were returned to the instructor, and the topic of matrices was introduced during the remainder of the class session. The instructors, in turn, returned the reading passages and questions to this investigator, who examined them and found that the students had read and responded to all materials they had been given.

On Tuesday, October 26, the P-O group received the reading passage (post organizer) during the last thirty minutes of the final session of instruction on matrices.

On Wednesday, October 27, classes did not meet, but copies of the achievement test were given to the instructors. On Thursday, October 28, a 30-minute achievement test was administered in five classes; a scheduling conflict existed in the sixth class (a control class), but the achievement test was administered on the following day, Friday, October 29. The achievement tests were returned to this investigator who graded the tests and returned them to the instructors the following day.

During the first week of November, the MBTI was administered in the remaining three classes, since the other three classes had already taken the MBTI two days prior to the start of the experiment. On Thursday, November 18, a three-week retention test was administered in all six classes. The retention tests were graded by the investigator and returned to the individual instructors on the following day.

Treatment of Data

Data analysis for this study was performed in two major stages. First, two dependent variables, learning (achievement) and retention, were examined. The independent variables consisted of three treatments and four personality dimensions. Each personality dimension consisted of two opposite preferences. Four analysis of variances were generated for each of the two dependent variables. Achievement and retention test scores were utilized in four 3 x 2 factorial analyses of variance to test for main and interaction effects of treatments.

Second, student preference scores on the MBTI were changed to continuous scores, then stepwise discriminant analysis was used as a statistical procedure to (1) examine differences among the three groups with respect to the four personality dimensions, and (2) study the relations among all four variables (dimensions) of personality, i.e., determine the nature of, and the relative contribution of each variable to, group differences.

CHAPTER IV

STATISTICAL ANALYSIS OF THE DATA

Hypotheses Testing

In the first stage of data analysis, Hypotheses 1 through 6 were tested. The data for the learning and retention tests were subjected to four 3 x 2 factorial analyses of variance. The factors considered were the three treatments and four personality dimensions. Each dimension consisted of two opposite preferences. The class means on the learning and retention tests for each preference were used for the unit of statistical analysis.

The grand mean on the achievement test was 18.11 with a standard deviation of 3.20. The means and standard deviations for each treatment cell in the experimental design are shown in Table 4.

The analyses of variance for the achievement test are shown in Table 5, Table 6, Table 7, and Table 8.

H_{01}: There are no significant interactions between the three treatments and the four personality dimensions as measured by mean learning test scores.

The F-ratios obtained for the interactions failed to reach significance at the 0.05 level. Thus H_{01} was not rejected.

H_{02}: There are no significant differences in mean learning test scores among the three treatments on each of the four personality dimensions.

The F-ratios obtained for the treatments on the E-I, S-N, and F-T dimensions failed to achieve significance at the 0.05 level, but the F-ratio obtained for the treatments on the J-P dimension (Table 8) is significant at the 0.05 level. Thus H_{02} can be rejected, and the conclusion made that there are significant differences among the three treatments on the J-P dimension of personality.

By employing Tukey's procedure for pair wise comparisons between groups, shown in Table 9, the advance organizer-control groups comparison achieved significance at the 0.05 level with 3/9 degrees of freedom. Thus it was concluded that the advance organizer group achieved significantly higher mean learning test scores than the control group on the J-P dimension of personality.

H_{03}: There are no significant differences in mean learning test scores between the two preferences on each of the four personality dimensions.

The F-ratios obtained for differences between the two preferences on each personality dimension failed to achieve significance at the 0.05 level. Thus H_{03} was not rejected.

Table 4

Achievement Test Means and Standard Deviations for

Six Cells on Each Personality Dimension

Treatment / Personality Dimension	Advance Organizer		Post Organizer		Control	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
Extraversion	19.17	3.78	18.13	3.26	16.68	3.16
Introversion	19.75	2.46	18.30	2.40	18.25	2.45
Sensing	19.00	3.62	17.67	3.40	17.55	2.80
Intuition	20.17	2.08	19.09	1.56	16.82	3.30
Thinking	19.75	3.21	17.75	2.95	17.25	2.74
Feeling	18.63	2.55	19.44	2.67	17.27	3.36
Judging	19.59	2.85	19.00	2.25	17.12	3.36
Perceiving	19.36	3.47	17.50	3.42	17.53	2.42

Table 5

Analysis of Variance for the Achievement Test

Scores on the E-I Dimension

Source	SS	DF	MS	F	$F_{0.05}$
Column	9.364	2	4.682	3.362	5.14
Row	1.613	1	1.613	1.158	5.99
Col x Row	0.465	2	0.233	0.167	5.14
Error	8.355	6	1.393		
Total	19.797	11			

Table 6

Analysis of Variance for the Achievement Test

Scores on the S-N Dimension

Source	SS	DF	MS	F	$F_{0.05}$
Column	10.730	2	5.365	3.282	5.14
Row	0.297	1	0.297	0.182	5.99
Col x Row	1.676	2	0.838	0.513	5.14
Error	9.809	6	1.635		
Total	22.512	11			

Table 7

Analysis of Variance for the Achievement Test

Scores on the T-F Dimension

Source	SS	DF	MS	F	$F_{0.05}$
Column	11.219	2	5.609	2.209	5.14
Row	0.074	1	0.074	0.029	5.99
Col x Row	6.492	2	3.246	1.278	5.14
Error	15.234	6	2.539		
Total	33.020	11			

Table 8

Analysis of Variance for the Achievement Test

Scores on the J-P Dimension

Source	SS	DF	MS	F	$F_{0.05}$
Column	11.834	2	5.917	5.378	5.14
Row	0.064	1	0.064	0.058	5.99
Col x Row	1.205	2	0.603	0.548	5.14
Error	6.602	6	1.100		
Total	19.706	11			

Table 9

Tukey's Test for Pairwise Comparisons Among

Treatment Mean Learning Test Scores

Groups	F	$F_{0.05}$
Advance organizer-Control	4.56	3.95
Post organizer-Control	3.01	3.95
Advance organizer-Post organizer	1.55	3.95

Table 10

Retention Test Means and Standard Deviations for

Six Cells on Each Personality Dimension

Treatment	Advance Organizer		Post Organizer		Control	
Personality Dimension	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
Extraversion	18.33	2.99	18.25	2.35	16.68	3.70
Introversion	18.56	2.71	18.85	2.64	20.17	2.95
Sensing	18.06	3.13	18.28	2.74	18.85	3.45
Intuition	19.00	2.56	18.82	2.09	17.25	4.25
Thinking	17.75	2.96	19.45	2.60	18.55	3.64
Feeling	18.75	2.73	18.10	2.34	17.95	3.75
Judging	17.97	2.53	19.40	2.30	18.24	4.09
Perceiving	19.27	3.26	17.57	2.34	17.79	3.60

The grand mean on the retention test was 18.41 with a standard deviation of 2.93. The means and standard deviations for each treatment cell in the experimental design are shown in Table 10.

The analyses of variance for the retention test are shown in Table 11, Table 12, Table 13, and Table 14.

H_{04}: There are no significant interactions between the three treatments and the four personality dimensions as measured by the mean retention test scores.

The F-ratios obtained for the interactions failed to achieve significance at the 0.05 level. Thus H_{04} was not rejected.

H_{05}: There are no significant differences in mean retention test scores among the three treatments on each of the four personality dimensions.

The F-ratios obtained for the three treatments on each personality dimension failed to achieve significance at the 0.05 level. Thus, H_{05} was not rejected.

H_{06}: There are no significant differences in mean retention test scores between the two preferences on each of the four personality dimensions.

The F-ratios obtained for the two preferences on each personality dimension failed to achieve significance at the 0.05 level. Thus, H_{06} was not rejected.

Table 11

Analysis of Variance for the Retention Test

Scores on the E-I Dimension

Source	SS	DF	MS	F	$F_{0.05}$
Column	1.228	2	0.614	0.161	5.14
Row	4.992	1	4.992	1.307	5.99
Col x Row	7.293	2	3.647	0.955	5.14
Error	22.914	6	3.819		
Total	36. 427	11			

Table 12

Analysis of Variance for the Retention Test

Scores on the S-N Dimension

Source	SS	DF	MS	F	$F_{0.05}$
Column	3.713	2	1.856	0.474	5.14
Row	1.442	1	1.442	0.368	5.99
Col x Row	0.672	2	0.336	0.086	5.14
Error	23.480	6	3.913		
Total	29.306	11			

Table 13

Analysis of Variance for the Retention Test

Scores on the T-F Dimension

Source	SS	DF	MS	F	$F_{0.05}$
Column	2.735	2	1.368	0.303	5.14
Row	1.241	1	1.241	0.275	5.99
Col x Row	4.136	2	2.068	0.458	5.14
Error	27.082	6	4.514		
Total	35.195	11			

Table 14

Analysis of Variance for the Retention Test

Scores on the J-P Dimension

Source	SS	DF	MS	F	$F_{0.05}$
Column	4.825	2	2.413	0.499	5.14
Row	0.037	1	0.037	0.008	5.99
Col x Row	3.872	2	1.936	0.400	5.14
Error	29.018	6	4.836		
Total	37.751	11			

Table 15

Means and Standard Deviations for the Three Groups on the Four Personality Dimensions

Treatment	Advance Organizer		Post Organizer		Control	
Personality Dimension	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
EI	101.79	25.74.	99.03	27.17	96.35	24.78
SN	99.14	21.28	97.83	23.27	90.48	27.25
TF	109.50	24.90	110.14	23.04	108.61	19.07
JP	96.86	31.33	94.55	25.59	99.00	31.70

In the second stage of data analysis, Hypothesis 7 was tested with the use of the computer program BMD 07M (Dixon, 1975).

The scoring of the MBTI was done by this investigator. Preference scores were changed to continuous scores, and the data was subjected to the stepwise discriminant analysis procedure. Table 15 shows means and standard deviations for the three groups on the four personality dimensions.

H_{07}: There are no significant differences among the three groups with respect to simultaneous measures on all and each of the four personality dimensions.

From the context of H_{07}, the variables whose means were compared are the EI, SN, TF, and JP dimensions of personality. These variables were considered as dependent variables, and the grouping variables (AO, PO, C) were considered as independent variables. Thus the purpose of the discriminant analysis in this case is that of separation and discrimination among groups rather than prediction and classification (Huberty, 1975; pp. 546-47).

Results of the discriminant analysis indicated that when considered individually as single predictors in the system of separation and discrimination, the scores on the variables EI, SN, TF, and JP were all nonsignificant predictors.

EI	SN	TF	JP
0.3238	1.1181	0.0353	0.1680

The F values, with 2/85 degrees of freedom were not significant. Thus H_{07} was not rejected.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

This study was designed to test Ausubel's theory of organizers coupled with Jung's theory of personality types. This theoretical merger led to the conjecture that different student personality types may benefit in varying ways from different organizers.

Ausubel, on the one hand, suggested that one can manipulate existing cognitive structures by using teaching strategies that include organizers whose function is that of facilitating the meaningful reception of a new learning task by providing "ideational scaffolding" for each unit of differentiated subject matter. The organizers are to be presented at a higher level of abstraction, generality, and inclusiveness than the new learning task. Jung, on the other hand, hypothesized that human behavior can be attributed to basic differences in the way people prefer to use perception and judgement.

The purpose of the study was to examine the manner in which student personality types, as measured by the Myers-Briggs-Type-Indicator, affect the extent to which cognitive organizers facilitate the meaningful reception and retention of a new mathematical task.

Six intact classes of Mathematics 1444, Mathematics for the Management, Social and Life Sciences, at the University of Oklahoma, were randomly assigned into three equal groups; then treatments were randomly assigned to groups. A pretest was administered to eliminate from the study those students with previous knowledge of the learning material and to ensure relative equality of groups. The final sample consisted of 88 students.

Students in the advance organizer group received a thirty-minute organizer prior to the actual presentation of the learning material on matrices. During the last thirty minutes of the final day of treatment, the post organizer group received the post organizer. A test for mastery of organizer was attached to both advance and post organizers. The control group received no organizer.

The experiment covered eight 50-minute class sessions of instruction. A 25-item achievement test was administered during the ninth class session, and a 25-item retention test was administered three weeks later.

Achievement and retention test scores were analyzed in four 3 x 2 (treatment by personality dimension) factorial analyses of variance. Class mean scores, for each preference on each personality dimension , were used as the statistical unit of analysis to ensure independence of subjects. Data from the Myers-Briggs-Type-Indicator were also analyzed separately by the stepwise discriminant analysis procedure to determine differences among groups on each personality dimension.

Findings

(1) There were no significant differences in achievement and retention test scores that could be attributed to an interaction between treatments and personality types.

(2) Cognitive organizers did not provide any facilitating effects in the learning and retention of mathematics as shown by the lack of significant differences among groups and between opposite preferences for each personality dimension.

(3) On the judging-perceiving dimension, the advance organizer treatment was significantly superior to the control treatment in facilitating learning, but not retention, of mathematics.

(4) Relative to student personality types, there were no significant differences among the three groups with respect to simultaneous measures on all and each of the four personality dimension.

Conclusions and Discussion

Based upon results of the statistical analysis, the major conclusion that was drawn is that there are no interactions between cognitive organizers and student personality types in learning and retention of mathematics.

Research reports relative to the facilitating effects of organizers seem to yield conflicting and sometimes contradictory results, and the evidence provided by the results of this study fails to confirm a number of previous findings while strongly supporting others. In particular, the results of this study fail to support Ausubel's theory of organizers and the claim by Cronbach and Snow (1969) that different personality types interact with different instructional techniques. The results also fail to confirm research findings related to the MBTI, in which it is claimed that students of different personality types exhibit differences in academic aptitude and achievement.

The failure of the organiser to achieve any significant interactions can be explained in several ways.

(1) According to Ausubel (1963) and Graber, et al., (1972), it is possible that the subjects participating in this study already possessed stable and subsuming concepts that provided anchorage for the learning material and the students were capable of subsuming the new material without the help of the organisers.

(2) Several types of organisers have been identified, but what constitutes an organiser is not clear. Ausubel has set forth no objective criteria for determining the legitimacy of an organizer. Thus, the organizers employed in this study may have not attained the level of abstraction, generality, and inclusiveness intended by Ausubel.

(3) A new learning task is considered potentially meaningful if the learning task can be related to relevant ideas in the cognitive structure of the learner. That is to say, the cognitive structure of the learner must include the requisite capabilities, ideational content, and experiential background (Ausubel, 1963). Therefore, it is possible that the learning requested in this study was not potentially meaningful and the organizer was unfit for the learning material.

(4) Ausubel (1960, 1963) pointed out that the effectiveness of organizers depends partly on the organizational qualities of the learning task itself. Therefore, it is possible that the qualities of the text used in this study may have reduced the effectiveness of the organizer.

(5) The failure of the organizers to achieve any significant interactive effects could be attributed to the small sample size (six classes), since class means for each preference, on each personality dimension, were used as the unit of statistical analysis. This affects the degrees of freedom associated with the F statistic, making it more difficult to detect real differences.

Recommendations

(1) Some research findings have suggested that graphic, pictorial, and visual organizers are superior to expository organizers. Therefore, it would be advantageous to conduct a study in which the effects of nonexpository organizers are examined in conjunction with student personality types.

(2) Lesh (1976) suggested that organizers that consist of counter examples facilitate learning better than organizers that consist of examples. Therefore, the investigator recommends that a study be conducted to examine the interactive effects of a counter examples organizer and an examples organizer and student personality types (or cognitive styles) in the learning of mathematics.

(3) Aptitude-organizer interaction research should be conducted on the learning of mathematical topics of level higher than most topics of previous studies, e.g., topics from calculus and higher algebra.

(4) Research relative to student characteristics might very well predict the success of organizers in facilitating learning. Therefore, a study should be conducted to determine the relationships between personality types and cognitive styles of students.

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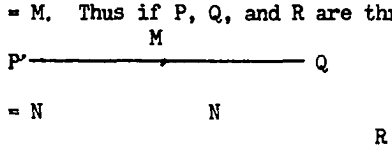
APPENDIX A

Advance Organizer

Suppose you were given the ordered pair of whole numbers (9,3), and were asked to <u>assign</u> a third number to this pair. Then you would possibly write (9,3) ⟶ 12 if you were thinking of addition (since 9 + 3 = 12), or (9,3) ⟶ 3 if you were thinking of division (since 9 ÷ 3 = 3). Similarly, for the ordered pairs (3,2) and (1,5), you might assign ((3,2), (1,5)) ⟶ (4,7), since (3,2) + (1,5) = (4,7) under "addition" of pairs.

Now consider the set of all ordered pairs of points. Then given two points P and Q, we can assign the P ——M—— Q <u>midway</u> point M. There is <u>one</u> and <u>only one</u> midway point between any two given points, and we can define mid(P,Q) = M. Thus if P, Q, and R are three points as shown, then:



mid(mid(P,Q),R) = mid(M,R) = N

In all preceding examples, the <u>assignment</u> of an element of a given set to an <u>ordered</u> pair of elements from the same set is called an "operation". We often speak of ordered pairs of numbers (elements) because the ordered pair (a,b) may not be assigned the same number as the ordered pair (b,a). In the ordered pair (a,b), a is the first element and b is the second. For example, if we were given the ordered pairs (9,3) and (3,9) and thought of division, then (9,3) ⟶ 3 which is not the same number as (3,9) ⟶ 1/3.

In mathematics, the concept of "operation" is not limited to the familiar operations of addition, subtraction, multiplication, and division. But rather one can define and perform many operations on a given set. The most important method of describing a particular operation on a given set, however, is to characterize the element assigned to each ordered pair by some property or rule defined in terms of the elements of the operation "*" by $a * b = a^2 + b^2$. Thus;

$$2 * 5 = 2^2 + 5^2 = 4 + 25 = 29, \text{ and}$$

$$(2 * 3) * 4 = (2^2 + 3^2) * 4$$

$$= (2^2 + 3^2)^2 + 4^2$$

$$(4 + 9)^2 + 4^2 = 13^2 + 4^2 = 169 + 16 = 185.$$

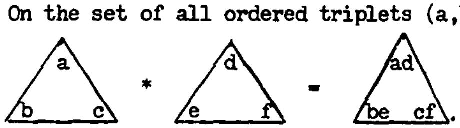
On the set of all ordered quadruples (a, b, c, d) of whole numbers define the operation "*" by

$$(a,b,c,d) * (e,f,g,h) = (ah, bg, cf, de)$$

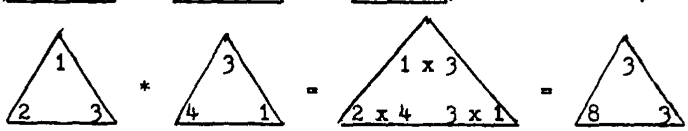
$$\text{Thus, } (1,2,4,3) + (2,1,2,3) = (1 \times 3, 2 \times 2, 4 \times 1, 3 \times 2)$$

$$= (3,4,4,).$$

On the set of all ordered triplets (a,b,c), define the operations "*" by



Thus,



In mathematics, a mathematical system is a set of elements together with a set of operations defined on those elements. There are certain important properties of operations in every mathematical system, and there are certain systems which do not always obey those properties.

I. An operation "*" on a set S is commutative if and only if a * b = b * a for all a and b in S.

On the set of whole numbers, the commutative property of operation "*" means: (1) a + b = b + a for addition. Thus 3 + 4 = 4 + 3, which means the number 7 is assigned to both ordered pairs (3,4) and (4,3); and (2) a x b = b x a for multiplication. Thus 4 x 3 = 3 x 4, which means the number 12 is assigned to both ordered pairs (3,4) and (4,3).

Let P and Q be two points in the plane as below. On the same line through P and Q, let R

be the reflection of P on Q.

Thus the distance from R to Q is the same as the distance from P to Q. Now define the operation "*" by P * Q = R. This operation is not commutative because Q * P = S. Thus P * Q ≠ Q * P, since R ≠ S.

II. An operation on a set S is associative if and only if (a * b) * c = a * (b * c) for all a, b, c, in S.

On the set of whole numbers, the associative property of operation "*" means: (1) (a + b) + c = a + (b + c) for addition. For example (3 + 4) + 2 = 3 + (4 + 2). So 7 + 2 = 3 + 6, because the number 9 is assigned to both ordered pairs ((3,4),2) and (3,(4,2)). And (2) for multiplication, (a x b) x c = a x (b x c). Thus (3 x 4) x 2 = 3 x (4 x 2). So 12 x 2 = 3 x 8, since the number 24 is assigned to both ordered pairs ((3,4),2) and (3,(4,2)).

Now consider the operation "*" defined by $a * b = a^2 + b^2$ on the set of whole numbers. This operation is not associative because $(a * b) * c \neq a * (b * c)$, since $(a * b) * c = (a * b)^2 + c^2$ and $(a * b)^2 + c^2 = (a^2 + b^2)^2 + c^2$ which is not the same as $a * (b * c) = a^2 + (b * c)^2 = a^2 + (b^2 + c^2)^2$. For example, $(2 * 3) * 4 = (2 * 3)^2 + 4^2 = (2^2 + 3^2)^2 + 4^2 = (4 + 9)^2 + 4^2 = (13)^2 + 4^2$ and $(13)^2 + 4^2 = 169 + 16 = 185$ which is not the same as $2 * (3 * 4) = 2^2 + (3 * 4)^2 = 2^2 + (3^2 + 4^2)^2 = 2^2 + (9 + 16)^2 = 2^2 + (25)^2$ and $2^2 + (25)^2 = 4 + 625 = 629$.

III. For every element a in S there is an identity element e in S such that $a * e = e * a = a$.

On the set of whole numbers, 0 is the identity element for addition; that is $a + 0 = 0 + 1 = 1$ so $3 + 0 = 0 + 3 = 3$. And 1 is the identity element for multiplication. Thus $a \times 1 = 1 \times a = a$, and $3 \times 1 = 1 \times 3 = 3$.

IV. For every element a in S there is an inverse element $-a$ such that $a * (-a) = (-a) * a = e$ in S.

Addition on the set of whole numbers does not obey this property of operation "*", for there are no negative numbers in the set of whole numbers. For example, 4 has no inverse since -4 is not an element of the set of whole numbers. Neither is the multiplicative property of operation "*" satisfied on the set of whole numbers, for there are no multiplicative inverses in the set of whole numbers. But on the set of all integers $I = (\ldots,-2,-1,0,1,2,\ldots)$, there exists an inverse element for addition. For example, $2 + (-2) = 0$ which is the identity element for addition on the set of integers. On the set of integers, there exists no inverse element for multiplication. But on the set of real numbers R, there exist multiplicative inverses for all elements (except 0) in R. For example, $3 \cdot 1/3 = 3 \cdot 3^{-1} = 3^{-1} \cdot 3 = 1$, which is the multiplicative identity in R.

The set of real numbers R, with the operations of addition and multiplication, is a well known mathematical system to all of you. In dealing with highly abstract systems, however, R can be used to serve an excellent comparison to many mathematical systems. In our case, we shall compare the system of matrices to the set of real numbers R. The comparison will point out similarities and differences between the two systems, relative to the operations of addition and multiplication on both systems, and the properties of operation "*" as developed earlier in this reading passage.

A matrix is defined as a set of real numbers arranged in a rectangular array. We can determine the size of a matrix by the number of rows and the number of columns it contains. In general, a matrix has one or many real numbers in its rows and columns.

On matrices, the operations of addition and multiplications will be defined in such a way that not all matrices can be added, and not all matrices can be multiplied. On R, however, addition and multiplication are defined in such a way that any two real numbers can be added and multiplied.

For matrices, the operation of addition will be commutative for those matrices which can be added, and multiplication, in general will not be commutative; you will find some matrices which can be multiplied and which will not be commutative. On R, the operations of addition and multiplication are both commutative.

For those matrices which can be added, and those matrices which can be multiplied, the operations of addition and multiplication will always be associative. For R, addition and multiplication are also associative.

Matrices which can be added will have identity elements, and will have inverse elements for addition, but not all matrices which can be multiplied will have identity and inverse elements for multiplication. For R, both operations of addition and multiplications have identity and inverse elements.

Thus you may have noticed that not all matrices will obey all properties of operation "*", as developed in this reading passage. Keep this in mind when you begin the topic of matrices.

Name________________

Section_____________

The following questions are related to the material which you have just read, and are designed to help you in understanding the material you have read. Please respond to all questions. You may refer back to the material you have read.

I. On the set of whole numbers W = (0,1,2,3,...), define the operation "*" by a * b = a for any <u>ordered</u> pair (a,b). Then:

1) 1 * 3 = ____

2) 0 * 2 = ____

3) 2 * 1 ≠ 1 * 2 ____True ____False

The operation does/does not satisfy the commutative property of operation. ________________

4) (4 * b) * 5 ≠ 4 * (6 * 5) ____True ____False

The operation does/does not satisfy the associative property of operation. ________________

II. Refer to page (1) for the midway point operation on the set of all ordered pairs of points (P,Q).

1) mid(Q,P) = ____

2) mid(Q,Q) = ____

3) mid(mid(P,Q,R) = mid(P,mid(Q,R)) ____True ____False

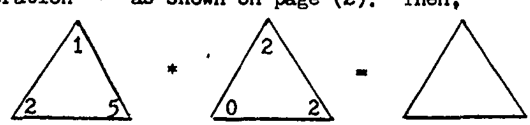
The operation does/does not satisfy which property?

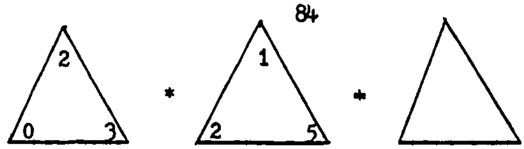
________________ ________________

4) The midway point operation is always commutative. ____True ____False

III. On the set of all <u>ordered</u> triplets (a,b,c) of whole numbers, define the operation "*" as shown on page (2). Then,

1)

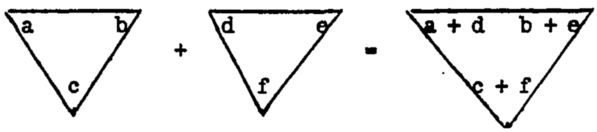


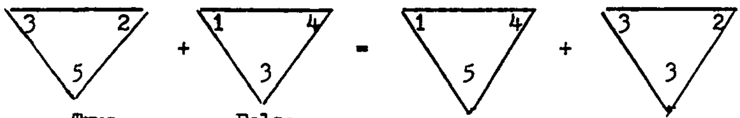
2) 

This operation does not obey the commutative property.

_____True _____False

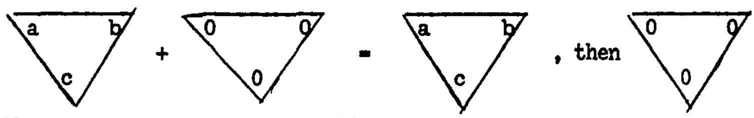
3) On the set of all <u>ordered</u> triplets (a,b,c) of whole numbers, define addition by





_____True _____False

4) Addition on the set of all ordered triplets of whole numbers is associative. _____True _____False

5) If 

is the ________ ________ for addition.

IV. The set of rational numbers Q = (...,-1,-1/2,0,1/2,1,...), consists of all positive and negative integers and all positive and negative fractions.

1) For any two rational numbers a and b, a * b = b * a. So the set of rational numbers Q satisfies the _____ property of operation "*".

2) For the rational numbers 2, 3, 5, and 3/4,

2 + 5 = 5 + 2 _____True _____False

3 x 3/4 = 3/4 x 3 _____True _____False

3) For any three rational numbers a, b, c, it is true that:

(a * b) * c = a * (b * c). So the set of rational numbers, Q, satisfies which property of operation "*"? ________________

4) For the rational numbers 4, 3, 1/2, 5, and 7,

(4 + 5) + 3 = 4 + (5 + 3) ____True ____False

(3 x 7) x 1/2 = 3 x (7 x 1/2) ____True ____False

5) The set of rational numbers, Q, contains the special identity element 0. Thus for any rational number 6, 6 + 0 = 0 + 6 = 6

____True ____False

6) Q also has a multiplicative identity element, namely _________.

7) For any rational number a, the additive inverse is -a. Thus, a + (-a) = ____ which is the ____ ____ in Q. For any nonzero element a in Q, the multiplicative inverse is ____ such that a(—) = 1.

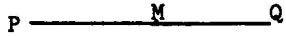
Post Organizer

A matrix is a rectangular array of numbers appearing in rows and columns. We can determine the size of a matrix by the number of rows and the number of columns it contains. In general, a matrix has one or many real numbers in its rows and columns.

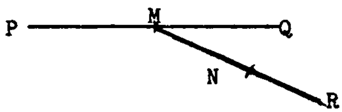
The set of real numbers R, with the operations of addition and multiplication, is a well known mathematical system to all of you. In dealing with highly abstract systems, such as matrices, R can be used to serve an excellent comparison to many mathematical systems. In our case, we shall compare matrices to the set of real numbers R. The comparison will point out similarities and differences between the two systems, relative to the operation of addition and multiplication and certain important properties of operations, which will be developed in this reading passage.

Now suppose you were given the ordered pair of whole numbers (9,3) and were asked to assign a third number to this pair. Then you would possibly write $(9,3) \longrightarrow 12$ if you were thinking of addition (since $9 + 3 = 12$), or $(9,3) \longrightarrow 3$ if you were thinking of division (since $9 \div 3 = 3$). Similarly, for the ordered pairs (3,2) and (1,5), you might assign $((3,2),(1,5)) \longrightarrow (4,7)$, since $(3,2) + (1,5) = (4,7)$ under "addition" of pairs.

On the set of all ordered pairs of points, given two points P and Q, we can assign the *midway* point M between P and Q. There is *one* and *only one* midway point between any two given points, and we can define mid(P,Q) = M.



Thus if P, Q, and R are three points as shown, then; mid(mid(P,Q),R) = mid(M,R) = N.



In all preceding examples, the *assignment* of an element of a given set to an *ordered* pair of elements from the same set is called an "operation". We often speak of ordered pairs of numbers (elements) because the ordered pair (a,b) may not be assigned the same number as the ordered pair (b,a). In the ordered pair (a,b), 'a' is the first element and 'b' is the second. For example, if we were given the ordered pairs (9,3) and (3,9), and thought of division, then $(9,3) \longrightarrow 3$ which is not the same as $(3,9) \longrightarrow 1/3$.

On matrices, the operations of addition and multiplication are defined in such a way that *not* all matrices can be added, and *not* all matrices can be multiplied. On the set of real numbers *R*, however, addition and multiplication are defined in such a way that any two real numbers can be added and multiplied.

In mathematics, the concept of "operation" is not limited to the familiar operations of addition, subtraction, division, and multiplication. But rather one can define and perform many interesting operations on a given set. The most important method of describing a particular operation on a given set, however, is to characterize the element assigned to each ordered pair by some property or *rule* defined in terms of the elements of the ordered pair. For example, on the set of whole numbers define the operation "*" by $a * b = a^2 + b^2$. Thus:

$$2 * 5 = 2^2 + 5^2 = 4 + 25 = 29, \text{ and}$$

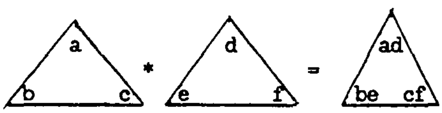
$$\begin{aligned}(2 * 3) * 4 &= (2^2 + 3^2) * 4 \\ &= (2^2 + 3^2)^2 + 4^2 \\ &= (4 + 9)^2 + 4^2 = 13^2 + 4^2 = 169 + 16 = 185.\end{aligned}$$

On the set of all ordered quadruples (a,b,c,d) of whole numbers, define the operation "*" by

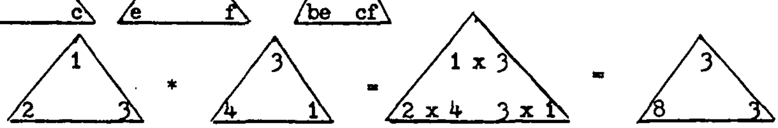
$$(a,b,c,d) * (e,f,g,h) = (ah,bg,cf,de). \text{ Thus}$$

$$\begin{aligned}(1,2,4,3) * (2,1,2,3) &= (1 \times 3,\ 2 \times 2,\ 4 \times 1,\ 3 \times 2) \\ &= (3,\ 4,\ 4,\ 6)\end{aligned}$$

On the set of all ordered triplets (a,b,c) of whole numbers define the operation "*" by



Thus



In mathematics, a mathematical system is a set of elements together with a set of operations defined on those elements. There are certain important properties of operation in every mathematical system, and there are certain systems which do not obey those properties. On a given set, the following properties of operation are of special interest to us:

I. An operation "*" on a set S is commutative if and only if $a * b = b * a$ for all a and b in S.

On the set of whole numbers, the commutative property of operation "*" means: (1) a + b = b + a for addition. Thus, 3 + 4 = 4 + 3, which means the number 7 is assigned to both ordered pairs (3,4) and (4,3); and (2) a x b = b x a for multiplication. Thus, 4 x 3 = 3 x 4, which means the number 12 is assigned to both ordered pairs (4,3) and (3,4).

Let P and Q be two points in the plane as shown. On the line though P and Q, let R be the reflection of P on Q.

Thus the distance from P and Q is the same as the distance from R to Q. Now define the operation "*" by P * Q = R. This operation is not commutative because Q * P = S. Thus P * Q $\neq$ Q * P, since R $\neq$ S.

For matrices, the operation of addition is commutative only for those matrices which can be added, and multiplication, in general, is not commutative; you can find some matrices which can be multiplied and which are not commutative. On the set of real numbers R, the operations of addition and multiplication are both commutative.

II. An operation "*" on a set 'S' is associative if and only if (a * b) * c = a * (b * c) for all a, b, and c in S.

On the set of whole numbers, the associative property of operation "*" means: (1) (a + b) + c = a + (b + c) for addition. For example, (3 + 4) + 2 = 3 + (4 + 2), 7 + 2 = 3 + 6, which means the number 9 is assigned to both ordered pairs ((3,4),2) and (3,(4,2)); and (2) (a x b) x c = a x (b x c) for multiplication. For example, (3 x 4) x 2 = 3 x (4 x 2), 12 x 2 = 3 x 8, which means the number 24 is assigned to both ordered pairs ((3,4),2) and (3,(4,2)).

On the set of whole numbers, consider the operation defined by $a * b = a^2 + b^2$. This operation is not associative because $(a * b) * c \neq a * (b * c)$, since $(a * b) * c = (a * b)^2 + c^2$ and $(a * b)^2 + c^2 = (a^2 + b^2)^2 + c^2$ which is not the same as $a * (b * c) = a^2 + (b * c)^2 = a^2 + (b^2 + c^2)^2$. For example,

$$\begin{aligned} (2 * c) * 4 = (2 * 3)^2 + 4^2 &= (2^2 + 3^2)^2 + 4^2 \\ &= (4 + 9)^2 + 4^2 \\ &= 13^2 + 4^2 \\ &= 169 + 16 = 180, \text{ which is} \end{aligned}$$

not the same as

$$\begin{aligned} 2 * (3 * 4) = 2^2 + (3 * 4)^2 &= 2^2 + (3^2 + 4^2)^2 \\ &= 2^2 + (9 + 16)^2 \\ &= 2^2 + 25^2 = 4 + 625 = 629 \end{aligned}$$

For those matrices which can be added, and those matrices which can be multiplied, the operations of addition and multiplication are always associative. For the set of real number R, addition and multiplication are also associative.

III. For every element a in S there is an identity element e in S such that $a * e = e * a = a$.

On the set of whole numbers, 0 is the identity element for addition; that is $a + 0 = 0 + a = a$, so $3 + 0 = 0 + 3$. And 1 is the identity element for multiplication; that is $a \times 1 = 1 \times a = a$, so $3 \times 1 = 1 \times 3 = 3$.

Matrices which can be added do have identity elements, but not all matrices which can be multiplied have identity elements. On the set of real numbers R, there exists an identity element for addition and an identity element for multiplication.

IV. For every element a in S there is an inverse element -a in S such that a * (-a) = (-a) * a = e in S.

Addition on the set of whole numbers does not obey this property of operation "*", for there are no negative numbers in the set of whole numbers. For example, 4 has no negative inverse since -4 is not an element of the set of whole numbers. Neither is the multiplicative property of operation "*" satisfied on the set of whole numbers, for there are no multiplicative inverses in the set of whole numbers. But on the set of all integers I = (..., -2, -1, 0,1,2,...), there exists an inverse element for addition. Thus 2 + (-2) = 0, which is the identity element for addition on the set of all integers I. On the set of all integers I, there exist no inverse elements for multiplication. But on the set of real numbers R, there exists a multiplicative inverse for every element (except 0) in R. For example $3 \cdot 3^{-1} = 3^{-1} \cdot 3 = 1$ which is the multiplicative identity in R.

Matrices which can be added do have inverse elements for addition, but not all matrices which can be multiplied have inverse elements for multiplication. For the set of real numbers R, both operations of addition and multiplication have inverse elements.

Thus you may have noticed that not all matrices obey all four properties of operation "*", as developed in this reading passage. Keep this in mind for future reference.

APPENDIX B

Name____________________

Section_________________

Pre-Test

1. Have you ever enrolled before in Math 1444?____ If so, did you complete the course?____

2. Have you ever enrolled in any math course <u>higher</u> than Math 1444?____ If so, which course was it?____, and did you complete the course?___

3. Determine the size (dimension) of each of the following matrices:

$A = \begin{bmatrix} 1 & 2 \\ 4 & 3 \end{bmatrix}$ ________ $B = \begin{bmatrix} 1 & -3 \\ 2 & 4 \\ -1 & 0 \end{bmatrix}$ ________

4. Add the following matrices:

a) $\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} + \begin{bmatrix} 2 & 0 \\ 4 & -1 \end{bmatrix} =$

b) $\begin{bmatrix} -1 & 3 \\ 2 & 0 \end{bmatrix} + \begin{bmatrix} 2 & 3 \\ 1 & -4 \\ 5 & 2 \end{bmatrix} =$

5. Multiply the following matrices:

a) $\begin{bmatrix} 1 & 3 \\ 2 & 4 \end{bmatrix} \times \begin{bmatrix} 3 & -1 \\ 1 & 2 \end{bmatrix} =$

b) $\begin{bmatrix} -3 & 3 \\ 2 & 1 \end{bmatrix} \times \begin{bmatrix} -1 & 3 \\ 2 & 4 \\ 1 & 2 \end{bmatrix} =$

6. Find the determinant of the following matrix:

$\begin{bmatrix} 1 & 3 \\ 2 & 4 \end{bmatrix}$ ___________

Name________________

Section_____________

Achievement Test

This is a multiple choice test. Please be sure to choose one and only one best response for each question. (T = ture; ST = sometimes ture; F = False).

1._____A matrix is a rectangular array of real numbers.

a) T b) ST c) F

2._____A matrix has an additive inverse.

a) T b) ST c) F

3._____Matrix addition is commutative when defined.

a) T b) ST c) F

4._____Matrix multiplication is associative when defined.

a) T b) ST c) F

5._____A matrix that is an identity element for multiplication is a square matrix.

a) T b) ST c) F

6._____A matrix has a multiplicative inverse.

a) T b) ST c) F

7._____If A is a matrix, the AI = IA.

a) T b) ST c) F

8._____If A is a square matrix, then $A^3 = A^2 \cdot A$.

a) T b) ST c) F

9._____If A, B, and C are three matrices, then $AB = AC \Rightarrow B = C$.

a) T b) ST c) F

10._____If A, B, and C are 2 x 2 matrices then, A(B + C) = AB + AC.

a) T b) ST c) F

11._____If A is a matrix, then $AA^{-1} = A^{-1}A$.

a) T b) ST c) F

12._____If A and B are 2 x 2 matrices then A x B ≠ B x A.

a) T   b) ST   c) F

Let $A = \begin{bmatrix} 1 & 2 \\ 3 & -5 \end{bmatrix}$ $B = \begin{bmatrix} 2 & -2 & 1 \\ -1 & 1 & -2 \\ 1 & - & -1 \end{bmatrix}$ $C = \begin{bmatrix} 0 & 1 & 2 \\ 3 & 4 & 5 \\ 2 & 0 & -1 \end{bmatrix}$

$D = \begin{bmatrix} 1 & 3 & -1 \\ 2 & 1 & 2 \end{bmatrix}$ $E = \begin{bmatrix} 3 & 1 \\ 1 & 0 \\ 2 & 1 \end{bmatrix}$ $F = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$

13._____The dimension of D is

a) 2 x 2   b) 3 x 2   c) 2 x 3   d) 3 x 3

e) none of these

14._____The identity for multiplication of 2 x 2 matrices is

a) $\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$ b) $\begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$ c) $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ d) $\begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$

e) none of these

15._____The determinant of C is:

a) -13   b) -3   c) 29   d) 3

e) none of these

16._____The determinant of E is:

a) 1   b) 0   c) 3   d) 2

e) none of these

17._____C + 2B is

a) $\begin{bmatrix} 2 & -3 & 4 \\ 3 & 5 & -3 \\ 3 & 0 & -2 \end{bmatrix}$ b) $\begin{bmatrix} 2 & 1 & 1 \\ 4 & -5 & 3 \\ 3 & 0 & 2 \end{bmatrix}$ c) $\begin{bmatrix} 2 & -1 & 3 \\ 2 & 5 & 3 \\ 3 & 0 & -2 \end{bmatrix}$

d) $\begin{bmatrix} 4 & -3 & 4 \\ 1 & 6 & 1 \\ 4 & 0 & -3 \end{bmatrix}$ e) none of these

18._____The dimension of $D \cdot E$ is

a) 3 x 3 b) 2 x 3 c) 2 x 2 d) 3 x 3

e) none of these

19._____$(D \cdot E) - F^2$ is

a) $\begin{bmatrix} 4 & 0 \\ 11 & 4 \end{bmatrix}$ b) $\begin{bmatrix} 5 & 0 \\ 11 & 5 \end{bmatrix}$ c) $\begin{bmatrix} 9 & 0 \\ 22 & 9 \end{bmatrix}$

d) $\begin{bmatrix} 3 & 0 \\ 11 & 3 \end{bmatrix}$ e) none of these

20._____A^{-1} is

a) $\begin{bmatrix} \frac{5}{11} & \frac{2}{11} \\ \frac{3}{11} & \frac{-1}{11} \end{bmatrix}$ b) $\begin{bmatrix} -5 & -2 \\ -3 & 1 \end{bmatrix}$ c) $\begin{bmatrix} \frac{-5}{11} & \frac{-2}{11} \\ \frac{-3}{11} & \frac{1}{11} \end{bmatrix}$

d) $\begin{bmatrix} 1 & 2 \\ 3 & -5 \end{bmatrix}$ e) none of these

21._____The equations represented by

$\begin{bmatrix} 1 & 2 \\ 3 & -5 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ are

a) $x - 2y = 1$ b) $x + 2y = 1$ c) $x + 2y = 0$

$3x + 5y = 0$ $3x - 5y = 0$ $3x - 5y = 1$

d) $x - 2y = 0$ e) none of these

$3x + 5y = 1$

22._____If $\begin{bmatrix} 1 & 2 \\ 3 & -5 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, then $\underline{x}$ and $\underline{y}$ are

a) $\frac{5}{11}, \frac{-3}{11}$ b) $\frac{-5}{11}, \frac{-3}{11}$ c) $\frac{3}{11}, \frac{5}{11}$ d) $\frac{5}{11}, \frac{3}{11}$

e) none of these

23._____If $3x + y = 6$

$2x - y = 14$, then $\underline{x}$ is

a) $\dfrac{\begin{vmatrix} 6 & 1 \\ 14 & -1 \end{vmatrix}}{\begin{vmatrix} 3 & 1 \\ 2 & -1 \end{vmatrix}}$ b) 4 c) $\dfrac{\begin{vmatrix} 3 & 6 \\ 2 & 14 \end{vmatrix}}{\begin{vmatrix} 3 & 1 \\ 2 & 14 \end{vmatrix}}$ d) 6

e) none of these

24._____If $x + y + 2 = 0$

$3x - y \quad = 1$

$x + 2y - 2z = -5$, then $\underline{y}$ is

a) $\dfrac{\begin{vmatrix} 0 & 1 & 1 \\ 1 & 3 & 0 \\ -5 & 1 & -2 \end{vmatrix}}{\begin{vmatrix} 1 & 1 & 1 \\ 3 & -1 & 0 \\ 1 & 2 & -2 \end{vmatrix}}$ b) $\dfrac{\begin{vmatrix} 1 & 1 & 1 \\ 3 & -1 & 0 \\ 1 & 2 & -2 \end{vmatrix}}{\begin{vmatrix} 1 & 0 & 1 \\ 3 & 1 & 0 \\ 1 & -5 & -2 \end{vmatrix}}$ c) $\dfrac{\begin{vmatrix} 1 & 0 & 1 \\ 3 & 1 & 0 \\ 1 & -5 & -2 \end{vmatrix}}{\begin{vmatrix} 1 & 1 & 1 \\ 3 & -1 & 0 \\ 1 & 2 & -2 \end{vmatrix}}$

d) $\dfrac{\begin{vmatrix} 0 & 1 & 1 \\ 1 & 0 & 3 \\ -5 & -2 & 1 \end{vmatrix}}{\begin{vmatrix} 1 & 1 & 1 \\ 3 & -1 & 0 \\ 1 & 2 & -2 \end{vmatrix}}$ e) none of these

25._____If the augmented matrix associated with a system of linear equations reduces to $\begin{bmatrix} 1 & 0 & 0 & -3 \\ 0 & 5 & 0 & 10 \\ 0 & 0 & -2 & \frac{-2}{3} \end{bmatrix}$, then the solution set is

a) $(1,5,-2)$ b) $(-3,10,\frac{-2}{3})$ c) $(-3,2,\frac{1}{3})$

d) $(3,-2,\frac{-1}{3})$ e) none of these

Name_______________

Section_______________

Retention Test

This is a multiple choice test. Please be sure to choose one and only one best response for each question. (T = true; ST = somtimes true; F = flase).

1.____Matrix multiplication is associative when defined.

a) T b) ST c) F

2.____A matrix that is an identity element for multiplication is a square matrix.

a) T b) ST c) F

3.____A matrix is a rectangular array of real numbers.

a) T b) ST c) F

4.____A matrix has a multiplicative inverse.

a) T b) ST c) F

5.____If A, B, and C are three matrices, then $AB = AC \Rightarrow B = C$.

a) T b) ST c) F

6.____A matrix has an additive inverse.

a) T b) ST c) F

7.____Matrix addition is commutative when defined.

a) T b) ST c) F

8.____If A is a matrix, the $AI = IA$.

a) T b) ST c) F

9.____If A is a square matrix, the $A^3 = A^2 \cdot A$.

a) T b) ST c) F

10.____If A and B are 2 x 2 matrices then $A \times B \neq B \times A$.

a) T b) ST c) F

11.____If A, B, and C are 2 x 2 matrices then, $A(B + C) = AB = AC$.

a) T b) ST c) F

12____If A is a matrix, then $AA^{-1} = A^{-1}A$.

a) T b) ST c) F

Let $A = \begin{bmatrix} 5 & 3 \\ 2 & 1 \end{bmatrix}$ $B = \begin{bmatrix} -2 & 2 & -1 \\ 1 & 1 & -2 \\ -1 & 0 & -1 \end{bmatrix}$ $C = \begin{bmatrix} 0 & -1 & 2 \\ 3 & -4 & 5 \\ 2 & 0 & -1 \end{bmatrix}$

$D = \begin{bmatrix} -1 & 3 & 1 \\ 2 & -1 & 2 \end{bmatrix}$ $E = \begin{bmatrix} 3 & -1 \\ 1 & 0 \\ 1 & 2 \end{bmatrix}$ $F = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$

13._____The dimension of E is:

a) 2 x 2 b) 3 x 2 c) 2 x 3 d) 3 x 3

e) none of these

14._____The identity for multiplication of 2 x 2 matrices is:

a) $\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$ b) $\begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$ c) $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ d) $\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

e) none of these

15._____The determinant of C is:

a) 13 b) -3 c) -29 d) 3

e) none of these

16._____The determinant of D is:

a) 1 b) 0 c) 3 d) 2

e) none of these

17._____C + 2B is

a) $\begin{bmatrix} 2 & -3 & 4 \\ 3 & 5 & -3 \\ 3 & 0 & -2 \end{bmatrix}$ b) $\begin{bmatrix} -2 & 1 & 1 \\ 4 & -3 & 3 \\ 1 & 0 & 0 \end{bmatrix}$ c) $\begin{bmatrix} 2 & -1 & 3 \\ 2 & 5 & 3 \\ 3 & 0 & -2 \end{bmatrix}$ d) $\begin{bmatrix} -4 & 3 & 0 \\ 5 & -2 & 1 \\ 0 & 0 & -3 \end{bmatrix}$

e) none of these

18._____The dimension of D · E is

a) 3 x 3 b) 2 x 3 c) 2 x 2 d) 3 x 2

e) none of these

19._____$(D \cdot E) - F^2$ is

a) $\begin{bmatrix} 6 & 1 \\ 7 & 1 \end{bmatrix}$ b) $\begin{bmatrix} 7 & 1 \\ 7 & 2 \end{bmatrix}$ c) $\begin{bmatrix} 8 & 1 \\ 7 & 3 \end{bmatrix}$ d) $\begin{bmatrix} 8 & 0 \\ 7 & 3 \end{bmatrix}$

e) none of these

20._____ A^{-1} is

a) $\begin{bmatrix} 5 & 2 \\ 3 & -1 \end{bmatrix}$ b) $\begin{bmatrix} -5 & -2 \\ -3 & 1 \end{bmatrix}$ c) $\begin{bmatrix} -5 & 2 \\ 3 & -1 \end{bmatrix}$ d) $\begin{bmatrix} -1 & 3 \\ 2 & -5 \end{bmatrix}$

e) none of these

21._____The equations represented by $\begin{bmatrix} 5 & 3 \\ 2 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ ARE

a) $\begin{aligned} 5x - 3y &= 1 \\ 2x + y &= 0 \end{aligned}$ b) $\begin{aligned} 5x + 3y &= 1 \\ 2x + y &= 0 \end{aligned}$ c) $\begin{aligned} x + 2y &= 0 \\ 3x - 5y &= 1 \end{aligned}$

d) $\begin{aligned} 5x - 2y &= 0 \\ 2x + y &= 1 \end{aligned}$ e) none of these

22._____If $\begin{bmatrix} 5 & 3 \\ 2 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$, then $\underline{x}$ and $\underline{y}$ are:

a) (2,1) b) (-1,2) c) (1,2) d) (-2,1)

e) none of these

23._____If $3x + y = 6$
$2x - y = 14$, then $\underline{y}$ is

a) $\dfrac{\begin{vmatrix} 6 & 1 \\ 14 & -1 \end{vmatrix}}{\begin{vmatrix} 3 & 1 \\ 2 & -1 \end{vmatrix}}$ b) 4 c) $\dfrac{\begin{vmatrix} 3 & 6 \\ 2 & 14 \end{vmatrix}}{\begin{vmatrix} 3 & 1 \\ 2 & -1 \end{vmatrix}}$ d) -6 e) none of these

24._____If $\begin{aligned} x + y + z &= 0 \\ 3x - y \quad &= 1 \\ x + 2y - 2z &= -5 \end{aligned}$, then $\underline{x}$ is

a) $\dfrac{\begin{vmatrix} 0 & 1 & 1 \\ 1 & 3 & 0 \\ -5 & 1 & -2 \end{vmatrix}}{\begin{vmatrix} 1 & 1 & 1 \\ 3 & -1 & 0 \\ 1 & 2 & -2 \end{vmatrix}}$ b) $\dfrac{\begin{vmatrix} 1 & 1 & 1 \\ 3 & -1 & 0 \\ 1 & 2 & -2 \end{vmatrix}}{\begin{vmatrix} 1 & 0 & 1 \\ 3 & 1 & 0 \\ 1 & -5 & -2 \end{vmatrix}}$ c) $\dfrac{\begin{vmatrix} 1 & 0 & 1 \\ 3 & 1 & 0 \\ 1 & -5 & -2 \end{vmatrix}}{\begin{vmatrix} 1 & 1 & 1 \\ 3 & -1 & 0 \\ 1 & 2 & -2 \end{vmatrix}}$ d) $\dfrac{\begin{vmatrix} 0 & 1 & 1 \\ 1 & 0 & 3 \\ -5 & -2 & 1 \end{vmatrix}}{\begin{vmatrix} 1 & 1 & 1 \\ 3 & -1 & 0 \\ 1 & 2 & -2 \end{vmatrix}}$

e) none of these

25._____If the augmented matrix associated with a system of linear equations reduces to $\left|\begin{matrix} 1 & 0 & 0 & -3 \\ 0 & -5 & 0 & 10 \\ 0 & 0 & 2 & -\frac{2}{3} \end{matrix}\right|$, then the solution set is

a) (1,5,-2) b) $(-3,10,-\frac{2}{3})$ c) $(-3,2,\frac{1}{3})$ d) $(3,-2,-\frac{1}{3})$

e) none of these

Table 16

Frequency Distribution of Achievement

Test Scores

Total Score	Frequency
0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	2
8	1
9	0
10	2
11	1
12	1
13	6
14	13
15	16
16	15
17	21
18	20
19	22
20	20
21	25
22	15
23	7
24	1
25	0

N = 188

Table 17

Elements of the Kuder-Richardson Formula

Variance	pq	$\sqrt{pq}$	$(\Sigma\sqrt{pq})^2$
10.2082	3.1286	10.24	104.8576

$$V_{tt} = \frac{S^2 - pq}{(\Sigma\sqrt{pq})^2 - pq} \cdot \frac{(\Sigma\sqrt{pq})^2}{S^2}$$

p = item difficulty = $\frac{\text{number of correct responses to the item}}{n}$

$q = 1 - p$

n = number of students who had taken the achievement test.

S^2 = variance of the total scores on the achievement test.

APPENDIX C

Table 18

Row Data for the Advance Organizer Group

Subject	EI	SN	TF	JP	AT	RT
1	101	119	149	093	23	19
2	109	085	115	093	21	23
3	071	105	137	071	19	18
4	127	087	141	085	18	19
5	069	119	145	147	20	21
6	139	133	119	151	20	21
7	073	093	123	103	23	23
8	077	069	077	073	15	18
9	063	079	077	047	19	15
10	113	069	115	047	21	16
11	123	081	087	097	19	21
12	101	083	109	097	22	20
13	137	103	117	119	16	17
14	075	073	059	075	15	15
15	125	079	119	109	19	14
16	123	141	077	089	17	15
17	135	103	109	053	23	21
18	123	085	057	063	21	17
19	125	081	131	079	22	18
20	053	097	117	101	10	15
21	133	137	109	149	21	19
22	085	129	121	129	21	16
23	079	103	099	077	21	18
24	093	095	079	141	22	23
25	075	123	125	135	22	21
26	111	123	101	137	19	22
27	097	087	135	079	23	17
28	115	095	117	073	14	15

Table 19

Row Data for the Post Organizer Group

Subject	EI	SN	TF	JP	AT	RT
1	103	091	095	067	14	19
2	083	087	118	078	19	16
3	097	129	105	093	17	21
4	143	095	119	079	18	16
5	093	117	083	115	21	20
6	047	133	131	127	19	18
7	087	057	115	063	21	18
8	156	125	121	119	19	17
9	111	067	059	069	22	21
10	101	075	123	085	22	17
11	077	123	123	067	21	19
12	073	087	143	101	15	14
13	087	123	095	129	21	21
14	143	087	057	051	22	24
15	121	111	117	101	16	17
16	059	099	115	093	17	19
17	083	061	121	101	15	18
18	141	129	119	093	19	22
19	107	129	109	067	18	19
20	073	073	069	047	18	18
21	139	127	077	121	21	15
22	105	063	119	101	16	17
23	059	099	119	105	08	14
24	091	113	095	119	20	20
25	107	091	129	095	17	20
26	093	087	133	115	20	16
27	087	089	145	067	20	22
28	119	079	133	141	16	21
29	087	091	107	133	18	18

Table 20

Row Data for the Control Group

Subject	EI	SN	TF	JP	AT	RT
1	083	079	135	129	18	18
2	129	117	131	115	21	25
3	115	045	131	065	18	22
4	103	089	115	109	19	18
5	061	127	123	095	15	17
6	137	067	089	059	21	23
7	107	119	107	141	17	20
8	127	067	087	051	17	20
9	125	091	119	069	23	22
10	079	113	121	117	15	18
11	067	083	089	091	17	19
12	107	041	101	089	15	22
13	089	087	101	073	14	22
14	059	137	127	149	21	16
15	099	089	089	105	17	23
16	077	059	103	107	13	18
17	097	089	069	065	22	21
18	093	061	125	063	15	19
19	085	087	091	079	16	17
20	085	071	111	059	18	15
21	091	135	099	137	18	17
22	127	113	077	083	18	19
23	079	069	091	065	13	09
24	079	137	121	159	15	11
25	083	055	143	073	22	18
26	071	099	199	149	17	14
27	125	087	123	103	19	17
28	075	103	087	123	21	14
29	153	063	127	097	14	14
30	061	101	091	099	10	11
31	119	125	125	151	14	20

Table 21

Advance Organizer Group Type Distribution

ISTJ 2	ISFJ 6	INFJ 2	INTJ 1
ISTP	ISFP 1	INFP 4	INTP
ESTP 1	ESFP 2	ENFP 3	ENTP
ESTJ 3	ESFJ 1	ENFJ 1	ENTJ 1

Table 22

Post Organizer Group Type Distribution

ISTJ 3	ISFJ 3	INFJ 2	INTJ
ISTP	ISFP 2	INFP 1	INTP 2
ESTP	ESFP 5	ENFP 1	ENTP 3
ESTJ 1	ESFJ 4	ENFJ 2	ENTJ

Table 23

Control Group Type Distribution

ISTJ 1	ISFJ 4	INFJ	INTJ 1
ISTP	ISFP 2	INFP 3	INTP
ESTP 1	ESFP 3	ENFP 3	ENTP 2
ESTJ 5	ESFJ 4	ENFJ 1	ENTJ 1

Table 24

Achievement Test Means and Standard Deviations for Each Class on Each Personality Dimension

Treatment / Personality Type	Advance Organizer $\bar{X}$	Advance Organizer S	Post Organizer $\bar{X}$	Post Organizer S	Control $\bar{X}$	Control S
Extraversion	18.50	2.81	17.55	3.65	16.57	3.96
	19.83	4.45	19.40	1.50	16.75	2.59
Introversion	19.88	2.03	17.45	2.11	17.00	1.87
	19.57	2.92	20.25	1.78	18.88	2.47
Sensing	19.20	2.56	16.62	3.32	17.60	2.94
	18.67	4.89	20.40	1.62	17.53	2.75
Intuitive	19.60	2.25	18.50	0.87	17.80	2.71
	20.57	1.84	19.43	1.76	16.00	3.51
Thinking	17.00	2.00	18.86	2.75	16.00	3.95
	20.25	1.92	21.50	0.50	18.33	2.92
Feeling	20.81	2.04	16.92	3.17	17.33	2.62
	19.44	4.25	19.29	1.58	17.21	2.78
Judging	19.20	2.56	18.44	2.27	16.00	4.15
	20.14	3.13	19.83	1.95	17.58	2.84
Perceiving	19.60	2.25	16.91	3.60	17.33	2.36
	19.17	4.22	19.67	0.94	17.63	2.60

Table 25

Retention Test Means and Standard Deviations for

Each Class on Each Personality Dimention

Treatment / Personality Dimension	Advance Organizer $\bar{X}$	Advance Organizer S	Post Organizer $\bar{X}$	Post Organizer S	Control $\bar{X}$	Control S
Extraversion	18.33	2.95	18.09	2.47	13.43	3.06
	18.33	2.81	18.60	1.74	18.58	2.29
Introversion	18.88	2.64	19.33	2.62	17.50	2.29
	18.14	2.53	17.75	1.92	21.50	2.00
Sensing	18.40	3.17	18.46	2.79	14.40	3.14
	17.50	2.69	17.60	1.85	19.93	2.35
Intuition	19.26	1.60	19.00	2.20	15.33	3.59
	18.86	2.47	18.50	1.50	19.20	3.19
Thinking	17.25	2.49	19.14	2.70	16.00	3.10
	18.25	2.94	20.50	0.50	20.50	2.14
Feeling	19.18	2.70	18.38	2.52	14.50	3.20
	18.22	2.53	17.57	1.59	19.93	2.71
Judging	18.40	2.46	20.22	1.87	14.20	3.87
	17.29	1.91	18.17	2.12	19.92	2.43
Perceiving	19.20	3.25	17.36	2.42	15.15	2.87
	19.33	2.98	18.33	1.25	19.50	2.83