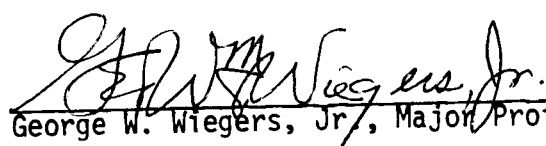
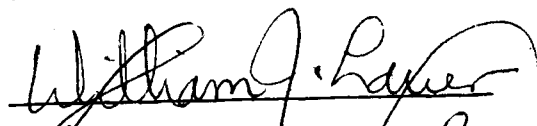
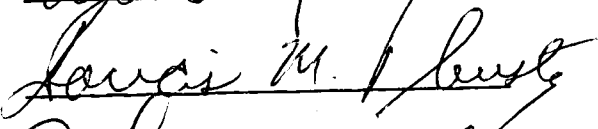
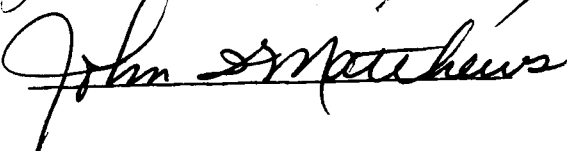


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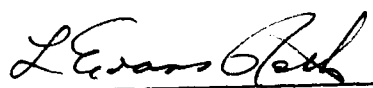
I am submitting herewith a dissertation written by Gwendolyn Owens Wilson entitled "Hemispheric Dominance and Student Performance in an Engineering-Graphics Course." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.


George W. Wieggers, Jr., Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:


Vice Chancellor
Graduate Studies and Research

HEMISPHERIC DOMINANCE AND STUDENT PERFORMANCE
IN AN ENGINEERING-GRAPHICS COURSE

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Gwendolyn Owens Wilson

August 1982

3063979

DEDICATION

To Grace E. Owens
and
Herbert G. Owens

ACKNOWLEDGMENTS

I wish to extend my sincere appreciation to the members of my committee: Associate Dean William J. Lauer, Dr. John I. Matthews, and Dr. Francis M. Trusty. I would like to express special gratitude to my chairman Dr. George W. Wieggers, Jr., for his adept guidance and encouragement.

Additionally, I wish to thank Drs. Toby J. Mitchell and Walter Cameron for their aid through the statistical cobwebs and David Job and George Littleton for their patience with the rigors of the experiment added to their already tight teaching schedules.

Recognition is given to State Technical Institute at Knoxville for permission to conduct the experiment and to the students for their willingness to participate.

I also wish to thank my spouse, Dr. D. George Wilson, for being a left hemisphere to my right hemisphere.

ABSTRACT

Factors affecting student performance in an engineering-graphics class were examined. The factors of sex, handedness, and eye dominance were considered in relation to hemispheric dominance and performance. The effect on student performance of introducing special right-brain oriented problems into a regular class also was considered.

The characteristics of handedness, sex, and eye dominance were related to the three hemispheric dominances established by Torrance's SOLAT test and to performance. A nonequivalent control group quasi-experimental design was used. The special problems were introduced at the rate of one each for eight consecutive weeks into selected sections of State Technical Institute at Knoxville's fall 1981 DR 101 course. Three of the five available sections received this treatment. Drawings, the evidence of performance, were collected on a regular basis and rated by consulting experts. The ratings of the initial drawings provided the initial measures of student performance which were used to test for homogeneity of variance. The entire portfolio of each student's drawings was rated by each of three consulting experts, and the average of the three ratings was used as a measure of the student's class performance.

The findings were that right-brain students performed better than left-brain students in an engineering graphics class, and integrated-brained females performed better than integrated-brained males.

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CHAPTER I

INTRODUCTION

A. INTRODUCTION TO STUDY

In the fall of 1979 the State Technical Institute at Knoxville added a new department combining both technology and art. This department, engineering-graphics, began its existence primarily as a service provider for the other four engineering technology departments. For the next three years the faculty members attempted to define the department's role in the Institute and in the community. It became apparent, however, that in order to do this, more information about the student population was needed. As a part of this information gathering, the department head wanted to know how the students processed information. A few informal attempts at obtaining this information were made and a need for a more conclusive study was seen.

B. BACKGROUND

Hemispheric dominance has become a new and unfolding field of interest to a variety of disciplines. A positive identification of hemisphericity in humans, the separate action of the left and right sides of the brain, was made approximately 20 years ago (in 1961) by a cooperating team of psychologists and surgeons (Gazzaniga, 1970). In the interim an impressive amount of information has been gathered regarding the specialized functions of the separate hemispheres, but

in 1981-1982 the problem was still young and there was much to be learned.

In 1981 the division of hemispheric function was as follows. The right hemisphere of the brain was thought to control the emotional, the intuitive and the creative functions; the left hemisphere controlled the verbal, logical and organizational functions (Edwards, 1979; Pines, 1973; Buzan, 1976; Claycomb, 1978). Springer and Deutsch (1981) expanded understanding by identifying left hemisphere function as dealing with logical representation of reality and communication with the external world, thinking, reading, writing, counting and time awareness. By contrast they identified right hemisphere function as concerning itself with understanding patterns and complex relationships which could not be precisely defined or might not be logical.

The 77th Yearbook of the National Society for the Study of Education, entitled Education and the Brain (Chall and Mirsky, 1978), was devoted to implications of hemispheric dominance for education. Robert L. Bailey, an electrical engineer and associate professor of electrical engineering at the University of Florida, authored a text, Disciplined Creativity for Engineers (1979), which attempted to enhance the creative ability of engineering students. Dr. Betty Edwards aimed her book, Drawing on the Right Side of the Brain (1979), to linking the hemispheric function with the ability to see in a specific way which enabled most students to draw in a superior manner. Vocational technical education as an educational area--particularly engineering-graphics--has traditionally pulled together these areas of the arts, engineering technology and education.

C. STATEMENT OF THE PROBLEM

There is a lack of information about the effect hemisphericity has upon student performance in an engineering-graphics course. This study was a beginning in supplying some of this information.

D. PURPOSE OF THE STUDY

This research problem concerned students' performance in an engineering-graphics course and their left/right/integrated brain dominance (hemisphericity). The specific questions addressed in the problem statement were: (1) do there exist differences in performance in an engineering-graphics course between groups of students determined by distinct hemispheric dominance categories, (2) do special right-brain oriented problems added to the regular course structure affect student performance in engineering-graphics course, and (3) do differences exist in performance in an engineering-graphics course between left-handed and right-handed students with the same hemispheric dominance, or between female and male students with the same hemispheric dominance, or between students with different eye dominance but with the same hemispheric dominance?

E. RATIONALE

One essential objective of this study was to add to the information which would make different approaches available for teaching engineering-graphics at the State Technical Institute at

Knoxville. Performance in a technical graphics course requires the abilities to draw and to process associated technical data; thus, information from both hemispheric domains is involved. By identifying students' functional hemispheric dominance, the way in which material was presented or the very choice of the material itself could be affected. Thus, the study attempted to establish some connection between performance in technical graphics and the hemispheric dominance types.

F. LIMITATIONS

Due to the nature of the selection of the course sections by the students (the use of intact groups) instead of a random assignment of the students to sections, there was a limit to the generalizability of the study information. Information gained about engineering-graphics students pertained only to those at the State Technical Institute at Knoxville.

Comparison of the size of the sample with the potential number of categories revealed that there was a potential void in the cross-referenced classes. There were 144 three-way crosses and only 68 individuals. This resulted in a number of empty cells, which was a definite limit upon the results.

Another limit upon this study was the self-report method of determining handedness, sex, and dominant eye. This method was most readily available to the classroom instructor and approximated

regular classroom information. The alternative, testing using special machinery, was inappropriate for this study.

At the State Technical Institute at Knoxville, there has been a high dropout rate of students within the first two or three weeks of each quarter. The dropout rate experienced in this study reflected this well known phenomenon. This was another limit on the study.

G. DEFINITIONS OF TERMS

The following terms, used in this study, are defined both conceptually and operationally.

Conceptual Definitions

Cerebral dominance. The literature on the subject of hemisphericity uses interchangeably the three terms "laterality," "cerebral dominance," and "hemispheric dominance" to designate the predominant use of one hemisphere of the brain. This study will use "hemispheric dominance."

Dominant eye. The eye which is used more predominantly in single eye acts.

Engineering-graphics. The combination of the vocabulary and concepts of the engineering technologies with the manual dexterity of drawing.

Handedness. The hand most frequently used to write or draw.

Hemispheric dominance. The predominance of one hemisphere of the brain in certain cognitive processes.

Integrated-brained. The use of both hemispheres of the brain together in certain cognitive processes.

Left-brained. The use of predominantly the left hemisphere of the brain in certain cognitive processes.

Right-brained. The use of predominantly the right hemisphere of the brain in certain cognitive processes.

Operational Definitions

Dominant left eye. The left eye when the student identified it as dominant using the focus test (described under experimental procedure).

Dominant right eye. The right eye when the student identified it as dominant using the focus test.

Engineering-graphics. A technical curriculum available at the State Technical Institute at Knoxville which includes drawing for the fields of mechanical, electrical, chemical, architectural and construction engineering and the subsidiary fields.

Hemispheric dominance. The dominance established by the SOLAT Test which is right, left, or integrated. (In 1976 E. P. Torrance defined a new category, mixed, to be assigned when the SOLAT Test did not establish one category of hemispheric function as dominant.)

Integrated-brained. The use of both hemispheres of the brain together as identified by the SOLAT Test.

Left-brained. The use of predominantly the left hemisphere of the brain as identified by the SOLAT Test.

Left-handed. Use of the left hand when identified by the student as the one predominantly used.

Mixed. A category established by E. P. Torrance for SOLAT Test results which indicated that no one category of hemispheric function was dominant (Torrance, et al., 1976).

Performance in an engineering-graphics course. The mean of three performance scores assigned to a portfolio of each student's drawings (described under experimental procedure).

Right-brained. The use of predominantly the right hemisphere of the brain as identified by the SOLAT Test.

Right-handed. Use of the right hand when identified by the student as the one predominantly used.

Sex. That identified by self report--either male or female.

H. ASSUMPTIONS

The following assumptions have been made.

1. The SOLAT Test was a valid measure of hemisphericity. This assumption is based upon information published in the section on validity in the Manual for Your Style of Learning and Thinking (Torrance, Riegel, and Reynolds, 1976).

2. The instructors of the five sections were comparable in their ability to teach the same material. This assumption was based upon student and supervisor ratings.

3. Grades given by three consulting experts to the students' drawings were satisfactory evidence of the students' performance in an engineering-graphics course. This assumption was based upon an interrater reliability test.

4. Students who selected the course in the fall quarter of 1981 were similar to those who would select the course in the future. This assumption was based on the researcher's observation that this student group was not atypical.

5. Self-reporting of handedness, sex, and dominant eye would yield usable information for future classroom use. This assumption was based on observation that most people know their own sex and dominant hand, and upon the recommendation of the eye dominance test by the consulting ophthalmologist.

I. RESEARCH HYPOTHESES

Seven research hypotheses, embodying the three specific questions of the research problem, were formulated. The t-tests were used to decide whether or not the hypotheses were to be rejected (as explained in Chapter III). The Hypotheses were tested for significance at the .05 probability level unless otherwise indicated. All seven hypotheses pertained to students at the State Technical Institute at Knoxville.

Because drawing usually is considered a right-brain activity, it might be expected that right-brain dominant students would perform better in an engineering-graphics course. However, since this particular graphics course was in the engineering curriculum, a considerable part of the course work also required skills usually associated with left hemispheric function. Thus, it might be expected that integrated-brain dominant students would perform better in an engineering-graphics course. The first three null hypotheses were

formulated to provide bases for testing expectations concerning hemispheric function and performance.

Null hypothesis four formalized the expectation that the special problems would be beneficial. The last three research hypotheses concerned the possibility of differences in performance to be associated with the factors of handedness, sex, or eye dominance among students of the same hemispheric dominance.

1. There is no significant difference in performance in an engineering-graphics course between left-brain dominant students and integrated-brain dominant students.

2. There is no significant difference in performance in an engineering-graphics course between right-brain dominant students and integrated-brain dominant students.

3. There is no significant difference in performance in an engineering-graphics course between left-brain dominant students and right-brain dominant students.

4. There is no significant difference in performance in an engineering-graphics course between students not receiving special right-brain-oriented problems and students receiving special problems.

5. When students of the same hemispheric dominance are considered, there is no significant difference in performance in an engineering-graphics course between left-handed students and right-handed students.

6. When students of the same hemispheric dominance are considered, there is no significant difference in performance in an

engineering-graphics course between female students and male students.

7. When students of the same hemispheric dominance are considered, there is no significant difference in performance in an engineering-graphics course between students whose left eye is dominant and students whose right eye is dominant.

CHAPTER II

SURVEY OF THE LITERATURE

A. INTRODUCTION

This study focused upon the combination of education and the known processing capabilities of the separate hemispheres of the brain. It was necessary to bring together several separate fields of interest and to tie them together. These included: medical and psychological history of hemisphericity and the attributes of right and left hemispheric function; the relation of hemisphericity and handedness, sex, and eye dominance; and education and its relationship with the current issue of hemisphericity.

Engineering-graphics used the left and right hemispheres. In its use of organization, presentation of material and terminology, and the systematic solving of problems, engineering-graphics involves the application of the logical left-brain. Viewing the objects to be drawn, drawing and placing the material on the page, and using the various symbols of the profession involves the application of the more graphically oriented right-brain.

Since a student of Engineering-Graphics must actively use both the left- and right-brain, it is evident that technical graphics education in particular can benefit from information about the logical, sequential information-processing, left cerebral hemisphere and the spatial, holistic information-processing, right cerebral hemisphere.

Section B contains a survey of the history and development of the ideas of hemisphericity and laterality. Section C surveys published work on the connection between hemisphericity and handedness, sex, and eye dominance. Section D surveys work dealing with the questions of determining hemisphericity and its changability. Section E discusses education in relation to hemisphericity.

Most of the papers in the medical, neurological, and psychological areas are brief reports of the results of single experiments and deal with single issues. Thus a report of this literature is by its very nature fragmented.

B. HISTORY AND DEVELOPMENT OF THE IDEAS OF HEMISPHERICITY

Since the 19th century, scientists have been aware that the brain was contracontrolling of the body (Claycomb, 1978). Joseph Jules Dejerine, a French neurologist, observed over a hundred years ago an example of hemisphericity--the separate action of the left and right hemispheres of the brain. DeJerine had a patient with a disability which allowed him to see only in the left visual field. This patient was unable to read, but he could spontaneously write down words dictated to him. Even though he had just written the words, he could not understand what he had written.

DeJerine, from this evidence and the further evidence of a destructive lesion found in the left visual cortex and in the corpus collosum after the patient's death, speculated about the function of the corpus collosum (Restak, 1979). These notes which established

the corpus collosum as a point of connection between right and left hemispheres went unnoticed until the 20th Century.

In the late 1930s and early 1940s surgical removal of the corpus collosum was done to relieve severe epilepsy. At that time the operation seemed to have no externally observable effect upon the patient except the cessation of the epileptic seizures.

In April 1961 the John Hopkins University School of Medicine held a two day conference which addressed the simple question, "Why do we have two brains?" Active researchers in the area of hemisphericity gathered and presented papers. The different functions of the hemispheres of the brain in animals and humans were discussed. H. Hacaen, of France, had studied humans with brain lesions. He presented his observations on their physiological problems. Hans-Lukas Teuber of the Psychophysiological Laboratory, Massachusetts Institute of Technology, had been following brain-injured humans for over ten years. These were 232 brain wounded and 118 with severed peripheral nerves who were veterans of World War II and Korea. At this time Teuber observed:

More recently, other differences in function have been noted: it becomes increasingly probable that right hemispheric lesions in man may alter perception in ways rather different from corresponding lesions in the left side of the brain (1962, p. 132).

Teuber spoke at that time of effected areas being auditory, visuo-spatial, tactile, sensory, time-error, and with dichotic listening. Hacaen had a similar list.

Roger Sperry also presented at this conference. His work had been with cats, but he had begun to speculate about human hemispheric

differences (1962). Papers presented at this conference appear in a volume edited by Vernon B. Mountcastle which was published in 1962.

Through a series of animal studies in the 1950s, Sperry had established that a main function of the corpus collosum was to allow transmission of memory and learning from one hemisphere to the other. These studies and earlier post-operative records led him to believe that the corpus collosum could be severed without significant observable effect (Sperry, 1968). After an operation in 1962 (described below) it was discovered that if this connecting cable was severed, the two brain halves continued to function independently. Each hemisphere of the human brain, unlike other mammalian brains, is specialized for different functions (Sperry, 1977).

In 1962 an attempt was made to aid a man suffering from chronic epileptic seizures by severing the corpus collosum. Joseph Bogen and Philip Vogel, neurosurgeons, performed the operation. Michael Gazzaniga, a student of Sperry's at the California Institute of Technology, did the post-operative follow-up observation of this patient. He reported that the patient was unable to respond to verbal instructions with the left side of his body. "Raise your left hand" brought no response. However, the left hand proved adept at swiftly copying a Greek cross outline when the right hand could only do a few lines at a time and could never finish it. The right-handed patient could read only the words in his right visual field, which made reading difficult and tiring. The right brain proved illiterate and speechless, but not useless as had been previously believed (Pines,

1973). This was one beginning of the search for detailed information about the specialization of the hemispheres of the brain.

In the following 20 years an impressive amount of information has been gathered, but progress has just begun. Sperry said:

Everything we have seen so far indicates that the surgery (commissurotomy) has left these people with two separate minds, that is, two separate spheres of consciousness. What is experienced in the right hemisphere seems to lie entirely outside the realm of experience of the left hemisphere. This mental dimension has been demonstrated in regard to perception, cognition, volition, learning and memory (1966).

Since 1966 separate lines of behavior for each hemisphere have been established. Wittrock (1978) tied the left hemisphere to cognitive function, handling of words and their meaning, and the structure of language. Springer and Deutsch (1981), however, state that two cognitive styles exist and each is related to hemispheric control. In addition to the language function, mentioned by Wittrock as a left-brain cognitive function, they added digital, analytic, rational and western thought as cognitive processes of the left-brain. The right cognitive style, which Springer and Deutsch detailed, is non-verbal, visuo-spatial, analogic, simultaneous, intuitive, and of eastern thought.

Springer and Deutsch saw the major business of the left hemisphere as the "logical representation of reality and communication with the external world." They identified the right hemisphere's business as the understanding of "patterns and complex relationships that cannot be precisely defined and may not be logical" (1981, p. 191).

Edwards (1979) agreed with Springer and Deutsch that each hemisphere has its own cognitive mode. She asserted that both cognitive modes involve "thinking, reasoning and complex mental functioning" (p. 30). According to Edwards, verbal ability distinguishes between the two hemispheric functions. The left hemisphere is verbal and the right hemisphere is non-verbal.

In Brain Research and Learning, a 1978 publication of the National Education Association, it was again observed that the hemispheres of the brain are contralaterally controlling of the body. Regarding specific hemispheric functions, it was asserted that the left hemisphere controlled the main language center dealing with vowels and sound manipulation; however, the right hemisphere was credited with "simple language comprehension" and with "vowel and consonant recognition" (p. 8).

Bogen (1978) listed functions of the two hemispheres and considered them parallel functions. Edwards (1979) compared Bogen's dual listing with the duality of Yin and Yang of the Chinese I Ching. Jerre Levy, et al. (1968) showed that the mode of right-brain processing is rapid, complex, and whole pattern which, though different than the verbal analytic left-brain, is equally complex.

Levy, et al. (1968) had findings which suggested that, "a possible reason for cerebral lateralization in humans is the basic incompatibility of the language function on the one hand and the synthetic perceptual function on the other" (p. 1151). Beaton (1979) said:

. . . it may not always be fruitful to consider the brain as a single channel of limited information processing capacity. There are two channels and their interaction is dependent upon the relation between input and output factors (p. 634).

Harshman and Krashen (1974) did research with children. They found the right hemisphere dominant in the early years, and they speculated that it had a special role in language "acquisition" which they liken to its later "gestalt processing and non-categorical perception" (p. 10).

The left hemisphere is the seat of logical operations and calculations (Heilman, 1975). The left hemisphere also processes information sequentially. The right hemisphere deals with less structured functions. It recognizes faces and patterns, deals with spatial identification, does sensory discrimination, and does all the visualizing and imaging. The right hemisphere processes information holistically (Edwards, 1979).

Kinsbourne and Hiscock (1978) observed that, "the concept of dominance . . . implies an executive function that is not implied in the term lateralization." They went on to introduce the concept of "double dominance." This is the situation in which one hemisphere is dominant for some functions and the opposite hemisphere is dominant for other functions. This would agree with Torrance's concept of integrated dominance.

Franco and Sperry (1977), in investigating geometry and hemispheric lateralization, found that:

An active interaction of the two hemispheres during the processing of geometrical problems seems implied and a similar interhemispheric integration would seem reasonable also for other cerebral activities involving spatial intuitions and their linguistic expression (p. 112).

This seems to imply a similar situation to that which Kinsbourne and Hiscock discussed--a double dominance.

Edwards (1979) described a similar concept. She maintained that each hemisphere contributes with its own special abilities. She went further and asserted that the two halves could also be in conflict with one another. One hemisphere may attempt to do what the other half knows it can do better. She considered the possibility that the hemispheres may also have a means of keeping knowledge from one another.

Philip Morrison disagreed with just about everyone. In a 1981 article in The Sciences he stated that while popular psychology divided the brain into different hemispheres and separate levels of logicity, he did not "believe this theory for one moment." He went on to say:

If I have learned anything in these matters, I learned a long time ago that it is very difficult to split algebra and geometry into this hand and that (p. 16).

An early connection between graphics and the brain's hemispheres was established by McKeever and Huling (1970). They found the right hemisphere superior in graphic reproduction of briefly viewed dot figures.

Russell Cassel (1978) established that the right hemisphere deals with perceptions of the environment and geometry. For Bailey (1979), spatial visualization is necessary before a drawing of a specific object is made. Spatial visualization involves right hemispheric function according to Wittrock (1978). This was supported by Franco and Sperry (1977) in their study of the

lateralization for cognitive processing of geometry. They found evidence which suggested that "preverbal apprehension of geometrical relation is mainly a right hemisphere function" (p. 112). Levy and Agresti (1968) found the right hemisphere superior when dealing with three dimensional form identification.

Umiltà (1978) found that the left hemisphere processed simple geometric forms but that the right hemisphere took over for the more complex forms. According to Longden's (1976) findings the right hemisphere performed better in comparing two curves to determine whether they were the "same" or "different." This agrees with what Wheatley (1977) indicated that the right hemisphere sensed complex shapes holistically and thought in images. A (1979) study by Leehey, et al., supported the idea that the right hemisphere is more involved when recognition of complex visuo-spatial stimuli are presented.

C. HANDEDNESS, SEX AND EYE DOMINANCE RELATED TO HEMISPHERICITY

At the 1962 Johns Hopkins conference on Interhemispheric Relations and Cerebral Dominance, the position papers presented were already linking the characteristics of handedness, sex, and eye dominance together when considering hemisphericity. A fourth factor was also occasionally considered and that was ear dominance. This trend has continued.

Handedness, sex, and eye dominance were collectively studied by the Gurs (1977). They used three different sighting tests and found that handedness was associated with "sighting dominance" for

males but not for females. In this study eye dominance came in three categories: left, right, and both.

Handedness and hemisphericity have been studied by several persons. Of particular interest are the studies by Peterson and Lansky. They conducted three studies of architects and architecture students and found an abnormal distribution of handedness with more left-handed students than expected. The normal distribution of handedness is 10 percent left-handers and 90 percent right-handers. They also established that the left-handed students could follow complex directions about drawing a spatial maze perfectly, whereas over 50 percent of the right-handed students erred (Peterson and Lansky, 1980).

Since the body is cross-controlled, the left hand is controlled by the right hemisphere which is the spatially oriented half of the brain. Gazzaniga (1970) found that cyclical reinforcement between handedness and hemispheric use occurs. That is, use of a hand stimulates the contralateral hemisphere which in turn reinforces the contralateral hand. Birkett (1977) when studying eye and hemisphericity supported Gazzaniga's findings but added a new factor, accuracy. Birkett said, ". . . data on each measure shows that right hemisphere 'dominance' for the task increases with accuracy" (p. 693).

McGlone, et al. (1973) took issue with some predecessors including Levy and Nebes. Her findings support Peterson and Lansky. She found "not all left-handers performed poorer than right-handers on spatial tests, only those showing higher left-ear scores on dichotic word tests" (p. 111). Further, she found that left handed

females with higher dichotic scores performed poorer on visuo-spatial tests, and that "visual, non-verbal cerebral dominance may be more right hemisphere dependent in males than in females" (p. 111).

A contrary conclusion, when comparing sex difference in spatial ability, was found by Harris (1978). He found that males had decidedly better spatial skills than females. His study showed only 20-25 percent of females outperformed the average male. Harris did not mention dichotic scores. He did, however, speculate on the possibility that environmental, genetic, and neurological factors could cause the sex related differences since they do not begin to appear until after a person is ten years old. Kurtas (1975) addressed the issue of handedness also. She attempted to replicate Nebes work and found non-supportive results. She found that left-handers performed a perceptual task slightly better than right-handers. This contradicted Nebes who had found no difference.

Wolff, et al. (1977) added a new twist. They found that the "left hand of right-hand preferers" was more accurate on manual tasks requiring form recognition or spatial discrimination. Two studies expressed concern that there was no single well established measure of handedness (Gilbert, 1977; Kurtas, 1975). Kurtas compared the existing tests when attempting to replicate Nebes study. She found that Nebes' test did not correlate well with the others.

Gilbert found familial handedness an important moderating variable which needed to be considered. He found that "facial recognition ability seemed diminished by FLH (familial-left-handedness) and FLH seemed closely associated with decreased cerebral

lateralization" (p. 779). LeDoux, et al. (1977) found that the right hemisphere advantage for split-brain patients on a variety of spatial tasks was highly dependent upon the involvement of manual activities in "the perception of spatial relationships or the production of spatial responses" (p. 743).

Levy (1976) studied aesthetic viewing, sex, and handedness. When comparing males and females within each handedness category, there was no significant difference between left-handers and right-handers when expressing a preference for mirror symmetric pictures.

Eye-brain connections also have been studied separately. Eyes are not like hands in their relationship to the brain. Hands are contralaterally controlled. Eyes are not contralaterally controlled, but the visual field of each eye is. The complete destruction of one brain hemisphere will result in the paralysis of the hand on the opposite side, but the eyes will both be partially affected (Goldberg, 1979). Horizontal movement of an eye can be evoked by stimulation of the contralateral occipital lobe. Vertical movement is controlled by both hemispheres operating together (Shakhnovich, 1977).

It is interesting to note that Gazzaniga (1970) found that visual information does not transfer from one hemisphere to the other. He also found no evidence, when looking at integration between the two visual half-fields, that the perceptual activities of one hemisphere influenced the other hemisphere. This was supported by Umiltà, et al. (1978), who found that establishing a dominant eye is not like establishing a dominant hand because each eye is

bilaterally controlled and thus not subject to input from a single hemisphere.

Early in the study of laterality, Mishkin (1962), working with both monkeys and man, observed:

Visual mechanisms in the two hemispheres are integrated, but not nearly so well as the visual mechanism within a hemisphere (p. 101).

Nebes (1973) combined eyes and figures. Subjects were more accurate at identifying figures when viewing displays in the visual half-field of the right hemisphere than they were when viewing displays in the half-field of the left hemisphere. He was using three commissurotomy patients and five normal persons as a control group. The normals failed to show a difference in accuracy between the two half-fields, and Nebes speculated that it was because of the simplicity of the task.

In looking at eyes and hemisphericity, Bagnara, et al. (1980) combined eyes and sex and found that males showed left visual field advantage. They found that females did not show a clear cut hemispheric asymmetry.

Much study has been done with eyes, ipsilaterality, contralaterality, and hemispheric control. A great deal of information has been gathered; however, there are still more questions than answers regarding eyes and their hemispheric control.

D. MEASUREMENT AND SHIFT OF HEMISPHERICITY

Can lateralization be measured effectively? All the people doing research on hemisphericity and associating particular functions

with particular hemispheres are proponents of the measurability of hemisphericity. However, not all are in agreement on ideas of measuring cerebral dominance.

Intelligence has historically been measured using "IQ" tests which researchers in the field of hemisphericity agree measure left hemisphere ability. Phillips (1975) wrote, "'Intelligence' is the ability to make adaptive choices" (p. 8). Researchers in the left-brain, right-brain field have agreed that only half a brain has been judged. They would not agree on how now to measure the halves.

Colbourn (1978) argued that current studies are misleading because the indices purporting to measure the extent of cerebral lateralization of a task or function are not based on any foundation. He states that this gives a false sense of quantification of the underlying hemispheric factors. Colbourn disagrees with Birkett who in 1977 published findings stating that the empirical relationship between hemispheric dominance and accuracy may reflect a psychological process which he would distinguish from statistical bias. Birkett concluded that the measurement of hemispheric dominance (or laterality) should be constructed around "dynamic theories" if the cerebral processes involved is performing a specific task. Birkett did not elaborate.

Brown and Jaffe (1975) had hypothesized that cerebral dominance was a continuous process which evolves throughout life. The measurement of cerebral dominance, they wrote, must be qualified to mean dominance for what function, at what age, and under what conditions of testing.

Richardson (1976) wrote that the derivation of measurement of laterality is not useful for evaluating cerebral organization. If laterality is to be measured, it is necessary to avoid the use of one hemisphere specialization when testing the other, because contamination will occur from one side to the other and the measurement will be inaccurate. He said that the basic assumptions necessary to derive this measurement are that at some point left hemisphere equals right hemisphere, and that if one is constant the measure can be totally upon the other. These assumptions are based upon theory which he called improper. Richardson proposed a theory-independent technique for ordering results of laterality experiments.

From the field of educational psychology, E. Paul Torrance (1976) supported the measurability of hemisphericity. Working from a number of testing instruments which have been used to measure eye movement, verbal and figural analogies, gestalt, etc., he has developed a self-report instrument which he claims measures left and right hemispheric dominance and also measures a third condition, integrated dominance or the combined activity of the two halves. This follows Kinsbourne and Hiscock's "executive function" mentioned earlier. A majority of the investigators have assumed, or determined to their own satisfaction, that dominance is measurable.

Can dominance shift or be effected? Ira Progoff (1967) said in his book The Symbolic and The Real:

We feel protected by reference to statistics, and yet we know that the major breakthroughs of knowledge have their origins in nonrational intuitions that burst unpredictably from the imaginative depths of personality (p. 3.).

This is a description of the use of right hemispheric function. Progoff has established workshops to assist individuals to reach these depths of personality.

Hines' (1978) study supports change. He found overloading input to a hemisphere would alter its functioning. Torrance and Sato studied the differences between Japanese and United States styles of thinking and found that the usual scoring procedures for "Your Style of Learning and Thinking" was questionable when applied to Japanese students. Differences were found in which hemisphere was used for intuitive vs. logical thinking, "planning and precision vs. spontaneity and open-endedness; and . . . verbal modes of learning, teaching, and communicating vs. non-verbal modes" (Torrance and Sato, 1979, p. 147).

Change is also supported by Sibatani (1980) who studied laterality in Japanese. He found that hemispheric function is cultural and thus that it is developed and changeable. Both Sibatani and Torrance quote a Japanese researcher, Tadanobu Tsunoda, who wrote The Japanese Brain (1978) which has not yet been translated into English.

Tsunoda, a specialist in hearing difficulties, found that in brains of right-handed Westerners, Koreans, Chinese and Bengalis, vowel sounds usually get processed in one side of the brain if they occur in isolation, but in the other side if they are spoken in context. However, Japanese and Polynesians usually process all vowels, whether spoken in context or in isolation, with the left hemisphere. The Japanese and Polynesian languages are rich in vowels. Tsunoda also inferred that emotion is processed by the Japanese in the left hemisphere, which is the opposite of what the westerners' emotional

processing is believed to be. Torrance and Sato's work supports Tsunoda's findings.

Endo, et al. (1978) looked at visual field dominances and found that random shape recognition of nonsense characters occurred more rapidly when the left hemisphere was utilized, and that the right hemisphere was superior when recognition of regular shapes was required. The conclusion from these studies was that cerebral discrimination is learned and cultural, and thus that it can be relearned in a new fashion.

One of the ways in which hemispheric dominance has been shown to be altered is by the exposure of individuals to a different way of processing information through problem solving. There are several definitions of problem solving most of which include some form of learning to think in new ways. Gagne (1965) said:

. . . Problem solving may be viewed as a process by which the learner discovers a combination of previously learned rules that he can apply to achieve a solution for a novel problem situation. . . . Problem solving is thus a natural extension of rule learning, in which the most important part of the process takes place within the learner (p. 214).

Those persons who tie creativity and problem solving to left-brain function are those whose approach is systematic and logical. For those persons for whom problem solving is more disorderly, it is a right-brain function.

Whimbey and Lochhead (1980) produced a text for teaching analytical reasoning. For them problem solving and creativity came from thinking more critically about available information and had very practical applications. Their approach was to assist the

student in improving analytical skills, a systematic approach concerned with accuracy.

DeBono looked at problem solving differently. He said, "A problem is simply the difference between what one has and what one wants" (1970, p. 78). In his approach to learning problem solving, the student has to be neither sequential nor correct. The provision DeBono made was that only the ultimate solution was right--the problem solved. Wheatley (1977) agreed with deBono that the right answer at every step is unnecessary. He said:

Showing students how to work the problems and then having them practice the process does little to improve their problem solving abilities. Students need to be faced with problems in which the approach is not apparent and encouraged to generate many alternative approaches. . . . In this way students will come to understand the nature of problem solving (p. 38).

Frequently problem solving and creativity are tied together in research and writing. The Journal of Creative Behavior frequently testifies to this union in reported studies. In the 1976 issue on testing, problem solving was connected with creativity measurement in almost every article. Prince (1970) wrote, "If, as I believe, each man and woman is a born creative problem solver, such potential demands expression and exercise . . ." (p. 3).

E. EDUCATION

What is the relationship between hemisphericity and education? In 1914 a federal Committee Report on Vocational Education included the following statement:

The absence of opportunity for creative work and, hence, for full self-expression is, without a doubt, one of the causes of the present unrest (p. 25).

This statement certainly can be interpreted in several ways. It is from a period when the average length of school attendance was six years and the entry age of an individual into the world of work was approximately ten. Creativity and independent thinking was desired, and yet stifled, in the work and education environment.

Years have passed, times have changed, and students now average many more years in school; however, approaches to education have not changed much if any. Writing of the current system John Holt, in How Children Fail (1970), ungraciously stated: "Any kid who is not paranoid by the time he graduates from high school is crazy" (p. 220). Lawrence Kubie (1967) added to this comment, but he presented his protests in a more subtle fashion. He said:

The function of education is . . . to show us how not to interfere with the thinking capacity which is inherent in the human mind (p. 41).

There is research to support the premise that creativity is still being stifled by the school. A study by V. J. Papenek as reported by George M. Prince (1970) is summarized in the following paragraph.

After World War II, several psychologists became interested in creativity and age. They found that they had no measure for the number of creative forty-five year olds but they felt that by this age creativity had passed. They decided to investigate how many forty-five year olds were still creative. They found that 2 percent of the forty-five year olds were highly creative.

One of the psychologists in this group decided to investigate when creativity "wore out." Beginning with this group of forty-five year olds, he began testing successively younger groups of individuals. The percentage of highly creative individuals remained 2 percent until he tested seven year olds. Then the percentage of highly creative individuals jumped to 10 percent, a five-fold increase! He persisted with the testing and found that at age five, 90 percent of the examinees were highly creative!

Most individuals begin attending school at age five or six. This is not to say that school attendance is lethal to creativity or right brain activity. But the correlation deserves investigation.

Creativity is not the sole province of the right brain, but a good portion of creative behavior is connected with this hemisphere's activity (Samples, 1975). The lack of creativity in individuals over six years of age suggests an effect that education is having on hemisphericity.

Roger W. Sperry has expressed concern about education's left-brain orientation. In his chapter "Left-Brain, Right-Brain" in Mind and Supermind edited by Albert Rosenfeld (1977), he said:

A second message that emerges from the findings on hemispheric specialization is that our educational system and modern society generally (with its very heavy emphasis on communication and on early training in the three R's) discriminate against one whole half of the brain. . . . In our present school system, the attention given to the minor hemisphere of the brain is minimal compared with the training lavished on the left, or major, hemisphere.

Wheatley (1977) also expressed this same concern. He pointed out that our society and particularly our schools emphasize and reward

left hemisphere activities. A premium is placed on being able to put ideas into words, to state them explicitly, and to operate with rules (p. 38). He went on to say that all this is detrimental to right hemisphere development. Wheatley was supported by Robert Samples (1980) who wrote:

Those in education must recognize that we have a strong bias toward specific ways of knowing, and toward particular ways of reporting and recording mind work. . . . In education, the widespread and unfortunate tendency to focus on a narrow range of skills means that most students never become aware of the broader area of their wisdom (p. 22).

Morris Cogan (1974) examined the question of the qualities teachers should have if the right hemisphere is also to be stimulated. He listed several items including: a theoretical orientation, a tolerance for complexity, a capacity for creative thinking, a low motivation for controlling children, courage, and an interest in intellectual activity and problem solving. Cogan was talking of the education of students within education systems.

Bennett (1964) was concerned with educating oneself. He distinguished between two activities called "thinking" differentiated by the sources. One of these activities, which he separated from "real thinking," was the collection of existing sensations from outside. He identified the second activity as follows: "Real thinking is the spontaneous arising, in the inner awareness, of an image that gives us a contact with some part of reality" (p. 19).

A National Education Association publication observed that educators should concern themselves with educating all areas of the brain. It stated that current research involving the brain and

learning supports the certainty that many modalities are needed in the contemporary classroom to match the difference in learning styles which may exist there (N.E.A., 1978).

Our schools reward left-brain approaches to living and learning. Richard Restak (1979) wrote of the way in which schools make learning easy for left-brain students and difficult for right-brain students. His study examined left hemisphere and right hemisphere student attitudes toward schools and preferences in learning styles.

Research supports change but, in education there is no rush to respond to the results of research. Ohmer Milton (1972) wrote:

Academic practices on most campuses indicate that the assumptions seem to have been modified not at all by research about learning or by advances made during this century in knowledge about the structure and functioning of the brain (p. 7).

Tyrus Hillway (1969) defended the education system as follows:

(In education) . . . countless problems remain unsolved . . . research in education is fairly new. . . . It has had only three quarters of a century to produce salient results. Before 1895 when the first research was conducted in the United States, educators attacked their problems mainly by trial and error.

Hillway was writing in 1969, and the concept of hemisphericity in humans and its potential effect on learning were relatively new at that time. Hart (1978) had a different view which he stated succinctly:

Over the last 30 years rapid advances in understanding the human brain have created the basis for important new insights into the nature and process of learning. They have profound significance for education.

Education is used to small gains, but new comprehension of human learning appears to hold the potential of a quantum jump perhaps comparable to that in chemistry a century ago

when Dmitri Mendeleev constructed the periodic table of elements. Chemistry became a coherent field. Theory connected more directly to practice. . . .

Education today is in a similar situation. We have a great fund of fragmentary knowledge. But, as the literature freely notes, it has not coalesced into a useful theory that can provide an effective basis for instruction and the organization of schools. Research effort has been intensive; but still the teacher and learner wait for practical, applicable help (p. 393).

How can education respond? There seem to be educators aware of the need for change. Bailey (1979) saw the need for his students to increase their creative ability in order to be better engineers. To assist them Bailey developed a course to increase student creativity which resulted in his book, Disciplined Creativity for Engineers. He was not alone in recognizing the need for engineers and engineering technicians to increase right hemisphere activity. In the September 26, 1977 issue of the magazine "Chemical Engineering," Eugene Raudsepp urged increased creativity and gave several problems whose solution might increase the engineer's ability to think creatively.

Chall and Mirsky (1978), editors of Education and the Brain, summarized the implications for education put forth by the writers of the essays included in the volume as follows:

Environmental stimulation and experience play central roles in the growth and development of the brain--even in overcoming the effects of inherited deficiencies and acquired injuries.

Certain kinds of training appear to be more effective than others. There seems to be a strong implication in work done to date that matching instructional methods with the aptitudes of the learner will cause learning to take place more efficiently.

Proper timing is important in the growth of both cognitive abilities and emotional capacities. Educators cannot ignore the great importance of left-right hemisphere interaction

for the development of human cognition and for the understanding of differences in learning styles.

The two strongest implications for education at this time seem to be (a) that we need to find out how to strengthen the "weak" right-hemisphere processes of some students by using more right-hemisphere activity to help them learn right-hemisphere functions; and (b) that students who are weak in academic skills (based on our dependence on left-hemisphere processes in our ordering of the curriculum) should be taught music, construction, and other activities involving right-hemisphere processing, in other words, activities in which they can excel.

Grady and Lucke (1978) wrote of balancing the curriculum based upon the findings of split brain research. They suggested the use of interdisciplinary approaches, adding subjects which require right-brain stimulation and which have content needed to balance the curriculum. They cite as an additional reason for including right-brain material the impact of television and other electronic media on students prior to their entry into the educational system. These are then deleted from the students' experiences in school. They recommend that schools begin taking a holistic approach.

Robert Samples (1980) wrote of a Project Viewpoint in Gresham, Oregon, which was conducted by a teacher in the school system there. In this project, the instructor attempted to increase the students' visual acuity, sense of aesthetics and self esteem through photography, film making, video projects, art, and graphic design and to express these increased sensibilities both visually and through the three Rs. The result was that the students not only became more adept at visual expression, but they also became more proficient at the basic reading, writing and arithmetic skills.

Torrance (1965) supported this idea and stated it as follows:

. . . in most of the statistical analyses, the pupils of the creatively motivated teachers showed significant growth, while those of the less creatively motivated teachers actually showed decrements . . . (p. 84).

This would seem to indicate that we need to pursue aiding teachers as well as students in using their total brains.

F. SUMMARY

Each of the previously mentioned authors contributed to the available information about the brain, its separate hemispheric functions, and by extension the need to have more information available for the field of education to improve our current system.

CHAPTER III

EXPERIMENTAL PROCEDURES

A. INTRODUCTION

This study examined some of the differences in performance in an engineering-graphics course between groups of students with distinct hemispheric dominances either left, right or integrated. It also examined the difference in performance in an engineering-graphics course between students receiving and not receiving the treatment of special problems added to the regular course work. Additional factors which were explored were handedness, sex, and eye dominance. A description of the methodology used to examine and correlate the differences is presented in the following sections.

B. THE EXPERIMENTAL SUBJECTS

The Population

The population with which this study was concerned consisted of the students in the engineering-graphics courses at the State Technical Institute at Knoxville.

The Sample

The experimental subjects for this study were those students enrolling in sections of a beginning engineering-graphics course (DR 101) at the State Technical Institute at Knoxville. In Fall 1981, DR 101 was the introductory course servicing four of the five

engineering-technology departments. The DR 101 course was not a part of the curriculum for Building Construction Technology students who began their drawing sequence with another course.

The experimental subjects were not randomly selected from majors in the five possible departments but were determined by class enrollment. A cross-section of the Engineering Division was represented.

Handedness, sex, and eye dominance distributions of the subjects were not the result of random selection but were determined as a result of the class enrollment. Data regarding these distributions were collected at the end of the first week of the quarter. These data are presented in Chapter IV.

C. THE INSTRUCTORS

The instructors of DR 101 were not selected randomly by the researcher, but were two of four possible instructors who were assigned by the department head to teach this course. These instructors were customarily assigned by qualifications and time available or time desired by the instructor. However, arrangements were made with the head of the Engineering Graphics Department to have instructors assigned to these sections who would be interested in cooperating with the researcher. Once these instructors had been assigned, a meeting was held to discuss the researcher's needs. An explanation of the project was given in written as well as oral form (see Appendix F). Frequent meetings were held between the researcher and the instructors of the DR 101 classes.

D. EXPERTS WHO EVALUATED STUDENT PERFORMANCE

Three consulting experts were selected from the researchers professional acquaintances. They were persons currently engaged in the practice of technical engineering drawing and who formerly had had teaching experience. Criteria were established by which the judging should be done. These criteria are discussed in section G. Orientation was done orally.

E. THE EXPERIMENTAL DESIGN

Because cluster sampling was used, and the random assignment of the treatment was only to the initial group, the design in this study is a nonequivalent control group quasi-experimental design. In the design O represents a measure of performance, X represents the treatment, and R represents random assignment. The design was as follows:

R	O	X	O

	O		O

Once the initial group to receive the treatment was randomly selected, the remaining groups to be treated were selected to balance for the time of day and the day of the week. The treatment problems were given to the students at the rate of one per week from the second through the ninth weeks of the quarter.

Threats to Internal Validity

The five class sections were pretested to check for initial equivalence as recommended by Gay (1981). Using Bartlett's test for homogeneity of variance a χ^2 of .71 was computed. This χ^2 was insufficient to reject. The groups could not be judged of unequal variance, because for $P = .05$ with 66 degrees of freedom $\chi^2 = 5.991$. This was a check against differential selection of subjects, which is a threat to internal validity.

As anticipated, the mortality rate of students in the five sections of this course followed historic patterns. Initial enrollment totaled 108 students. In the past each section had served from 15 to 25 students. Section participation by students was limited by the number of drawing stations which were available in each drafting room. Two historic occurrences recurred. First, the classes were over-enrolled and second, a high number of students enrolled and then dropped in the early weeks of the quarter. This phenomenon of dropout from the class sections included dropouts from those sections in the experiment. Available data on the dropouts is presented in Chapter IV.

F. COLLECTION OF DATA

At the beginning of the quarter, with the first request for information, students were asked in writing to participate in the experiment with the option of being excluded (see Appendix B). All students agreed to participate. Demographic data were collected from participants at the end of the first week. These data described the

distribution of the characteristics of handedness, sex, and eye dominance. The students who participated received an explanation of the project at the end of the quarter (see Appendix A).

Determination of students' hemispheric dominances was made using the SOLAT test described below (see Appendix D). This information was collected in the tenth and final week of the quarter.

To facilitate obtaining a measure of each student's performance in the engineering-graphics course, the instructors made additional copies of each class-assignment drawing which the students turned in. These copies of drawings were provided to the researcher who assembled them into portfolios of individual student's work. The first drawing from each student provided the initial measure of performance used in the test for homogeneity of variance. The students' identities were concealed, and an identifying code was assigned to each student's work. The portfolios and scoring forms, upon which the portfolios were identified by codes, were provided to consulting experts (not the course instructors) who did the evaluation.

G. INSTRUMENTATION

Course Performance

Course performance was a measure of the students' performance in DR 101 or more specifically a judgment of the ability with which the students' performed the combined tasks necessary to produce a technical drawing. This performance was measured by grading the regularly assigned drawings. Copies of these were collected for the researcher

by the instructors. The first drawing which the student turned in was used as the initial measure of performance.

To insure impartiality, each portfolio of student drawings was evaluated and given a numerical grade by each of three consulting experts. The mean of the three grades was used as the measure of student performance in the course. The resulting data were continuous, interval level data. An interrater reliability test of the marks of the experts was calculated at $r = .81$.

Criteria were established by which the judging should be done. The factors which were to be considered were: line type, line weight, line quality, line placement, tangents, lettering quality, appropriate labeling, and presentation. In the grading system used, a number from one through twelve was assigned to each portfolio. The best possible score was twelve, and the worst possible score was one.

Special Problems/Treatment

Randomly selected sections of the graphics class were given special, supplemental problems which were expected to improve performance and which were thought to possibly increase right-brain activity. These problems were selected from the publications of deBono (1968, 1970), Malik (1981), McKim (1972), Polya (1957, 1962), and Raudsepp (1977, 1980). Evaluations of the problems' effectiveness in stimulating right-brain activity were solicited from E. P. Torrance and other experts of the researchers acquaintance. The problems were to be done outside of class. This avoided disturbing the normal class routine, and did not use class time which was already scheduled for drawing.

Although work on these problems was done completely outside of the regular class, solutions to the problems were systematically presented in class.

Teaching the students to obtain correct solutions to the problems was not the ultimate objective. The object was to expose them to problems which could be analyzed by right-brain function. The selected problems are attached as Appendix E.

Hemispheric Dominance

The existing dominance of each student was established using form "CC" of "Your Style of Learning and Thinking" (SOLAT). This instrument was developed by E. P. Torrance, et al. In the introduction to the associated technical manual it states,

This manual . . . has been designed and made available to facilitate future research both of these instruments and on educational problems related to the differential functioning of the right and left cerebral hemispheres . . . (Torrance, et al., 1976, p. 3).

This test was developed for "simple, straightforward self-report" usage as opposed to instruments which required individual administration and psychometric skills and training (Torrance, et al., 1976). Reliability was established using the alternate forms, test-retest methods. The procedure used is described on page 4 of the Manual. An item analysis was conducted. The way this test has been validated is described on pages 7 through 15 of the Manual. Correlation was done with the Weiten and Etaugh eye movement test, the Street "Gestalt" test, the "Something About Myself" test, the "What Kind of Person Are You?" test, the figural and verbal forms of "Torrance

Tests of Creative Thinking," Stein's "Physiognomic Cue Test," Mednick's "Remote Associates Test," and Guglielmino's "Self Directed Learning Readiness Scale." Reliability was also based upon the assumption that the testees are aware of their response styles and will report them accurately.

The form administered was a 50 item multiple-choice test which was based upon accumulated research findings concerning the specialized functions of the left and right cerebral hemispheres. It was a paper-and-pencil test which could be self-scored. The SOLAT test presented three alternative possible answers for each question: one representing the specialized function of the right cerebral hemisphere, a second representing the left hemisphere's function, and a third representing the "complementary or integrated functioning of both cerebral hemispheres" (Torrance, et al., 1976).

The testee's dominance was determined by identifying a score greater than or equal to a standard score, corresponding to the 84 percentile rank, in at most one of the three categories. The mixed category, established by Torrance, et al. (1976) was assigned when no single category score satisfied the selection criterion. A copy of SOLAT CC is included in the Appendices (see Appendix D).

Handedness

This characteristic was a self-reported item. The determining factor was the hand with which the student does drawing. In addition to "left" and "right," "ambidextrous" was also a choice on the report form (see Appendix C).

Sex

This characteristic was identified by a self-report method relying upon the integrity of the student.

Eye-dominance

A self-report method of eye dominance was selected. The method which was used to establish the dominant eye was as follows. With both eyes open the student aligned a nearby object, such as his thumb held at arm's length, with another object in the middle distance. By alternately closing left and right eyes, the student determined for which open eye the near object stayed most nearly in the same place in relation to the distant object. This determined the dominant eye (Ballou, 1982). Each student was asked to perform the above test and to report, on a form provided, his own determination of his eye dominance (see Appendix C).

H. STATISTICS

Two types of statistics were used in this study. First, descriptive statistics were used to describe the composition of the group in three stages: the original group, the experiment completers, and the experiment dropouts. Second, inferential statistics in the form of the t-tests for independent samples were used.

The t-test was selected for two reasons. The first reason was the small sample sizes. In this study 10 was the smallest sample size used for comparison and 68 was the largest. The t-test was an appropriate parametric test for small samples. The second reason

it was selected was that the comparisons of means to be made were between two independent and unequal groups. The t-test is a powerful and appropriate test for pairwise comparisons (Gay, 1981; Guilford, 1978).

A test of the assumption of homogeneity of variance was performed upon the group performance scores. This was necessary both because the numbers in different groups were unequal, and because the groups were independent (Huck, et al., 1974). This test showed that the hypothesis that the variances were equal could not be rejected at the .05 probability level.

The t-tests were actually performed using SPSS (the Statistical Package for the Social Sciences), a suite of computer programs for analyzing social science information. Statistical significance was determined at the .05 level of probability.

CHAPTER IV

FINDINGS

A. INTRODUCTION

The principal objectives of this study were: to examine some of the differences between the levels of performance in an engineering-graphics course at State Technical Institute at Knoxville of groups of students with distinct hemispheric dominances, and to determine if the addition to the regular course work of special problems (which were predetermined to be right hemispheric utilization increasers) would affect performance in a an engineering-graphics course. Another objective was to examine the factors of handedness, sex, and eye dominance in relation to course performance and hemispheric dominance. To achieve these objectives seven null hypotheses were formulated. Due to insufficient data not all the original hypotheses could be tested.

Student performance in the course was quantified by a course performance score determined by averaging three critics' numerical evaluations of each student's work. Each critic evaluated a portfolio of the collected drawings of each student's work. A scale of one to twelve inclusive was used. A high score indicated good performance, and a low score indicated poor performance.

Statistical analyses were performed to determine the effects of the independent variables, hemispheric dominance, treatment with special

problems, handedness, sex, and eye dominance upon performance. T-tests were used to decide if the research hypotheses were to be rejected. This statistical test was selected because of its power and applicability to small samples (Gay, 1981; Guilford, 1978). The Statistical Package for the Social Sciences (SPSS), a system of statistical computer programs designed to analyze social science information, was used to analyze the data. Differences were determined to be statistically significant at the .05 probability level.

This chapter presents the results of the statistical analyses. These include: (1) descriptive statistics on the experimental subjects; (2) findings related to performance and hemispheric dominance; (3) findings related to the effect of the treatment, special problems introduced into the regular class sessions; (4) findings related to performance and handedness, sex, eye dominance, and hemispheric dominance.

B. DESCRIPTIVE STATISTICS ON THE EXPERIMENTAL SUBJECTS

In the fall of 1981 108 persons enrolled in five sections of DR 101, an introductory engineering-graphics course at State Technical Institute at Knoxville. Twelve students dropped out before demographic data were collected. Thus the description of the original group applied only to the 96 persons who made it through the first week and the time of the first data collection. Of these, 22 (23 percent) were female and 74 (77 percent) were male (see Figure 1). The distribution of handedness was: 7 percent left-handed, 90 percent right-handed and

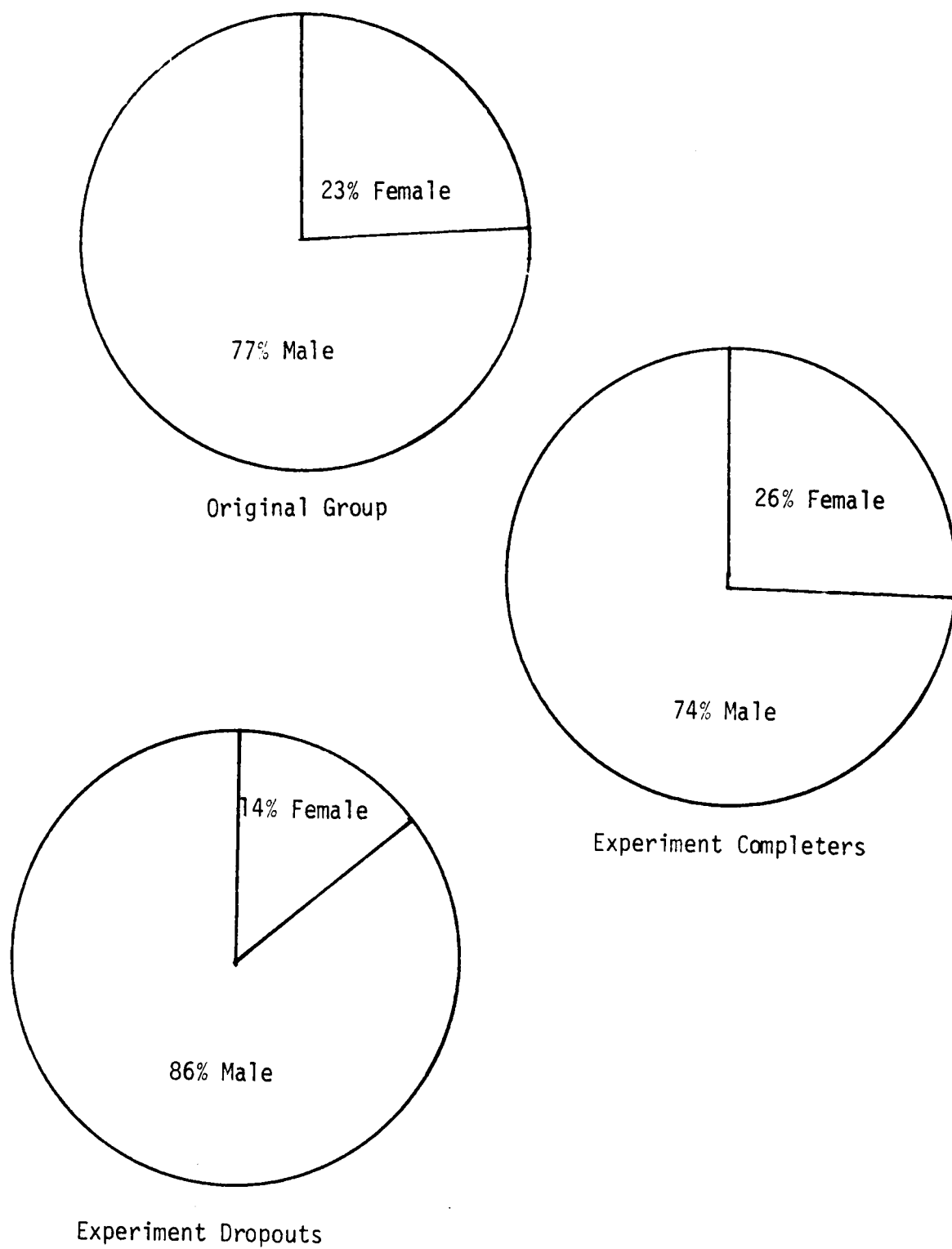


Figure 1. Sex Distribution of the Original Group, Dropouts and Experiment Completers.

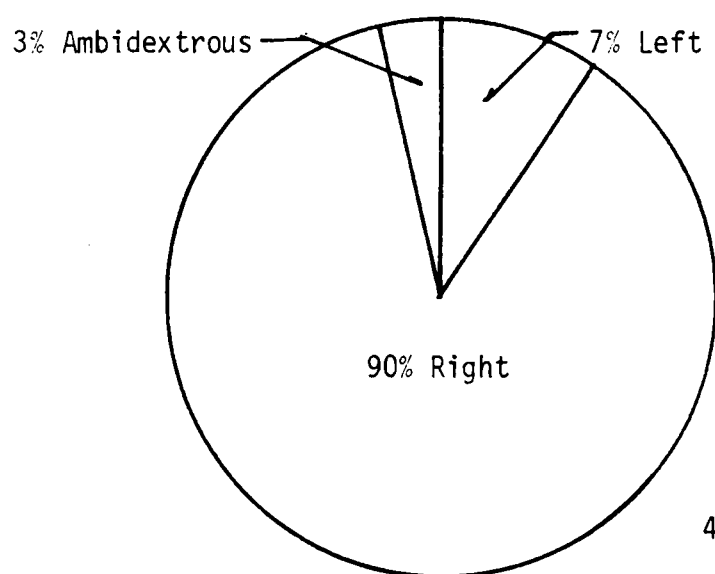
3 percent ambidextrous (see Figure 2); and the distribution for dominant eyes was: 23 percent left-eye, 54 percent right-eye and 23 percent both (see Figure 3). The majors of the students in this original group were distributed as follows: 32 percent were from Electrical Engineering Technology, 28 percent from Mechanical Engineering Technology, 2 percent from Chemical Engineering Technology, 1 percent from Construction Technology and 28 percent from Engineering-Graphics Technology (see Figure 4). One person had not decided in which subject to major. Not all of the initial group were tested for hemispheric dominance and thus the original distribution of hemispheric dominance is unknown.

Experiment Completers

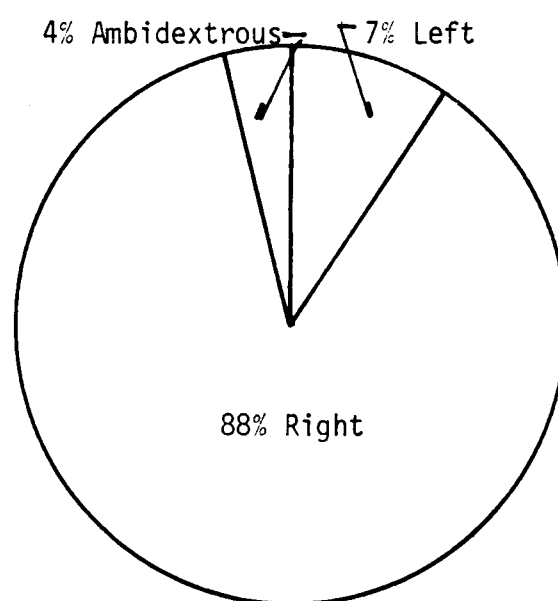
The group of 68 students who completed the project was 26 percent female and 74 percent male (see Figure 1). Seven percent were left-handed, 88 percent were right-handed and 4 percent were ambidextrous (see Figure 2). The distribution of eye dominance had become 28 percent left, 54 percent right and 18 percent both (see Figure 3). Their hemispheric dominance distribution was 8 percent left, 15 percent right and 43 percent integrated. Thirty-four percent tested mixed (see Figure 5).

Experiment Dropouts

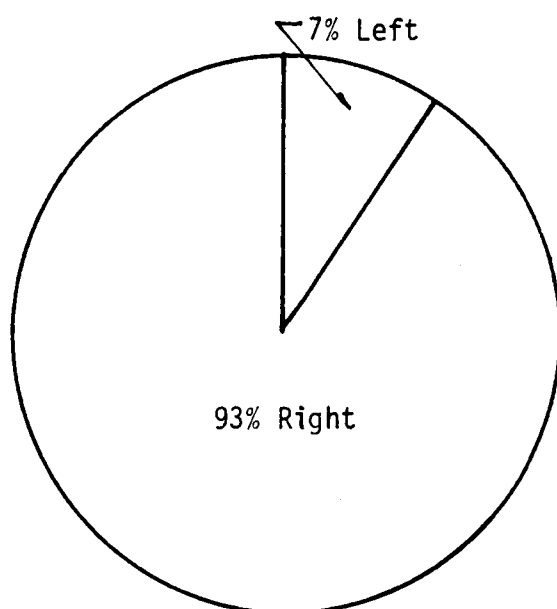
Thirty-four percent of the original group did not complete the quarter. Fourteen percent of this group were female, and 86 percent were male (see Figure 1). Seven percent were left-handed and 93 percent right-handed. No ambidextrous students dropped out (see



Original Group



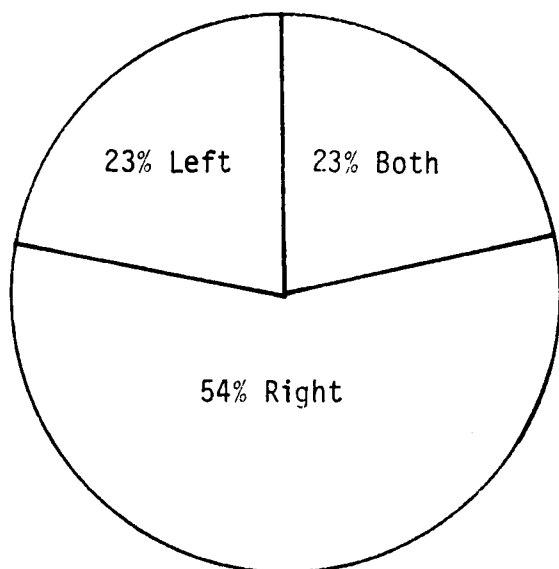
Experiment Completers



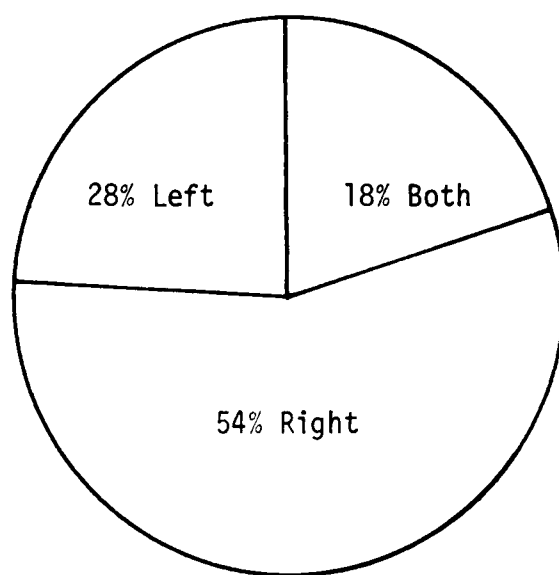
Experiment Dropouts

(No ambidextrous
students dropped)

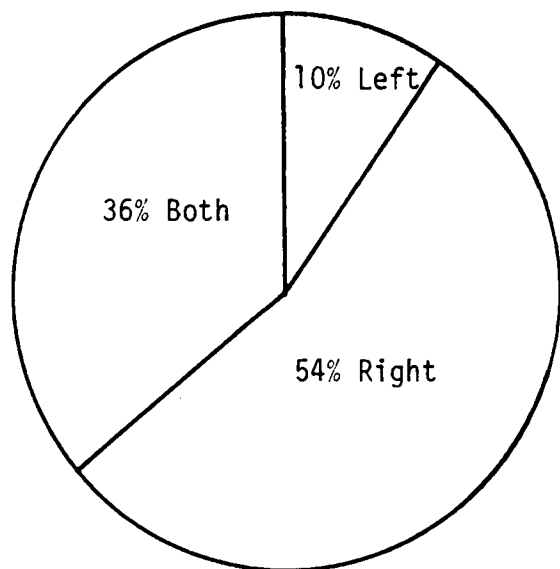
Figure 2. Handedness Distribution of the Original Group, Dropouts and Experiment Completers.



Original Group

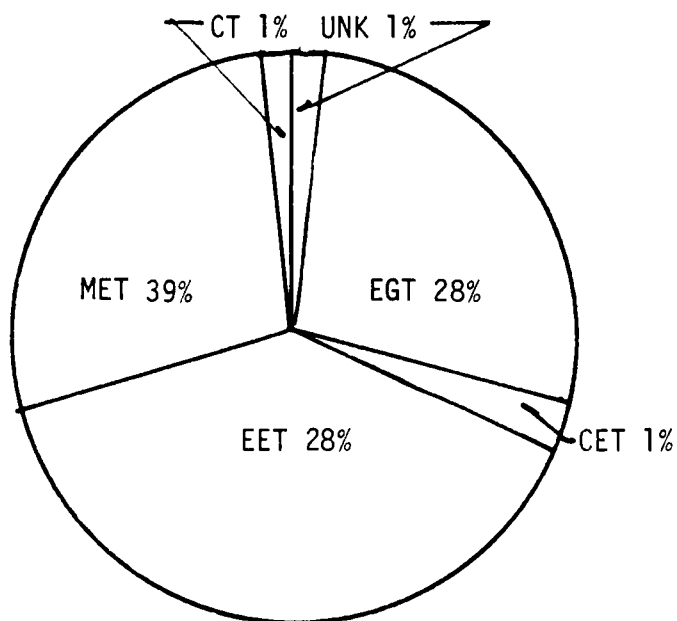


Experiment Completers



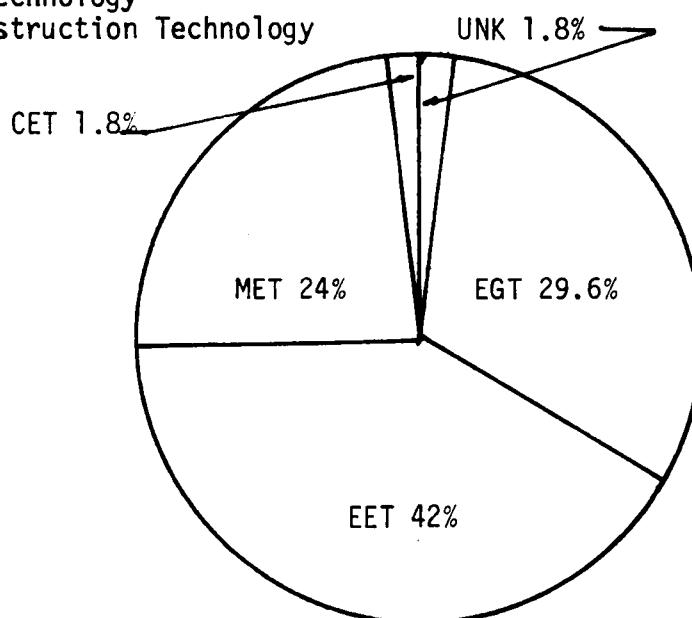
Experiment Dropouts

Figure 3. Dominant Eye Distribution of the Original Group, Dropouts, and Experiment Completers.



ORIGINAL GROUP

UNK Unknown
EGT Engineering Graphics
Technology
CET Chemical Engineering
Technology
EET Electrical Engineering
Technology
MET Mechanical Engineering
Technology
CT Construction Technology



EXPERIMENT COMPLETERS

Figure 4. Distribution of Major Subject of Original Group and Experiment Completers.

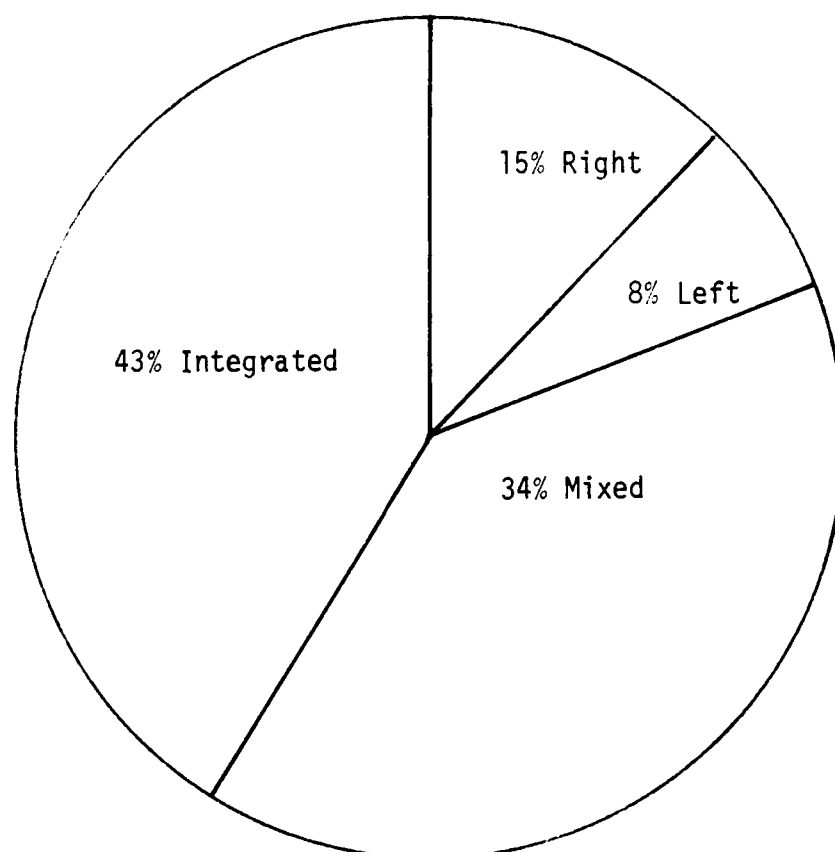


Figure 5. Hemispheric Dominance Distribution of Experiment Completers.

Figure 2). The distribution of eye dominance was 10 percent left, 54 percent right, and 36 percent both (see Figure 3).

C. FINDINGS RELATED TO PERFORMANCE AND HEMISPHERIC DOMINANCE

The predominance of students with integrated hemispheric dominance was to be expected. The course was basically a course in drawing which research has identified as a right hemispheric function. But the course was also an engineering technology course which required certain skills usually were associated with the function of the left hemisphere.

The initial three null hypotheses were related to hemispheric dominance and performance in this course.

The first of these hypotheses was as follows:

1. There is no significant difference in performance in an engineering-graphics course between left-brain dominant students and integrated-brain dominant students.

Table 1 shows the data used to test hypothesis one. The resulting value of "t" was insufficient to justify rejecting this hypothesis at the .05 level.

The second hypothesis tested was as follows:

2. There is no significant difference in performance in an engineering-graphics course between right-brain dominant students and integrated-brain dominant students.

TABLE 1

Mean Performance Scores for Students with Left
and Integrated Hemispheric Dominances

Dominant Hemisphere	Number of Students	Mean Score	Value of t
Left	6	5.83	1.60
Integrated	29	7.80	

$P.05 \geq$ a t value of 2.03 (with 33 degrees of freedom).

Table 2 shows the data used to test hypothesis two. The resulting value of "t" was not sufficient to justify rejecting this hypothesis.

TABLE 2

Mean Performance Scores for Students with Right
and Integrated Hemispheric Dominances

Dominant Hemisphere	Number of Students	Mean Score	Value of t
Right	10	7.80	0.34
Integrated	29	7.52	0.34

$P.05 \geq$ a t value of 2.03 (with 37 degrees of freedom).

The third hypothesis tested was as follows:

3. There is no significant difference in performance in an engineering-graphics course between left-brain dominant students and right-brain dominant students.

Table 3 shows the data used to test hypothesis three. The resulting "t" value was sufficient to justify rejecting this hypothesis.

TABLE 3
Mean Performance Scores for Students with Left
and Right Hemispheric Dominances

Dominant Hemisphere	Number of Students	Mean Score	Value of t
Right	10	7.80	2.36
Left	6	5.83	

$P.05 \geq$ a t value of 1.74 (with 16 degrees of freedom).

In summary, t-tests used to make pairwise comparisons between mean student performance scores in different hemispheric dominance categories revealed that statistically significant differences existed between right hemispherically dominant and left hemispherically dominant students at the .05 level. There was no statistically significant difference between the mean performance scores of right and integrated hemispherically dominant students or of left and integrated hemispherically dominant students at the .05 level. Therefore, null

hypotheses one and two could be rejected, but null hypothesis three could not be rejected at the .05 level.

The "mixed" category is not really a hemispheric dominance category. There were twenty-three students who were classified as mixed. Their mean performance score was 6.30. No students who tested as mixed had appeared in the pilot study, and no hypotheses were formulated concerning this group.

D. FINDINGS RELATED TO THE EFFECT OF INTRODUCING SPECIAL PROBLEMS

The fourth hypothesis concerned the introduction of special problems into the regular classwork. This hypothesis was stated as follows:

4. There is no significant difference in performance in an engineering-graphics course between students not receiving special problems and students receiving special problems.

Table 4 shows the data used to test hypothesis four. The resulting "t" value was not sufficient to justify rejecting this hypothesis at the .05 level.

In summary, null hypothesis four could not be rejected at the .05 level.

TABLE 4

Mean Performance Scores for Students Who Did and
Students Who Did Not Receive Special Problems

Special Problems	Number of Students	Mean Score	Value of t
Not received	33	6.67	1.66
Received	35	7.54	

$P.05 \geq$ a t value of 1.99 (with 66 degrees of freedom).

E. FINDINGS RELATED TO PERFORMANCE AND HANDEDNESS,

SEX, EYE DOMINANCE AND HEMISPHERIC DOMINANCE

Performance Related to Handedness and Hemispheric Dominance

The fifth null hypothesis concerned students' performance in relation to their handedness. This hypothesis was stated as follows:

5. When students of the same hemispheric dominance are considered, there is no significant difference in performance in an engineering-graphics course between left-handed students and right-handed students.

In this study population there were no left-handed students or ambidextrous students who tested either right-brained or left-brained. Thus, it was impossible to investigate the original hypothesis except for integrated-brain dominant students. The number of students who tested left-handed was inadequate to test with ambidextrous or right-handed students. In considering integrated-brained students

who were right-handed and ambidextrous the distribution was skewed and thus not testable.

Performance Related to Sex and Hemispheric Dominance

The sixth null hypothesis concerned the difference in performance between females and males of the same hemisphericity. This hypothesis was stated as follows:

6. When students of the same hemispheric dominance are considered, there is no significant difference in performance in an engineering-graphics course between female students and male students.

Table 5 presents the data used to test hypothesis six for integrated-brain dominant students. No female students in this study were left-brain dominant. This prevented testing hypothesis six for students in this category. There were four female and twelve male students with right-brain dominance. The data from this skewed sample is not presented.

TABLE 5
Mean Performance Scores for Female and Male Students
with Integrated-Brain Dominance

Sex	Number of Students	Mean Score	Value of t
Female	12	9.17	3.29
Male	24	6.67	

$P.05 \geq a$ t value of 2.03 (with 34 degrees of freedom).

This value of "t" was sufficient to justify rejecting hypothesis six for integrated-brained students.

When relating sex to hemispheric dominance, integrated-brain dominant females' mean performance score was statistically significantly different from that of the integrated-brain dominant males (see Table 5). There was inadequate data to show statistically significant difference between the performance of females and males when comparing right-brained or left-brained students. Thus for integrated-brained students, null hypothesis six could be rejected. Null hypothesis six could not be investigated for left-brained or right-brained students because of a lack of data.

Performance Related to Eye Dominance and Hemispheric Dominance

The seventh null hypothesis concerned the difference in performance between groups of students with distinct eye dominances but the same hemispheric dominance. This null hypothesis was stated as follows:

7. When students of the same hemispheric dominance are considered, there is no significant difference in performance in an engineering-graphics course between students whose left eye is dominant and students whose right eye is dominant.

Table 6 presents the data used to test hypothesis seven for integrated-brain dominant students. The calculated value of $t = 1.62$ was not sufficient to justify rejecting hypothesis seven for integrated-brained students.

TABLE 6

Mean Performance Scores for Left-Eyed and Right-Eyed
Students with Integrated-Brain Dominance

Dominant Eye	Number of Students	Mean Score	Value of t
Left	8	9.00	1.62
Right	14	7.36	

$P.05 \geq$ a t value of 2.09 (with 20 degrees of freedom).

When considering groups of students who were left hemispherically dominant or right hemispherically dominant there was either skewed or insufficient data to consider the left-eye and right-eye dominant categories. For integrated hemispherically dominant students, there was no statistically significant difference between the mean performance scores of left-eyed and right-eyed students. Thus null hypothesis seven could not be rejected for any hemispheric dominance category.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents a brief review of the study and conclusions based upon the findings. In addition, recommendations are made for further research and for how to use the results.

A. SUMMARY

This study was an investigation of students' performance in an engineering-graphics course and their hemisphericity. Differences between groups of students in various categories were examined in relation to their performance in an engineering-graphics class at State Technical Institute at Knoxville. These categories were defined by the following factors: hemispheric dominance, special problems added to the regular course, handedness, sex, and eye dominance. Seven research hypotheses were formulated. Because of a lack of data, not all of these hypotheses were tested.

Information was generated which would assist instructors in formulating different approaches to the teaching of engineering-graphics classes at State Tech. It had been accepted from the beginning that information from this study would not be generalizable to students outside State Tech.

The hemispheric dominance of the students was identified and comparison tests made. These tests were to determine if there were statistically significant differences in the level of performance of

students in the distinct categories. Differences were determined to be statistically significant at the .05 level. Special problems were added to the regular classwork in selected sections and their effect upon students' performance was observed. The characteristics of handedness, sex, and eye dominance were examined in relation to student performance.

The treatment, adding special problems to the regular class, did not result in improved student performance. In relation to hemispheric dominance, it was found that right-brain dominant students performed better than their left-brain dominant peers in the engineering-graphics class. Integrated-brain and right-brained students did not perform significantly differently from one another. Integrated-brain and left-brain students did not perform significantly differently from one another. No students in the pilot study had tested mixed, and no hypotheses were formulated regarding this classification.

When considering handedness within hemispheric dominance categories, statistical tests were not possible or relevant because of insufficient data. Left-brain dominant and right-brain dominant students were all right-handed, so between handedness categories only comparisons among the integrated-brain dominant students were possible. Among integrated-brain dominant students there were only two left-handed and three ambidextrous students. Tests on such small or skewed samples were not regarded as conclusive.

Considering sex by hemispheric dominance category, it was found that integrated-brain dominant females performed better than

integrated-brain dominant males. The number of right-brain dominant females and males was not sufficient to perform significant difference tests upon the data. There were no left-brain dominant females in the sample. Therefore, no comparisons could be made and no conclusions drawn regarding their performance relative to that of left-brain dominant and right-brain dominant groups.

Statistical testing for the comparison of left-eyed and right-eyed students within hemispheric dominance categories was impossible because of insufficient data. Thus no indication of significant differences in performance were included. The relevant research hypothesis did not allow for the existence of ambibismous students (those who had equal eye dominance) and no statistical tests were performed involving this group.

B. CONCLUSIONS

The conclusions of this study are as follows:

1. In this study, right-brained students performed better than left-brained students in an engineering-graphics course.
2. In this study, integrated-brain dominant females performed better than their integrated-brain dominant male peers.

C. RECOMMENDATIONS

Recommendations have been made for further research and for the use of the results of this study.

There were potentially 144 individual categories for comparison of the characteristics and their combinations used in this study. The sample for this study put data into 41 of these. The lack of data in the other categories left many questions unanswerable. A major void was the lack of left-brain dominant females which created 18 empty categories. This prevented comparisons of any group of characteristics which included this designation. Furthermore, it was only within the integrated hemispherically dominant category that there were left-handed, right-handed and ambidextrous students and even then in insufficient numbers for comparisons in all combinations.

It is recommended that the study be repeated either with a larger sample, or repeated sequentially until more cells are filled or determined unfillable. It is further recommended that for each future study, an initial determination be made of the number of cells which will be generated and of the number of students available in the sample to fill these cells; and that if the number of students in the sample is insufficient, then either the objectives of the study be redefined or a different sample be selected. It is only by filling these cells that a full picture can be obtained.

Unlike the rest of the body the eyes are not contralaterally controlled. Each eye is connected to both cerebral hemispheres. A distinction regarding the processing of material seen with each eye is made within each individual cerebral hemisphere and not solely within the contralateral hemisphere. Thus because of the eyes' unique position as windows into both hemispheres, it is difficult to correlate a dominant eye with hemispheric dominance.

A logical conclusion from this study would appear to be that eye dominance is not a good predictor of performance in an engineering-graphics class. However, it is recommended that further research into questions concerning eye and hemispheric dominance and performance in a graphics class be conducted. In particular, research hypotheses involving groups of ambibismous students should be formulated and tested.

It is recommended that right-brain oriented problems be introduced in future DR 101 classes to assist in improving student performance.

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APPENDICES

APPENDIX A

DEAR STUDENT

You are participating in a survey of the Engineering Graphics Students at the State Technical Institute, Knoxville.

The information you are providing will be used for two purposes:

1. to determine the learning styles of the students enrolled in the E. G. classes; and 2. to determine appropriate teaching methods based upon what these learning styles are.

The questionnaire attempts to determine whether the students in E. G. classes are dominant left, right or integrated-brain. Engineering Graphics is a unique field in that it appeals to both the left and right hemispheres of the human brain - the left with the technical terminology and the right with the line drawings. It is our assumption that students in this field need to develop both halves of their brain so that they can perform in their field with greater ease.

If you are interested in information about the results of your personal questionnaire, this information will be available to you by contacting Gwen Wilson at STIK. If you are interested in general information about this survey, you may attend a presentation made by Gwen Wilson to an AIDD Meeting in January. Announcement of the exact date will be made in the Technician.

(Signed)

Gwen Wilson

APPENDIX B

DEAR STUDENT

We are asking you to participate in an Information Gathering Process about the Engineering Graphics Classes at the State Technical Institute Knoxville.

If you answer the following questionnaire, you will be giving us permission to include your data in this effort. We appreciate your cooperation and assistance.

Thank you.

APPENDIX C

NAME _____ AGE _____
 MAJOR _____ Today's Date _____
 SEX _____

HANDED (left/right/both) _____
 EYED (left/right/both) _____
 FOOTED (left/right/both) _____

Have you had any previous drafting classes? (yes/no) _____

(If you answered yes, how many classes have you had?) _____

Mark through the letter best representing your answer.

Example: (a) (b) (c)

- | | | | |
|-----------------|-----------------|-----------------|-----------------|
| 1. (a) (b) (c) | 14. (a) (b) (c) | 27. (a) (b) (c) | 40. (a) (b) (c) |
| 2. (a) (b) (c) | 15. (a) (b) (c) | 28. (a) (b) (c) | 41. (a) (b) (c) |
| 3. (a) (b) (c) | 16. (a) (b) (c) | 29. (a) (b) (c) | 42. (a) (b) (c) |
| 4. (a) (b) (c) | 17. (a) (b) (c) | 30. (a) (b) (c) | 43. (a) (b) (c) |
| 5. (a) (b) (c) | 18. (a) (b) (c) | 31. (a) (b) (c) | 44. (a) (b) (c) |
| 6. (a) (b) (c) | 19. (a) (b) (c) | 32. (a) (b) (c) | 45. (a) (b) (c) |
| 7. (a) (b) (c) | 20. (a) (b) (c) | 33. (a) (b) (c) | 46. (a) (b) (c) |
| 8. (a) (b) (c) | 21. (a) (b) (c) | 34. (a) (b) (c) | 47. (a) (b) (c) |
| 9. (a) (b) (c) | 22. (a) (b) (c) | 35. (a) (b) (c) | 48. (a) (b) (c) |
| 10. (a) (b) (c) | 23. (a) (b) (c) | 36. (a) (b) (c) | 49. (a) (b) (c) |
| 11. (a) (b) (c) | 24. (a) (b) (c) | 37. (a) (b) (c) | 50. (a) (b) (c) |
| 12. (a) (b) (c) | 25. (a) (b) (c) | 38. (a) (b) (c) | |
| 13. (a) (b) (c) | 26. (a) (b) (c) | 39. (a) (b) (c) | |

APPENDIX D

YOUR STYLE OF LEARNING AND THINKING

INSTRUCTIONS: On the answer sheet provided, describe the ways you prefer to learn and think by marking through the appropriate letter on the accompanying answer sheet.

1. I prefer to have things explained to me
 - a. with words
 - b. by showing them to me
 - c. both ways.
2. I remember best
 - a. names
 - b. faces
 - c. both names and faces.
3. I prefer classes
 - a. with one assignment at a time
 - b. where I work on many things at once
 - c. both ways.
4. I prefer
 - a. multiple choice tests
 - b. essay tests
 - c. both kinds of tests.
5. I am
 - a. not good at body language, I prefer to listen to what people say
 - b. good at body language
 - c. sometimes good, but other times not good.
6. I am
 - a. not good at thinking of funny things to say and do
 - b. good at thinking of funny things to say and do
 - c. somewhat good at thinking of funny things.
7. I prefer classes
 - a. where I listen to the teacher
 - b. in which I move around and try things
 - c. where I listen and also try things.
8. I decide what I think about things
 - a. by looking at the facts
 - b. based on my experience
 - c. both ways

9. I generally solve problems
 - a. with a serious, business-like approach
 - b. with a playful approach
 - c. with both approaches.
10. I like
 - a. to use the proper materials to get jobs done
 - b. to use whatever is available to get jobs done
 - c. a little of both.
11. I like for my classes or work to be
 - a. planned so I know exactly what to do
 - b. open with opportunities for changes as I go along
 - c. both planned and open to changes.
12. I am
 - a. almost never inventive
 - b. very inventive
 - c. occasionally inventive.
13. I prefer classes when I am expected
 - a. to learn about things I can use in the future
 - b. to learn things I can use right away
 - c. both kinds of classes.
14. I
 - a. would rather not guess or play hunches
 - b. like to guess and play hunches
 - c. sometimes guess and play hunches.
15. I like to express feelings and ideas
 - a. in plain language
 - b. in poetry, song, dance, art
 - c. both ways.
16. I get insights from poetry, symbols, etc.
 - a. rarely
 - b. usually
 - c. sometimes.
17. I prefer
 - a. solving one problem at a time
 - b. working on several problems at the same time
 - c. both equally.
18. I respond more to people when
 - a. they appeal to my logical side, my intellect
 - b. they appeal to my emotional side, my feelings
 - c. equally respond to both kinds of appeal.

19. I prefer to learn
 - a. only what we can be sure of, the well established
 - b. about uncertainties, hidden possibilities
 - c. both ways.
20. I prefer
 - a. analytic reading, taking ideas apart and thinking about them separately
 - b. creative reading, putting lots of ideas together
 - c. do both.
21. I prefer
 - a. to use logic in solving problems
 - b. to use feelings and intuitions in solving problems
 - c. both equally.
22. I prefer to
 - a. analyze problems by reading and listening to teachers who know
 - b. see and imagine things when I solve problems
 - c. do both.
23. I'm very good at
 - a. explaining things with words
 - b. explaining things with hand movements and actions
 - c. both.
24. I learn best from teachers who explain with
 - a. words
 - b. movement and actions
 - c. no preference.
25. When I remember things or think about things, do so best with
 - a. words
 - b. pictures and images
 - c. both equally well.
26. I prefer to
 - a. examine something that is finished and completed
 - b. organize and complete something that is unfinished
 - c. do both.
27. I enjoy
 - a. talking and writing
 - b. drawing and handling
 - c. both.
28. I am
 - a. easily lost in finding directions
 - b. good at finding directions
 - c. not bad or really good at finding directions.

29. I am primarily
 - a. intellectual
 - b. intuitive
 - c. equally intellectual and intuitive.
30. I prefer to learn
 - a. details and specific facts
 - b. from a general overview, to look at the whole picture
 - c. from both ways equally.
31. I read for
 - a. specific details and facts
 - b. main ideas
 - c. both equally.
32. I learn and remember
 - a. only those things specifically studied
 - b. details and facts I pick up from things happening around me
 - c. have noticed no differences in these two areas.
33. I like to read
 - a. realistic stories
 - b. fantasy stories
 - c. no preference.
34. I feel it is more fun to
 - a. plan realistically
 - b. dream
 - c. both dream and plan realistically.
35. I
 - a. prefer total quiet when reading or studying
 - b. prefer music while reading or studying
 - c. listen to music only when reading for enjoyment, not if studying.
36. I would like to write
 - a. non-fiction books
 - b. fiction books
 - c. no preference.
37. If I were upset and troubled about something I would prefer
 - a. the confidentiality of individual counseling
 - b. group counseling and sharing of feelings with others
 - c. no preference for group over individual counseling.
38. I enjoy
 - a. copying and filling in details
 - b. drawing my own images and ideas
 - c. both equally.

39. It is more exciting to
 - a. improve something
 - b. invent something
 - c. both equally.
40. I prefer to learn by
 - a. examining
 - b. exploring
 - c. both ways equally.
41. I prefer
 - a. algebra
 - b. geometry
 - c. both equally.
42. I am skilled in
 - a. putting ideas into sequence or order
 - b. showing relationships among ideas
 - c. both equally.
43. I am good at remembering
 - a. verbal materials
 - b. sounds and tones
 - c. both equally.
44. I
 - a. use time to organize myself and personal activities
 - b. have difficulty in pacing activities to meet time limits
 - c. pace activities to time limits with ease.
45. I have
 - a. almost no mood changes
 - b. frequent mood changes
 - c. few mood changes.
46. I am
 - a. almost never absent minded
 - b. frequently somewhat absent minded
 - c. occasionally absent minded.
47. I am strong in recalling
 - a. verbal materials
 - b. spatial material
 - c. equal in both.
48. I enjoy
 - a. rhyming words
 - b. moving rhythmically
 - c. equal in both.

49. I prefer
- a. outlining over summarizing
 - b. summarizing over outlining
 - c. have no real preference.
50. I prefer
- a. verbal instructions
 - b. demonstrations
 - c. no real preference.

APPENDIX E

THE PROBLEM: Draw four straight lines through these nine dots without retracing and without lifting your pencil from the paper.



PEBBLE PROBLEM

Many years ago when a person who owed money could be thrown into jail, a merchant in London had the misfortune to owe a huge sum to a money-lender. The money-lender, who was old and ugly, fancied the merchant's beautiful teen-age daughter. He proposed a bargain. He said he would cancel the merchant's debt if he could have the girl instead.

Both the merchant and his daughter were horrified at the proposal. So the cunning money-lender proposed that they let Providence decide the matter. He told them that he would put a black pebble and a white pebble into an empty money-bag and then the girl would have to pick out one of the pebbles. If she chose the black pebble she would become his wife and her father's debt would be cancelled. If she chose the white pebble she would stay with her father and the debt would be cancelled. But if she refused to pick out a pebble, her father would be thrown into jail and she would starve.

Reluctantly the merchant agreed. They were standing on a pebble-strewn path in the merchant's garden as they talked and the money-lender stooped down to pick up the two pebbles. As he picked up the pebbles the girl, sharp-eyed with fright, noticed that he picked up two black pebbles and put them into the money-bag. He then asked the girl to pick out the pebble that was to decide her fate and that of her father.

Imagine that you are the girl standing on that pebble-strewn path in the garden, what will you do?

Name----- Section----- Date---

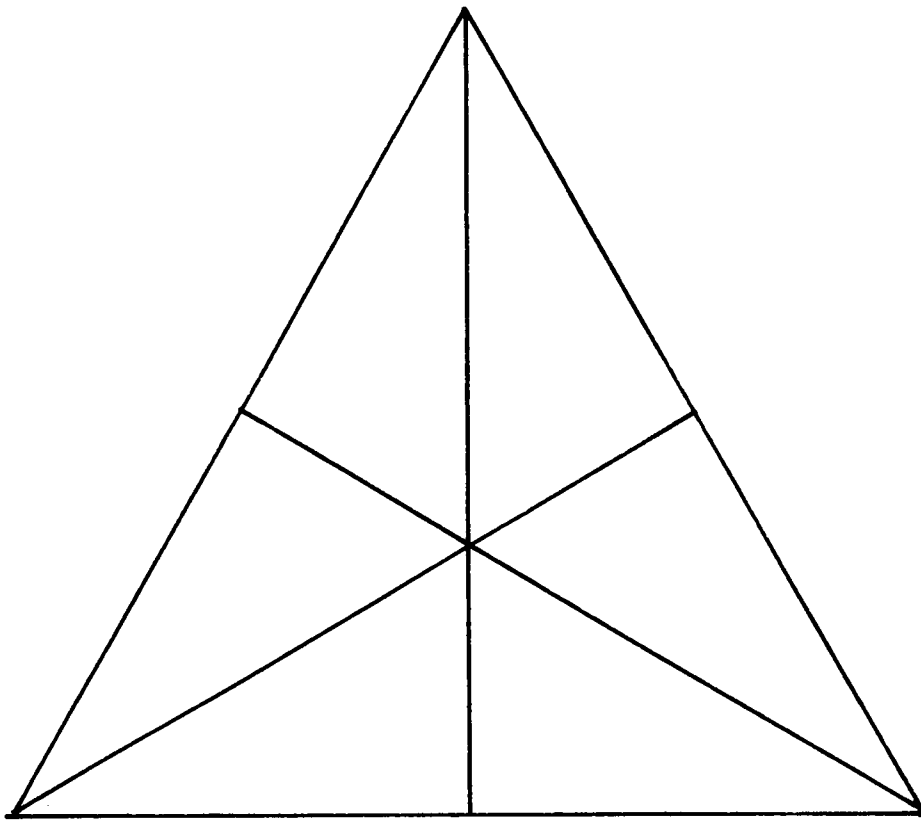
ANSWER TO THE PEBBLE PROBLEM

The girl in the pebble story put her hand into the money-bag and drew out a pebble. Without looking at it she fumbled and let it fall to the path where it was immediately lost among all the others.

"Oh, how clumsy of me," she said, "but never mind--if you look into the bag you will be able to tell which pebble I took by the color of the one that is left."

The girl is actually better off than if the money-lender had been honest and put one black and one white pebble into the bag, for then she would have had only an even chance of being saved. As it is, she is sure of remaining with her father and at the same time having his debt cancelled.

COUNT THE NUMBER OF TRIANGLES WHICH ARE REPRESENTED BELOW.

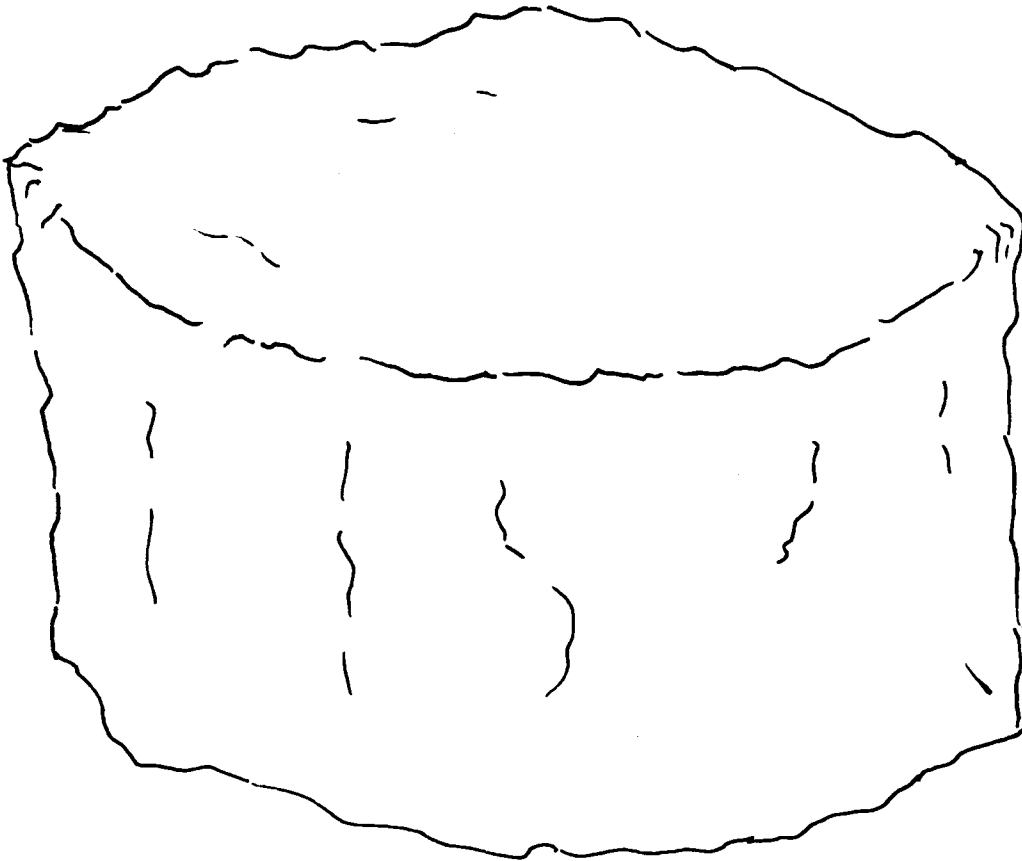


There are -----triangles.

Name----- Section----- Date----

PROBLEM NO. 3

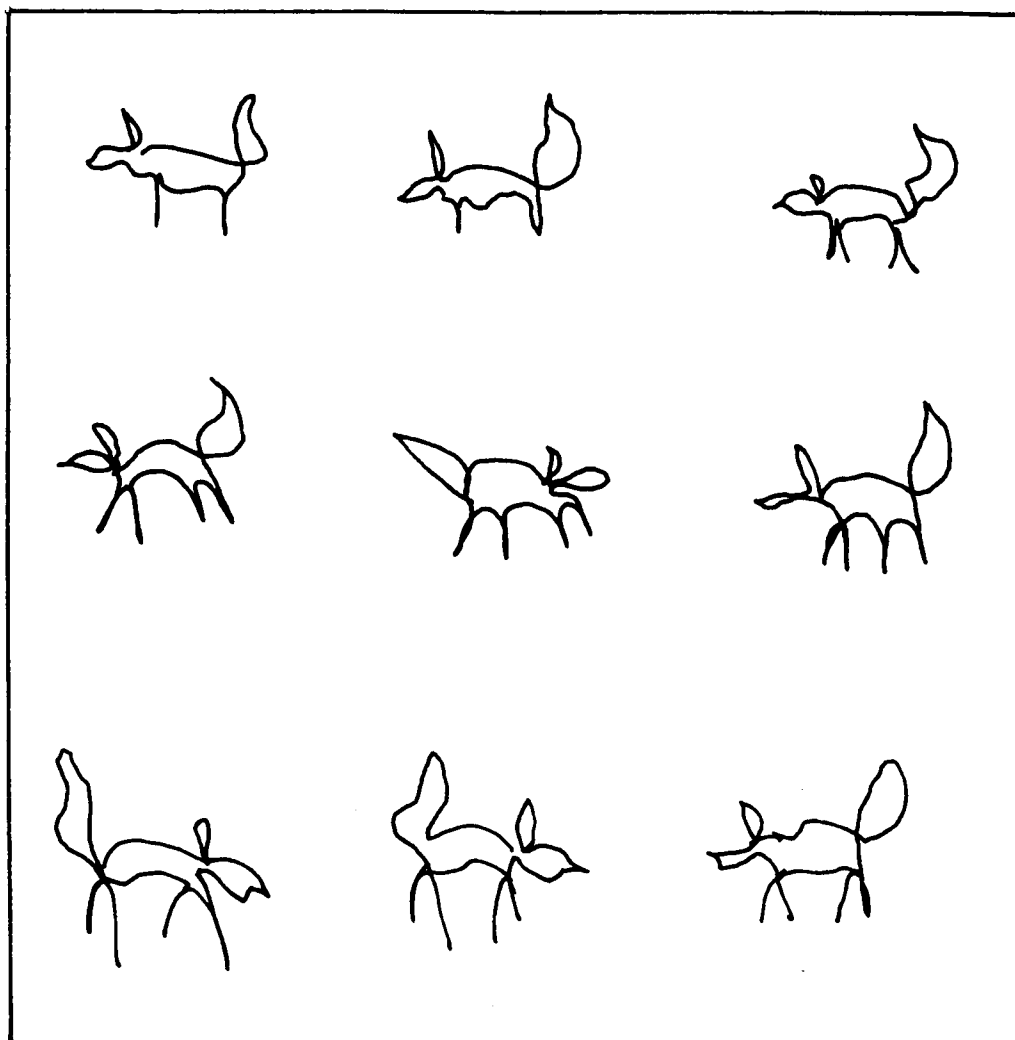
CUT THE CAKE SHOWN BELOW INTO 8 EQUAL PIECES WITH ONLY THREE CUTS.



Name----- Section----- Date----

PROBLEM NO. 4

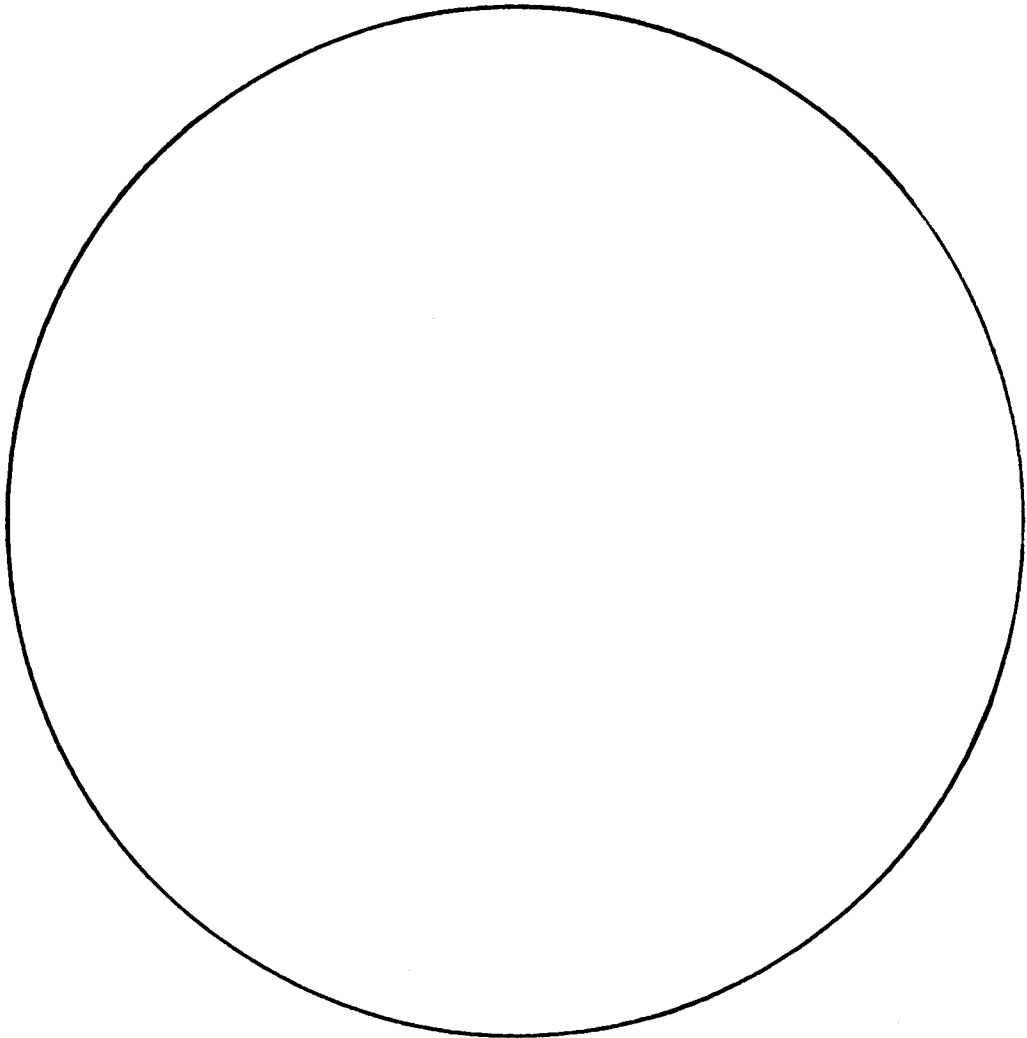
Build two more square enclosures and put each wolf in a pen by itself. Draw your solution on the drawing below.



Name----- Section----- Date-----

PROBLEM NO. 5

WHAT IS THE MAXIMUM NUMBER OF PARTS INTO WHICH A CIRCLE MAY BE
DIVIDED DRAWING FOUR STRAIGHT LINES?

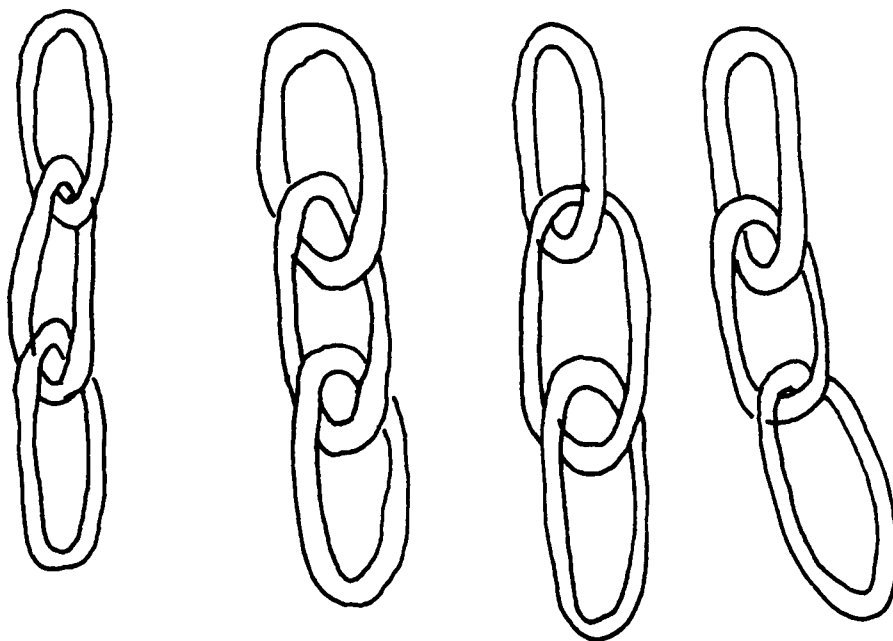


The circle can be cut into ----- sections.

Name----- Section----- Date----

PROBLEM NO. 6

You have the four pieces of gold chain shown below. Each piece has three links. You have just been told that it will cost you \$100 for each weld you make or have made. What is the least amount of money which you will have to spend to have these four pieces made into a necklace which will just slip over your head.



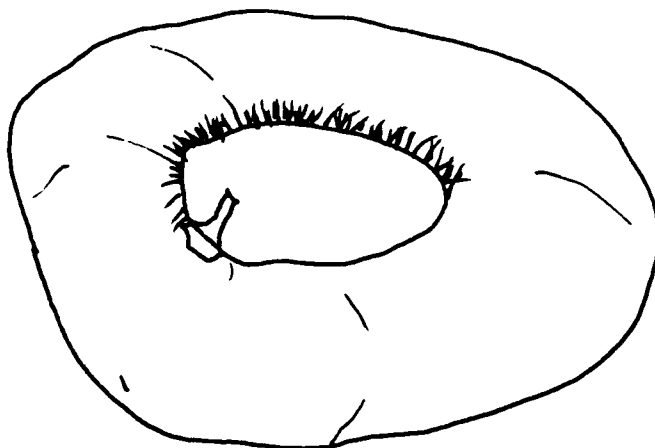
Name----- Section----- Date---

COUNT THE NUMBER OF TRIANGLES WHICH ARE REPRESENTED BELOW.

PROBLEM NO. 7

You have an innertube from an automobile. What shape would it become if you cut the valve core out and reached through the hole and pulled the innertube through the hole.

Draw the shape below.



Name----- Section----- Date---

PROBLEM. NO. 8

APPENDIX F

To DR 101 INSTRUCTORS

This is an explanation of what I am attempting to do in this experiment in which you have become involved.

In the past two years I have used the SOLAT Test and established that Engineering Graphics students are like everyone else--either left or right or integrated hemispherically dominant. I became interested in examining the relationship between engineering graphics students and hemisphericity.

To do this in a controlled fashion I needed several beginning classes so I could treat individual sections in different manners and then see if their performance is affected. This fall we have five beginning classes. This is a good number because I can divide them into groups and give three groups the problems and have two groups which do not receive the problems. I think these problems will increase right brain activity more than just the exposure to the drawing class itself. Theoretically if right brain activity increases the easier will be the act of drawing and student performance will improve.

The problems will be supplied you at the rate of one per week. Please give them to your students with instructions to work the problem and return the answers the next time the class meets. I will pick them up the following class session. To avoid students using valuable class drawing time for solving the problems, I recommend that the problems be given out at the end of the period. It is intended that no class time be used for this exercise. I know we are over-scheduled as it is.

What is under consideration is this ability of the students to perform in an Engineering Graphics class. Does the right hemisphere dominant student do better than one which is left or integrated dominant in DR101? Or will the left or integrated cerebrally dominant student perform better than the right, etc.? Because this is an area of technical information as well as one involving the art of drawing, it is possible that someone who is of integrated dominance will out-perform the other two categories of dominance. Incidentally, some correlation will be done with students' handedness and eye dominance as well. Information regarding the hemispheric dominance of the students will be gathered through the self administered SOLAT Test which we discussed. A copy of the test is attached. In addition there will be a questionnaire to gather demographic data upon the students.

What has all this to do with the copies (which I acknowledge are a pain in the neck) of the students' drawings? It was recommended (one of those kind of suggestions that you cannot refuse) that I have objectivity in the grading which could be satisfied by using three experts. So I am collecting copies of each student's work which will be bound and graded by three experts. The measure of success of each student in the course will be determined by the average of the grades given by these three.

This is my current plan. Should you have any ideas or questions, please contact me.

VITA

Gwendolyn Owens Wilson was born in Des Moines, Iowa. She was educated in the Des Moines public school system graduating from Roosevelt High School. She studied architecture at Howard University and was awarded a Bachelor's of Architecture.

After working in Washington, D.C., she moved to Knoxville and adopted Tennessee. She was employed as interim director of the Housing Research and Development Center at The University of Tennessee and taught in the School of Architecture. She started G. Wilson Designs which did energy aware architectural design for new and renovated residential buildings.

After adding teaching at State Technical Institute Knoxville to her activities, she entered The Graduate School at The University of Tennessee, Knoxville in Vocational Technical Education. She received her Doctor of Philosophy degree in Education in August 1982.

The author is a member of Tau Beta Pi, Pi Lambda Theta, Phi Delta Kappa and the American Vocational Association. Ms. Wilson was employed by Kansas State University, Manhattan, Kansas, after graduation.