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ABSTRACT

A study determined the effectiveness of computer-aided drafting (CAD) and standard drafting instruction on the ability of students with differing visual-haptic perceptual styles to solve orthographic projection problems. A 2x2x2 factorial design was chosen to compare two levels of perceptual style with two levels of treatment and two levels of prior drafting experience. Activities were administration of the Successive Perception I test to determine visual-haptic style; administration of a questionnaire regarding prior drafting experience; provision of CAD instruction to the experimental group and traditional instruction to the control group; administration of the direct measure of orthographic projection ability; and collection of plate grades. The sample consisted of 188 beginning drafting students at the University of Missouri-Columbia. Three-way univariate analyses of covariance were used to test the hypotheses. The lack of significant differences between student scores on plate grades or the unit exam grades indicated that either instructional method could be used with equal success, visual and nonvisual students benefited equally from drafting instruction, and prior drafting experience did not ensure better skills in solving orthographic projection problems. Findings implied that visual-haptic perceptual style may not affect ability to solve orthographic projection problems. (15 references) (YLB)

THE CORRELATION BETWEEN VISUAL-HAPTIC PERCEPTUAL STYLE AND STUDENT ABILITY TO SOLVE ORTHOGRAPHIC PROJECTION PROBLEMS IN A BEGINNING COLLEGE DRAFTING COURSE INCORPORATING COMPUTER AIDED DRAFTING

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INTRODUCTION

Every engineering student must know how to create and read technical drawings as a basis for self expression and professional communication (Giesecke, 1981). The importance of this skill becomes apparent with the understanding that lines and technical symbols are considered the language of engineering graphics (French & Vierck, 1978). Engineering schools recognize the importance of this ability and require students to take one or more courses of engineering graphics as a foundation for engineering and design majors. These courses are among the first that thousands of engineering students are exposed to each year (Hepler, 1957).

One of the major abilities to be learned during a basic drafting c 'rse is orthographic projection, or multiview drawing. Clark (1971) states that:

> From its inception as a school subject, orthographic projection has been taught for its practical values. The primary value claimed for the study of orthographic projection is the graphical representation of the exact shape and size of three dimensional objects on two dimensional paper. (p. 1)

The ability to think, or visualize, in three dimensions is one of the most important skills an engineer or technician can posses (Giesecke et al., 1981).

> In practice, this means the ability to study the views of an object and to form a mental picture of it--to visualize its

three-dimensional shape. To the designer it means the ability to synthesize or form a mental picture before the object even exists, and the ability to express this image in terms of views. (Giesecke et al, 1981, p. 164)

This one area of beginning drafting, visualization, appears to be the most difficult for some students to master. Visualization, as it applies to drafting, is divided into two separate, but related, tasks or skills. The first is the ability to convert from a pictorial to a multiview drawing and the second is the reverse of this process, converting from a multiview to a pictorial drawing. Some students find any visualization task extremely difficult and frustrating.

Some students receive more accurate information about the interrelationships of objects if they are provided the opportunity to handle the objects. Others, however, are just as accurate if the information they receive is visual in nature. These two groups of individuals can be identified as either visual or haptic learners (Lowenfeld, 1945). The visual learner prefers to receive information visually while the haptic learner prefers to handle objects.

Lowenfeld's studies emphasize the implications of visual-haptic perceptual style for the field of art education. One distinguishing characteristic of visually oriented subjects was their ability to retain and manipulate a mental image (Lowenfeld, 1945). It would seem entirely possible that visual learners have an easier time of converting multiview drawings to pictorial drawings than do haptic learners and could, therefore, account for some students' difficulties with these tasks.

Many times throughout the years new tools have prompted new teaching methods. For example, film strips, overhead projectors, opaque projectors, and one of the most recent, the computer, have all brought about differing instructional techniques, most of which have been adopted with little consideration being given to individual learning styles. However, perceptual style affects learning ability. Therefore, the appropriateness of these technologies must be determined for students with differing perceptual styles.

The microcomputer is capable of performing tasks that only recently required the use of a mainframe or mini-computer. This fact, coupled with decreasing costs, has prompted educators to press the microcomputer into service in ever increasing numbers.

This relatively new tool, to the field of education, brought with it new methods of teaching drafting and descriptive geometry. However, being relatively new, little scientific research has been conducted to determine the best use of computer aided drafting (CADD) as a tool in teaching beginning drafting skills.

Unresolved questions still exist relative to the effectiveness of CADD instruction. Do students acquire the ability to solve orthographic projection problems as well or better with computers? Or, is the traditional method of instruction superior for teaching the basics, reserving the computer for advanced learning and practice? Do students with differing visual-haptic perceptual styles learn skills optimally with one system over another?

PURPOSE OF THE STUDY

The purpose of this study was to ascertain the effectiveness of computer aided drafting instruction and standard drafting instruction on the ability of students, with differing visual-haptic perceptual styles, to solve orthographic projection problems. More specifically this study investigated the following questions. Do students enrolled in beginning drafting classes at the college level:

1. differ when provided traditional drafting instruction or CADD instruction in their ability to solve orthographic projection problems, as measured by plate grades, when GPA and ACT are held constant?
2. classified as visual or non-visual, perform with significant differences in solving orthographic projection problems, as measured by plate grades, when GPA and ACT are held constant?
3. with and without prior drafting experience differ in their ability to solve orthographic projection problems, as measured by plate grades, when GPA and ACT are held constant?
4. differ when provided traditional drafting instruction or CADD instruction in their ability to solve

orthographic projection problems, as measured by the unit exam grade, when GPA and ACT are held constant?

5. classified as visual or non-visual, perform with significant differences in solving orthographic projection problems, as measured by the unit exam grade, when GPA and ACT are held constant?

6. with and without prior drafting experience differ in their ability to solve orthographic projection problems, as measured by the unit exam grade, when GPA and ACT are held constant?

Additionally, the following questions were investigated relative to first order interaction effects.

7. Do perceptual style and treatment have an interaction effect on students' ability to solve orthographic projection problems as measured by plate grades?

8. Do perceptual style and experience have an interaction effect on students' ability to solve orthographic projection problems as measured by plate grades?

9. Do treatment and experience have an interaction effect on students' ability to solve orthographic projection problems as measured by plate grades?

10. Do perceptual style and treatment have an interaction effect on students' ability to solve orthographic projection problems as measured by the unit exam?

11. Do perceptual style and experience have an interaction effect on students' ability to solve orthographic projection problems as measured by the unit exam?
12. Do treatment and experience have an interaction effect on students' ability to solve orthographic projection problems as measured by the unit exam?

Finally, the questions related to secondary interactions were investigated. These questions were:

13. do perceptual style, treatment, and experience have an interaction effect on students' ability to solve orthographic projection problems as measured by plate grades?
14. do perceptual style, treatment, and experience have an interaction effect on students' ability to solve orthographic projection problems as measured by the unit exam?

IMPORTANCE OF THE STUDY

The results of this study are important in order for college educators in basic drafting courses to provide instruction which compliments students' abilities, aptitudes and perceptual styles. "It would appear that designing instruction to minimize gaps in the links between learner capabilities and task requirements is likely to be more productive than trying to alter learners' cognitive style characteristics" (F. B. Ausburn, 1979). If individual student differences are identified and instruction tailored to meet these needs, the result will be stronger, more positive educational experiences for all students.

RELATED LITERATURE

Dennis Murphy (1987), in an unpublished masters thesis, compared beginning drafting achievement of students using traditional equipment and those using CADD equipment. Murphy conducted the study with Utah State University students. He divided his subjects into two groups of 16 students each. A pretest, treatment, post-test design was then used to determine any difference in overall student achievement. Murphy concluded that no statistically significant differences exist between student achievement using either traditional equipment or CADD equipment. One study was located (Hill, 1971) that compared the effectiveness of two strategies of computer-assisted instruction for teaching orthographic projection. This study was a 3 x 2 factorial experiment comparing three levels of visual-haptic perceptual style with two levels of teaching strategy with the computer. The population sample for this study was comprised of 116 sixth grade elementary students. Conclusions drawn from this research were:

1. Tutorial strategy is more effective than linear presentation.
2. Visual students comprehend orthographic projection principles better than haptics under this type of presentation.

Design of the Study

A 2 x 2 x 2 factorial design was chosen for this research project. It compared two levels of perceptual style with two levels of treatment and two levels of prior drafting experience. The first order interactions and the second order interaction between these factors was also investigated. This design was selected because "factorial analysis of variance is the statistical method that analyzes the independent and interactive effects of two or more independent variables on a dependent variable" (Kerlinger, 1986 p. 228).

Additionally, the research project was primarily, representative in nature. Six items were listed by Borg and Gall (1983) in their discussion of representative research. They state that a representative design provides for both real-life environments and the learners' natural characteristics. Specifically this type of design should:

1. Be conducted in actual school settings.
2. Incorporate environmental variations, such as several instructors, into the design.
3. Observe the student activity, during the experiment, in order to more accurately interpret the results.
4. Note the social context, in which the experiment is taking place, in order to determine if events outside the experiment have affected it's results.
5. Prepare, in greater detail, the students for the research.

5. Utilize a control group that allows students to use the customary methods.

The posttest-only control-group design was intentionally selected for this project in order to more closely match the real-world. It was understood that unnecessary manipulation of the study's parameters could create an artificial environment. Therefore, it was decided not to use a pretest which would bias the dependent measures, due to the unique nature of the learning content. This bias would then lessen the potential for impact on teaching methods currently utilized in college drafting classes.

The one source of internal validity problems, mortality (loss of subjects) (Borg & Gall, 1983), was minimized due to the relatively short time period required to conduct the research. The following diagram illustrates, in shorthand form, the design of the study.

$$X_1 \quad O$$

$$X_2 \quad O$$

This research undertaking was also quasi-experimental, due principally to the nature of the population sample which was available. According to Campbell and Stanley (1963), any study in which it is impossible to assign subjects randomly to treatment groups is quasi-experimental. Borg and Gall (1983) state that "quasi-experiments, if carefully designed, can yield useful knowledge" (p. 680).

In summary, this research project was a quasi-experiment of the posttest-only control-group, 2 x 2 x 2 factorial design. It was also representative in nature, which helps to alleviate some of the potential external validity problems inherent in some experimental designs.

Methodology

The activities carried out in the process of this research project were:

1. Administer the Successive Perception I test in order to determine the visual-haptic perceptual style of each student.
2. Administer the questionnaire to students in order to collect data relative to their prior drafting experience.
3. Assign the experimental treatment to drafting lab groups.
4. Provide the experimental group with CADD orthographic projection instruction and the control group with traditional orthographic projection instruction.
5. Administer the direct measure of orthographic projection ability to both control and experimental groups.
6. Collect orthographic projection plate grades on each student.
7. Collect grade point averages on each student.
8. Collect Scholastic Aptitude scores on each student.
9. Tabulate and analyze the data obtained from the experiment.

10. Report findings and draw conclusions and recommendations.

Population

The population sample for this study consisted of eleven sections of Engineering Graphics students, enrolled in the Fall semester 1988, at the University of Missouri - Columbia. Students were not assigned to these sections randomly. They were somewhat self selected, and partially University selected, due to University enrollment procedures. Treatment was, however, assigned to each group at random.

One hundred and eighty-eight beginning drafting students were divided into two major groups; experimental and control. This division was: the first 6 sections (A through F) received traditional drafting instruction; the last five sections (G, H, J, K and L) received CADD instruction.

Variables

Two student response characteristics (Borg & Gall, 1983) were controlled through univariate analysis of covariance (ANCOVA) techniques. They are: GPA and SAT scores. Three independent variables; student visual-haptic perceptual style, prior drafting experience and the type of orthographic projection instruction the students received, were controlled for this experiment. These variables were divided into two levels each. Perceptual style was divided into visual and non-visual categories. Orthographic projection instruction was divided into traditional and CADD. Prior drafting was treated dichotomously due to the fact that any drafting instruction must include principles of orthographic projection. Therefore, any instruction the students received previously would include this subject.

The traditional method of instruction is to instruct students through lectures and demonstrations using traditional drafting equipment. This equipment consisted of the following: "elbow" drafting machine, 45 deg. triangle, 30/60 deg. triangle, two scales (engineer and architectural), erasing shield, two fine line lead holders (.05mm and .07mm), protractor, compass, dividers, circle template, and eraser. The drawings were graded directly from the originals.

The CADD method of instruction included lectures and demonstrations using computer drafting equipment. CADD equipment for this study was comprised of: IBM AT computer equipped with 30 meg. hard drive, Enhanced graphic adapter (EGA) card, color monitor; mouse; IBM dot matrix (ProPrinter) and a Hewlet Packard laser printer. The software available for the study was Cadkey version 3.01. Finished drawing output was from the laser printer.

Two levels of the visual-haptic perceptual style variable were used. Visuals were those students scoring 60% or more correct on the Successive Perceptions Test I. Haptics were those scoring 40% or less correct on the same test. Indefinites were those students whose scores fall between the visual and haptic definitions. The haptic classification and the indefinite classification were combined and labeled as the non-visual group. This was done because according to Lowenfeld (1939) only approximately 50% of the public can profit from visual stimuli.

The instrument chosen to determine this division was the Successive Perception Test I (SPT-1) test which was produced originally by Gibson, Gagne, and associates (1947) for use in the military. "The test has yielded research results consistent with theory-based hypotheses. In addition, SPT-1 is the only currently available instrument for assessing perceptual type for which reliability has been established empirically" (L. J. Ausburn, 1979, p. 9).

The scaling properties of this test are ordinal in nature. However, they were converted to a classification variety by imposing the artificial divisions of either visual, or non-visual as recommended by Lowenfeld (1945).

Prior drafting experience was also used as a dichotomous variable. The reason for this division is that the topic of orthographic projection will be taught early in any drafting training program. And therefore, anyone with prior training will possess instruction in this area.

The dependent variables examined were the student's ability to solve orthographic projection problems, as evidenced through plate grades, and through an instructor created examination that tested cognitive elements of the task as well.

All students were required to produce the same set of plates which were graded by teaching assistants assigned to each lab section. Two versions of the unit exam were administered by the teaching assistants and graded by the lead teacher. This approach, one of using several teachers, is a requirement in representational research (Borg and Gall, 1983).

In theory, plate grades are ratio in nature. However, if a student turns a plate in to be graded it is virtually impossible for it to receive absolutely no credit. The question exists as to whether one mistake is equivalent to another. Therefore, it is doubtful that the scores are truly interval. For these reasons it was decided to treat plate grades as ordinal in nature.

Limitations of the Study

Due to the design of the study the results are significantly limited in their applicability to situations with differing parameters. It is believed, however, that the majority of beginning engineering drawing collegiate classes are handled in essentially the same manner as those at the University of Missouri and this limitation then becomes less important.

The majority of external validity problems were, at least to a degree, nullified by the selection of a representative type of research design. Borg and Gall (1983) state that the effective use of the procedures of representational research "should increase the generalizability of findings from experiments to the real world of educational practice" (p. 645).

A major threat to the internal validity of this research project is through differential mortality of subjects. Due to the relatively short duration of the experimental treatment this concern is minimized. The other threats to internal validity, such as maturation and selection, were considered. With a treatment duration of four weeks validity problems attributable to maturation was considered to be minimal. Validity problems attributable to selection were also minimized due to the random assignment of treatments to each group.

Due to legal constraints, the subjects were aware of their involvement in a research project and this may have exhibited limiting effects on the studie's accuracy. Even though the students were not told the exact nature of the study, they most probably interacted and discussed the different methods that were used to instruct their classes; stimulating interest and an interchange of information. This interaction effect was considered and it was determined that due to the nature of the subject being studied, the ability to solve orthographic projection problems, it did not play a significant role.

The John Henry effect, that of the traditional or control group trying harder and therefore distorting the results, was considered and an attempt was made to negate it. Both groups were led to believe they were the experimental group with the hope that each would perform equally. This technique could possibly lead to a Hawthorne effect. The Hawthorne effect is a result of the experimental group performing better due to the knowledge that they are involved in an experiment and possibly just the added attention the group receives causes elevated performance. However, it is presumed that both groups were affected equally and did not distort the results.

The study was limited to students enrolled in Engineering Graphics at the University of Missouri - Columbia during the Fall semester of 1988. This sample population limits the generalizability of the findings of this study to groups that adequately match the attributes of this group.

With the post-only type of design it is difficult to determine if either treatment had any effect. It was assumed however, that over a period of time within a college class, teaching and learning take place.

Finally, the study is limited to the extent that the dependent measures do measure, accurately, what they are intended to measure. As with any test, they are limited to the extent that all of the subjects understood and performed to the best of their abilities on each question.

Treatment-field

Regular classrooms and laboratories located in the Engineering building on the University of Missouri - Columbia campus were utilized for this research project. This again, re-enforces the representative nature of the project.

Design

A three factor univariate between groups design was used for this study. A three way univariate analysis of covariance (ANCOVA) was used to test the hypotheses dealing with the first dependent variable of plate grades. Another three way analysis of covariance (ANCOVA) was used to test the hypotheses dealing with the second dependent variable of unit exam. Even though a multivariate analysis of covariance was justified on the basis of high correlation between the dependent variables, due to small cell sizes separate univariates were calculated.

The experimental paradigm for this study is illustrated in Table 1. The statistical analysis of this paradigm required that correlations be calculated with respect to both dependent measures separately. One was calculated for correlation with plate grades while the other was correlated with unit exam grades. A significance level of .05 was chosen for rejecting the null hypotheses.

Table 1

Experimental Paradigm

		Perceptual Style			
		Visual (A_1)		Non-visual (A_2)	
Experience		Y (C_1)	N (C_2)	Y (C_1)	N (C_2)
Treatment	Trad (B_1)	$A_1B_1C_1$	$A_1B_1C_2$	$A_2B_1C_1$	$A_2B_1C_2$
	CADD (B_2)	$A_1B_2C_1$	$A_1B_2C_2$	$A_2B_2C_1$	$A_2B_2C_2$

Analysis

Due to attrition and incomplete data on some students, the original population of 188 students was reduced to 136. These numbers indicate that just over 72% of the original population was available for inclusion in the following computations.

The following tables; 2, 3, 4, and 5 include the descriptive data related to this study. Table 2 lists treatment group membership. Table 3 lists perceptual style group membership. Table 4 lists prior drafting group membership. Table 5 indicates the means of the entire population sample on the covariates as well as the two dependent measures.

Table 2

Treatment group Frequency and Percent

Treat	Frequency	Percent	Cumulative Frequency	Cumulative Percent
CADD	66	48.5	66	48.5
TRAD	70	51.5	136	100.0

Note: CADD = computer aided drafting instruction; TRAD = traditional instruction

Table 3

Perceptual Style Group Membership

Group	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Visual	84	61.8	84	61.8
Non-visual	52	38.2	136	100.0

Treatment group membership was approximately equal. However, the perceptual style group membership was split approximately 62% to 38%. These tables show that statistically, this study must be treated as an unbalanced type of design.

Table 4

Prior Drafting Group Membership

Prior draft	Frequency	Percent	Cumulative Frequency	Cumulative Percent
none	63	46.3	63	46.3
experience	73	53.7	136	100.0

Table 5

Descriptive Means

Variable	Mean	Std. Dev.	Sum	Minimum	Maximum
ACT	25.2721	3.5890	3437.0000	15.0000	32.0000
GPA	2.3797	0.7783	323.6420	0.2400	3.9510
Examper	67.9044	16.0245	9235.0000	25.0000	95.0000
Plgr	81.1544	13.6934	11037.0000	19.0000	98.0000

Note. Examper = exam percentage; Plgr = plate grade.

A Pearson product moment correlation was run to determine the degree of correlation between the covariates and the dependent measures. Table 6 shows the results of that computation. It can be seen from this table that all of the variables were correlated in a positive manner. Further, all but one, plate grade and ACT, were highly significant at the .0001 level.

Table 6

Intercorrelation Table

Pearson correlation coefficients

PROB > |R| UNDER H0:RHO=0 / N = 136

	ACT	GPA	Examper	Plgr
ACT	1.0000	0.3993	0.4167	0.0844
	0.0000	0.0001	0.0001	0.3283
GPA		1.0000	0.4396	0.5328
		0.0000	0.0001	0.0001
Examper			1.0000	0.4625
			0.0000	0.0001
Plgr				1.0000
				0.0000

Note. Examper = exam percentage; Plgr = plate grade.

A univariate analysis of covariance was run on the variables using GPA and ACT as covariates. The dependent variable was the unit exam percentage.

The only significant main effect, at the .05 level, was between prior drafting experience and the unit exam grade. None of the other first order or second order effects were significant with respect to this dependent measure. Table 7 summarizes these results. GPA and ACT, the covariates, were left in the table and show their significant correlation with the unit exam grade.

Table 7

ANCOVA with GPA and ACT as Covariates: General Linear Models Procedure with the Dependent Variable of Exam Percentage

Source	DF	SS	F Value	PR > F
Vishapgp	1	13.8849	0.09	0.7661
Treatgp	1	392.9402	2.52	0.1152
Pridraft	1	4703.3839	30.12	0.0001
GPA	1	3116.3111	19.95	0.0001
ACT	1	2395.3966	15.34	0.0001
Vishapgp*Treatgp	1	0.7057	0.00	0.9465
Vishapgp*Pridraft	1	2.0189	0.01	0.9097
Treatgp*Pridraft	1	44.1591	0.28	0.5958
Vishap*Treatg*Pridra	1	10.7380	0.07	0.7936
ERROR	126	19677.1717		
CORRECTED TOTAL	135	34665.7573		

Note. Vishapgp = visual-haptic group; Treatgp = treatment group; Pridraft = prior drafting; Vishap = visual-haptic group; Treatg = treatment group; Pridra = prior drafting.

An additional univariate analysis of covariance was run on the variables using GPA and ACT as covariates. The dependent variable for this comparison was the plate grade percentages. None of the correlations were significant with respect to this dependent measure. Table 8 summarizes these results.

Table 8

ANCOVA with GPA and ACT as Covariates: General Linear Models Procedure with the Dependent Variable of Plate Grades

Source	DF	SS	F Value	PR > F
Vishapgp	1	116.1445	0.88	0.3508
Treatgp	1	99.9158	0.75	0.3867
Pridraft	1	88.2036	0.67	0.4160
GPA	1	6225.7199	47.01	0.0001
ACT	1	369.8146	2.79	0.0972
Vishapgp*Treatgp	1	40.8397	0.31	0.5797
Vishapgp*Pridraft	1	1.4678	0.01	0.9163
Treatgp*Pridraft	1	412.6702	3.12	0.0800
Vishap*Treatg*Pridra	1	371.9153	2.81	0.0963
Error	126	16687.2800		
Corrected total	135	25313.7573		

Note. Vishapgp = visual-haptic group; Treatgp = treatment group; Pridraft = prior drafting; Vishap = visual-haptic group; Treatg = treatment group; Pridra = prior drafting.

Conclusions

To the extent that the data and findings from this research endeavor are valid and representative of students enrolled in beginning college drafting classes, the following conclusions may be drawn.

Since there were no significant differences between student scores on plate grades or the unit exam grades, when instructed with either traditional or CADD orthographic projection instruction, it may be concluded that either method may be utilized with equal success. However, choosing only traditional equipment for instruction will not prepare students to perform engineering design tasks commonly accomplished on the computer.

Since there were no significant differences between student scores on plate grades or unit exam grades earned by students classified as visual and non-visual it may be concluded both groups benefit equally from drafting instruction at the college level. The student's visual-haptic perceptual style has no bearing on that students ability to profit from instruction in orthographic projection at the college level. Both groups performed equally in skill development, as measured by plate grades, and informational achievement, as measured by unit exam grades.

It was concluded that prior drafting experience does not necessarily insure better skills in solving orthographic projection problems. This may be determined since there was no statistically significant difference in plate grades between students possessing prior drafting experience and those lacking this experience. Therefore, prior drafting experience does not function well as a predictor of success in orthographic projection at the college level.

It was concluded that the ability to solve orthographic projection problems under test conditions is enhanced through prior drafting experience. This conclusion may be drawn due to the statistically significant difference between orthographic projection unit exam grades of those students with and those without prior drafting experience.

No combination of visual-haptic perceptual style, treatment, and experience was found that created statistically significant differences between group scores on plate grades or unit exam grades. Therefore, it may be concluded that, combinations of visual-haptic perceptual style, treatment, and experience do not combine to affect, either positively or negatively, students abilities in orthographic projection. Neither skill nor informational attainment are affected by a combination of these factors. It is further concluded, with this information in mind, that beginning college drafting classes are taught in such a manner as to negate any effects of these factors.

Implications and Discussion

In view of the findings and conclusions of this study, the following implications were evidenced:

Computer aided drafting and design (CADD) can be implemented into beginning college drafting classes with little concern for students' visual-haptic perceptual styles. This further implies that perceptual style, as identified in this study, is not a good predictor of the type of instruction a student may profit from. A student who is hapticaly inclined may learn just as well from traditional instruction as from CADD instruction. Unseen factors, such as motivation, may play a major part in a student's ability to profit from instruction that is not delivered in their preferred perceptual style.

Students' visual-haptic perceptual style may not affect their ability to solve orthographic projection problems at the college level. Normally orthographic projection is thought to include a great deal of visualization. Apparently, some non-visual students adapt to their environment and learn to perform this visualization task.

Visual-haptic perceptual style, treatment, and prior experience are not good predictors, either alone or in combination, of student success in beginning college drafting. Therefore, these factors should not be used to assign students to remedial or developmental types of drafting courses.

Prior drafting experience does not build skill in creating orthographic projection drawings at the college level. With the current trend toward technology education, within the nation's secondary schools, skill training is being ignored with the focus being on concepts. This means that high school graduates entering college to become engineers or technicians do not possess the basic skills of those graduates from a few years earlier. It is entirely possible that this change in focus at the high school level has already changed the types of skills students come to colleges possessing.

The total number of non-visual students in this study differed substantially from the divisions found by Lowenfeld (1945) and L. J. Ausburn (1979). They more closely matched the distributions found by Hutchinson (1981). This would imply that non-visual students do not enroll in beginning college drafting classes and possibly do not major in fields where this type of study is required. The questions raised by Hutchinson: "Does our technological bias affect perceptual type?" "Does perceptual type influence vocational preference?" "Would a heavier distribution of haptics occur in a community college setting?" (1981, p. 21) are again raised in this study.

Murphy (1987) concluded that there was no difference between student achievement using either traditional or CADD equipment. This study has shown this to be true for orthographic projection at the college level. Therefore, retention of traditional drafting equipment and it's use in instruction of basic drafting concepts is no longer required. Students can learn these concepts equally as well on the computer as they can with traditional drawing equipment.

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