DOCUMENT RESUME

ED 368 935 CE 066 246

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TITLE A Comparison of the Effectiveness between Computer Aided Drafting and the Traditional Drafting Techniques as Methods of Teaching Pictorial and Multiview Drawings.

PUB DATE [Dec 93]

NOTE 23p.; Paper presented at the American Vocational Association Convention (Nashville, TN, December 1993).

PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.

DESCRIPTORS *Computer Assisted Design; *Computer Graphics; *Drafting; Higher Education; Instructional Effectiveness; *Outcomes of Education; Teaching Methods

IDENTIFIERS *AutoCAD

ABSTRACT

A study was conducted to determine the effectiveness of teaching multiview and pictorial drawing using traditional methods and using computer-aided drafting (CAD). Research used a quasi-experimental design; subjects were 37 full- and part-time undergraduate students in industrial technology or technology education courses. The students were enrolled in two sections of the same drafting course, and both groups were pretested. The control group members were taught the traditional method of drafting, and the experimental group used AutoCAD. Performance tests administered after students had completed 7 weeks of the courses showed no significant difference in either group's ability to do multiview and pictorial drawings. The study recommended that, since CAD is as effective as traditional teaching methods and is the way of the future, this method be used in teaching drafting. (Contains 24 references.) (KC)

A Comparison of the Effectiveness Between Computer Aided Drafting and the Traditional Drafting Techniques as Methods of Teaching Pictorial and Multiview Drawings.

Ali E. Kashef

Competition in the world's markets has driven most educators and executives in educational institutions and manufacturing firms to search for greater efficiency and productivity. Therefore, the communication of engineering data is becoming increasingly crucial in the global educational and manufacturing environment. In the last twenty years, technological advances have prompted a gradual transition from a reliance on traditional drafting tools to the use of computer aided design (CAD). Today, personnel in almost every institution and industry in the western world are using more CAD in their work than in the past.

As CAD technology has become an essential part of the design process in industry and education, a debate has also arisen among the concerned trainer as to how students can learn and visualize differently with CAD than with traditional methods. Can students learn and visualize the principles and concepts of multiview and pictorial drawing skills by using a CAD system equally as well as by using traditional drafting equipment? This question should be addressed in a serious and organized manner.

This paper is a summary of research that was designed to address the question of whether or not there is a statistically significant difference between groups of students who were taught by using CAD tools and those who were taught by using traditional drafting tools. This type of study should help trainers determine the curriculum content and the most efficient method of teaching pictorial and multiview drawings.

The Problem Statement

Do students, instructed in beginning technical drafting using CAD methods, learn and visualize multiview drawings from pictorial drawings (and vice versa) as well as those who were instructed using traditional drafting methods?

Review of the Research and the Related Literature

Drawing is one of the oldest forms of communication, dating back further than verbal communication. It is a language used to communicate ideas into lines and symbols, and it has been a useful tool for understanding that which cannot be understood by the use of verbal communication. (Goetsch, Nelson & Chalk, 1989).

Showing the shape of a part is a primary purpose of graphic communication. The trainer, drafter, engineer, and designer must select the best method available to visualize and draw a part. The two basic techniques used are two-dimensional (multiview) drawing and three-dimensional (pictorial) drawing. The two-dimensional technique is known as multiview drawing. Perspective projection, oblique projection, and axonometric are three-dimensional techniques of "pictorial representation" (French, Viercik & Foster, 1986).

French, Svensen, Helsel and Urbanick (1985) indicated that visualization is the ability to see clearly what a machine, device, or other object looks like in the mind's eye. Implementation is the drawing of the object that has been visualized. These requirements, experts agree, may be learned during the study of multiview and pictorial drawings.

To create a three-dimensional (3D) drawing requires spatial visualization skill. Visualization in this context is the process of creating a 3D image of an object in a person's mind by using the evidence and clues provided by multiview drawings (two-dimensional) or other presentations. Thus, the goal of reading a multiview drawing is to visualize information about the relative positions of an object's surfaces and geometric features (Goetsch, Nelson & Chalk, 1989). It is the most effective way to describe the size and shape of a three-dimensional (pictorial drawing) object in a flat, two-dimensional drawing space by either freehand or with the aid of instruments. Each of these methods have specific merits and applications. Training in freehand work emphasizes form, speed, hand control, and appreciation of proportion. It is valuable because it allows drafters to use sketches to communicate design ideas, explain problem solutions, or suggest changes in design, construction, or production methods. Traditional working instruments may be used to formalize a high-quality, realistically detailed, and accurately proportioned record of the design. But, these tools are being replaced by CAD systems.

Duelm (1989) reported for all the differences between traditional drafting and CAD, the process of drafting still requires the technical knowledge of the drafter. A CAD system is only a tool of the draftsman, and it cannot create a drawing without human skills. CAD does not change what draftsmen do, but rather how they do it.

Mandell & Mandell (1989) reported that computers are a more efficient and effective tool to represent design graphically than the traditional tools. Hawkins (1989) stated that CAD is one of the more popular forms of computer simulation. It improves tutorials and drills through enhanced motivation, transfer of learning, and efficiency. CAD simulation has the advantages of convenience, safety, and controllability over real experience, is a good forerunner to real experiences, and is useful for giving students experiences that would not otherwise be possible.

Friedhoff & Benzon (1989) noted the claim, "computer interaction allows visualization to take off from our familiar world of objects, even to further dimensions of space. So a computer generated four-dimensional hypercube, although at first a meaningless jumble of lines, becomes a richly meaningful object as it is explored by moving it around under the control of the viewer. A fascinating question is how powerful computer graphics will ultimately enhance visual awareness and conceptual power to understand and invent" (p. 8). Fitzgerald, Lindblom, Zetterbers, and Dalton (1971) defined a hypercube as a four-dimensional object with a point-set in 4-space. Five-dimensional, or even n-dimensional objects may be described mathematically, but drawings of them are quite complicated. These communication skills require an understanding of language fundamentals and an ability to visualize in three-dimensional form. While visualizing in three dimensions can generally be learned through the study of multiview and pictorial drawings, students often have difficulty mastering this important communication skill. Because of its importance in technological society, educators continue to seek teaching methods and instructional strategies to enhance the teaching and learning of visualization.

Shumaker and Madsen (1989) indicated that three-dimensional visualization and drawing are skills that every drafter, designer, and engineer should possess. This is especially important now that with most CAD systems, it is possible to rotate a 3D model on the display screen to provide views from different angles. While the computer actually calculates the points, lines, and surfaces of the object in space, the person giving the computer information must have good 3D visualization skills.

Dimarco (1989) advised, "Stress the fundamentals, but start now to help your students think about new technology" (p. 30). Dimarco believes that CAD is here to stay and curriculums must be updated. Resetarits (1989) believes that students can learn the principles and concepts of drafting by using a CAD system equally as well as by using traditional drafting tools. Hardy (1989) indicated that CAD and traditional drafting will each serve a need and must coexist. Gorman (1990) believed that traditional drafting has effectively served drafting programs in the past and will continue to serve students in the future. This is the traditional position of some educators in that drafting is not a task or operation, but a way of thinking that thrives on change and is a central part of change. Students who understand this tradition can adapt to the changes that technology will require throughout their careers. With change a certainty for the future, it is important to teach attitudes and flexibility (whether they use a T-square and tri-angle, a keyboard, or even voice-operated equipment) rather than particular technical content. Perkins and Rivers (1991) stated that CAD has been used in diverse industries, therefore, its use is coming to be seen as a basic skill. They also reported that teachers are finding all kinds of new ways to put CAD to work in helping students conceptualize, organize, manipulate, and learn.

Giesecke, Mitchell, Spencer, Hill, Loving and Dygdon (1990) described the current connection between engineering and science and that the universal graphic language is more vital than ever before. The old days of fine-line drawing and of shading and washes are gone forever; artistic talent is no longer a prerequisite to learning the fundamentals of the graphic language. Instead, today's students must understand the fundamental principles, or the grammar of the language, and be able to execute the work with reasonable skills of penmanship.

Lewis (1990) reported that engineering drawings make heavy demands on intellectual skills, requiring a good mathematical foundation, and an ability to understand and visualize the object depicted. Not all students can do this. The combination of skills needed and the prospect of spending hour after hour sitting at a table drawing and erasing lines was not attracting students. CAD is an attractive skill for the twenty first century.

Hull & Jacobs (1992) have designated a ten step list of design processes for industry that can be used to reach the best solution to a design problem. In short, all steps directly involve using computer graphics application software.

Lowrey (1992) has reported that design, analysis, manufacturing, testing, marketing, and others involved in the product development process can work more closely together to improve the development time, cost, and quality benefits to the product. This can be achieved only by integration of computer graphic applications software such as CAD, CAM, CAE, and CIM.

In the last five years, most studies (Ross, 1989; Bertoline, 1991; Miller, 1992) have stated that computer-generated models in engineering graphics have aided in advancing students' spatial abilities. As both computer power and capabilities of software tools increase, interactive computer graphics have also become the most effective tools in visualization for engineers (Hamilton, 1990)

Those involved in the integration of CAD into the design curriculums such as engineering, technology, and related disciplines question the value of using CAD for drafting instruction. One question which needs answering is: can CAD systems be used to teach pictorial and multiview orthographic drawings as effective as traditional tools? To answer the above problem, six research questions were proposed for this research effort.

Research Questions

The purpose of This study was to contribute to an understanding of the relative effectiveness of two different methods of teaching multiview and pictorial drawing. After controlling for initial differences on the pre-test, the following questions were in this study.

1. Is there a difference in scores acquired on visualization tests that were developed to identify pictorial equivalents of given multiview drawings between students who were instructed in beginning technical drafting using CAD and those instructed using traditional drafting methods?

2. Is there a difference in scores acquired on visualization tests that were developed to identify multiview equivalents of given pictorial drawings between students who were instructed in beginning technical drafting using CAD and those instructed using traditional drafting methods?

3. Is there a difference in the amount of time required to identify pictorial equivalents of given multiview drawings on visualization tests between students who were instructed in beginning technical drafting using CAD and those instructed using traditional drafting methods?

4. Is there a difference in the amount of time required to identify multiview equivalents of given pictorial drawings on visualization tests between students who were instructed in beginning technical drafting using CAD and those instructed using traditional drafting methods?

5. What is the relationship between test scores and completion time on the pictorial to multiview visualization tests for students who were instructed using CAD and those who were instructed using traditional drafting methods?

6. What is the relationship between test scores and completion time on the multiview to pictorial visualization tests for students who were instructed using CAD and those who were instructed using traditional drafting methods?

Methods

A quasi-experimental design of the nonequivalent control group was utilized for the study (Tuckman, 1988). The procedures for quasi-experimental design are the same as for a true experimental design except that intact groups rather than randomly assigned ones are used. This created a control problem in terms of selection bias, but this problem was solved by administrating a pre-test to all subjects in each group to determine whether the two intact groups were equal as to the dependent variable at the beginning of the instructional program.

The cluster method of sampling was used to draw two sections from the three sections of technical graphics offered during the fall semester. Two intact (the subjects were not assigned randomly to treatments) groups of subjects were selected. One section was assigned randomly to a CAD (experimental) group and the other one assigned randomly to a traditional (control) group.

The subjects for this study were 37 full-and part-time undergraduate male and female students who volunteered to participate in this study in industrial technology, or technology education at Montclair State college (NJ). Students in these classes were chosen because technical graphics is a typical technical course at the college and university levels, and the study of multiview and pictorial drawings is the most important part of the course. Technical graphics at Montclair State college was a three hour course with no prerequisites. Enrollment in each of the two sections was restricted to 20 students, although one section of the two (CAD) drew only 17 during the period of this research. According to Gay (1987) a minimum of 15 subjects per group for experimental studies is sufficient and valid. In an effort to improve the external validity of the study, the same instructor with six years of teaching and three years of the industrial experience was assigned to both classes. Both groups of CAD and traditional students spent a considerable amount of time (six weeks) to learn the tools without exposing them to the concept of pictorial and multiview drawings.

A single testing instrument was developed for both the CAD and the traditional groups and validated by a panel of experts which consisted of six members: three educators, each of whom had a minimum of eight semesters of experience teaching pictorial drawing and multiview drawing; and three industry representatives with work experience in both CAD and traditional drafting. Each section was tested at the beginning of the study (seventh week) to determine whether the two intact groups were equal as to the dependent variable at the beginning of the instructional program and post-tested at the end of the study (twelfth week). The instrument consisted of two parts. The first part was designed to measure 2D (multiview drawings) to 3D (pictorial drawings) perception and the second part was designed to measure 3D to 2D perception as they related to the research questions. Each section was limited to twenty-five questions to minimize any fatigue factor that might influence test results. The content of the post-test was the same as that of the pre-test except that the questions were reordered to determine the reliability of the testing instrument. The Pearson correlation coefficients technique (Pearson's r) was used to determine the relationship and reliability of the instrument. Since no manipulation of the drawings was required, both groups were tested on paper, i.e. there were no computers used in the testing situation.

The CAD system used for the experimental group was AUTOCAD version 10 software, which provided both two-dimension and three-dimension drafting. The computer hardware included the IBM compatible XT 8088-level 8-bit machines equipped with 8087 Math Co-Processor chips, 640K of random access memory, EGA standard monitors containing 16 colors and 640 x 350 resolution, and digitizing tablets. In support of the drafting concepts and principles, both groups used the same drafting textbooks.

This research was designed to investigate differences which existed between the two groups for each test using the two components of the dependent variable performance (i.e. score and time). While there was no time limitation on the test, the time measure indicated the amount of time (in minutes) required by the students in each group to complete the test. A higher mean score for either group indicated that the students were slower (i.e: took a longer time to complete the test). Scores on the test component of the tests were computed by tabulating correct answers. The descriptive statistics and inferential statistical tests were performed. Means and standard deviations for the scores and time were presented and discussed. Results of several "t" tests conducted on the data were also documented. The data collected were analyzed using the "t" test statistical technique, in order to examine whether the differences between group means were significantly large enough to assume that the two group means were different. Data were analyzed using the "t" test, Pearson correlation coefficient and transformation of r to Fisher's Z. The "t" test was used to compare group mean scores on the test and to compare the amount of time needed to complete various parts of the test. Pearson r and Fisher's Z was used to compare the difference between two independent correlations. The level of significance was established at .05. A preliminary test on the pre-test was used to check group equivalency.

Findings

The statistical analyses applied to the data was performed. The findings of data can be categorized in three major parts:

A) Group equivalency--A pre-test, designed by the instructor and validated by a panel of experts, was given to determine the equivalency (homogeneity) of two groups. This was important in establishing the internal validity of the study because random assignment of subjects was not possible. A "t" test was performed between the mean of the two groups for score and time on the pre-test. The values of the "t" tests for determining the difference between the two groups on pre-tests for scores were -1.82, -0.93, -1.19, and -1.31. These values show that there were no significant differences between group means at the .05 probability level, indicating that the two groups were equal at the beginning of the instructional program. To reject the null hypotheses an actual "t" value of 2.031 for 35 degrees of freedom at the .05 probability level would have been required.

The values of "t" tests for the difference between the two groups on pre-tests for time scores were 0.38, -1.62, -1.21, and -1.61. These values also showed that they were not statistically significant at the .05 probability level, therefore, the registration process employed apparently formed similar groups for the experiment.

B) The Test Reliability-- The test was composed of two-parts. It was designed to measure 2D to 3D perception as well as 3D to 2D perception as they related to the research questions. The instrument was an objective, paper-and-pencil test with each part containing 25 questions. The Pearson correlation coefficient technique was used to determine the relationship and reliability of the two parts. Each part of this test was administered a total of four times. The reliability coefficients for part 1 were 0.94319, 0.88881, 0.76129, and 0.87827, and for part 2 they were 0.82990, 0.84484, 0.89783, and 0.85510. Therefore, according to Balian (1982) the reliability of part 1 and part 2 were determined to be within the "very good" range (+0.85 to +0.89).

C) Six hypotheses were tested at the .05 level of significance and none of them was rejected. There was no significant difference in score or in the amount of time required to identify pictorial equivalents of given multiview drawings on a test between students who were instructed in beginning technical drafting using CAD and those instructed using traditional drafting methods.

Research Results

Six hypotheses were tested at the .05 level of significance. The hypotheses and the summary of the results are presented.

1. HO: There was no significant difference in scores acquired on visualization tests that were developed to identify pictorial equivalents of given orthographic drawings between students who were instructed in beginning technical drafting using CAD and those instructed using traditional drafting methods.
2. HO: There was no significant difference in scores acquired on visualization tests that were developed to identify orthographic equivalents of given pictorial drawings between students who were instructed in beginning technical drafting using CAD and those instructed using traditional drafting methods.

The procedure to test the first two hypotheses involved the use of the "t" test to compare the mean on post-tests of each group in the study. The "t" values for the first hypothesis were 0.06 and -0.70, which were not statistically significant at the .05 probability level. The "t" values for the second hypotheses were -1.38 and -1.40, which also were not statistically significant at the .05 probability level.

To reject the null hypotheses, an actual "t" value of 2.031 for 35 degrees of freedom would have been required. In result, there were no significant differences in scores between the two groups on the post-tests. Therefore, the two different teaching methods, CAD and traditional, are assumed to be equally effective for teaching pictorial and multiview drawings.

3. HO:There was no significant difference in the amount of time required to identify pictorial equivalents of given multiview drawings on visualization tests between students who were instructed in beginning technical drafting using CAD and those instructed using traditional drafting methods.
4. HO:There was no significant difference in the amount of time required to identify multiview equivalents of given pictorial drawings on visualization tests between students who were instructed in beginning technical drafting using CAD and those instructed using traditional drafting methods.

The procedure to test hypotheses three and four involved the use of the "t" test to compare the mean on post-test TIME scores (time in minutes) of each group in the study. The "t" values of 1.56 and -0.04 for the third hypothesis were not statistically significant at the .05 probability level. The "t" values of 0.78 and 0.53 for the fourth hypothesis were not statistically significant at the .05 probability level.

To reject the null hypotheses, an actual "t" value of 2.031 for 35 degrees of freedom was required. In result, there were no significant differences in TIME scores between the two groups on the post-tests. Therefore, the two different teaching methods, CAD and traditional, were assumed to be equally effective for teaching pictorial and multiview drawing.

5. HO: There was no significant difference in the relationship between completion time and test scores on the pictorial to multiview visualization tests for students who were instructed using CAD and those who were instructed using traditional drafting methods.
6. HO: There was no significant difference in the relationship between completion time and test scores on the multiview to pictorial visualization tests for students who were instructed using CAD and those who were instructed using traditional drafting methods.

Correlation between time required to complete the tests and scores obtained on the tests are reported in Tables I and II. PRE1, PRE2, PRE3, and PRE4 are pre-tests for scores; TPRE1, TPRE2, TPRE3, and TPRE4 are pre-tests for times; POST1, POST2, POST3, and POST4 are post-tests for scores; and, TPOST1, TPOST2, TPOST3, TPOST4 are post-tests for times. Numbers in parentheses indicate the p values, and the others indicate the correlation coefficients.

TABLE I
CORRELATION BETWEEN TIME REQUIRED TO COMPLETE THE TEST AND SCORE OBTAINED ON THE TEST

GROUP A (TRADITIONAL)

	TPRE1	TPRE2	TPRE3	TPRE4	TPOST1	TPOST2	TPOST3	TPOST4
PRE1	0.3795 (0.099)							
PRE2		0.2318 (0.326)						
PRE3			0.1930 (0.415)					
PRE4				0.3462 (0.135)				
POST1					-0.0187 (0.938)			
POST2						0.2959 (0.205)		
POST3							-0.3215 (0.167)	
POST4								0.2888 (0.217)

GROUP B (CAD)

	TPRE1	TPRE2	TPRE3	TPRE4	TPOST1	TPOST2	TPOST3	TPOST4
PRE1	0.3729 (0.140)							
PRE2		0.3768 (0.136)						
PRE3			0.3254 (0.202)					
PRE4				0.4333 (0.082)				
POST1					-0.0832 (0.751)			
POST2						0.2393 (0.355)		
POST3							0.1860 (0.475)	
POST4								0.2024 (0.436)

As shown in Table I, none of the correlation values between time required to complete the tests and scores obtained on the tests were significant at the .05 level. To reject the null hypotheses the P value needed to be less than 0.05.

TABLE II

RESULTS OF THE DIFFERENCE BETWEEN TWO INDEPENDENT CORRELATIONS

Group		Correlation Coefficient	Z Value	P Value
PRE TEST	Traditional	0.3795	0.03	0.9760
	CAD	0.3729		
	Traditional	0.2318	-0.46	0.6456
	CAD	0.3768		
	Traditional	0.1930	-0.39	0.6966
	CAD	0.3253		
	Traditional	0.3462	-0.26	0.7948
	CAD	0.4332		
POST TEST	Traditional	-0.0187	0.17	0.0865
	CAD	-0.0831		
	Traditional	0.2959	0.18	0.8572
	CAD	0.2393		
	Traditional	-0.3215	-1.45	0.1470
	CAD	0.1860		
	Traditional	0.2888	0.27	0.7872
	CAD	0.2023		

The results of the differences between two independent correlations (CAD, Traditional) which was not statistically significant at the .05 probability level is shown in table II. A P value greater than 0.05 indicates that was no significant difference in the scores. Therefore, there was no significant difference in the relationship between completion times and test scores on the pictorial to multiview visualization tests for students who were instructed using CAD and those who were instructed using traditional drafting methods.

Conclusions

Based upon the findings of this study, and with consideration of the assumptions, limitations and delimitations, and the researcher's experience, it was concluded that multiview and pictorial concepts can be taught with CAD as well as with traditional tools.

Recommendations

Several recommendations can be made as a result of this research. They are based upon the development, execution, evaluation, and findings of this study plus the presenter's expertise.

The study should be replicated with larger samples, a longer period of learning, random assignment of subjects, and with the utilization of other powerful software packages designed for 3D such as catia, pro-engineering, etc. or with a future version of AutoCAD and a more advanced hardware. Based on the presenter's expertise, there is no doubt it is extremely important to focus on the future of CAD to bring a new dimension for learning and empower students by computer software applications. Students should use the best tool to optimum a design within a given set of parameters. Learning multiview & pictorial drawing methods on CAD systems is important to technology and engineering majors. Today's CAD systems can support 3D modeling of complex objects and assemblies, however, CAD 3D software packages are difficult to use for beginners. This may require a longer period of learning for students.

It is time for drafting trainers and educators to start helping students work, think, visualize, and draw objects in 3D with CAD systems. Drawing on CAD is an effective way to communicate and express ideas. Actually, CAD is the first stepping stone into several new technologies such as solid modeling, rendering, finite element analysis, simulation, animation, and last but not least, rapid prototyping. These systems are all being used in industry and education. Integration of CAD into a technical drafting course will prepare students for the real world challenges and cutting edge technologies. It also allows room for another course to be added to the student's major. In fact, in today's highly competitive and technical conditions, some students who do not get training on CAD systems, will not be competitive in the work place. Indeed, the use of CAD software increases productivity and helps introduce consumer products to the marketplace in a shorter period of time.

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