The comparative effects of manual drafting and computer assisted drafting on secondary students' sectional view and auxiliary view drawings

Glenn R. Smith Jr.
Rowan University

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by
Glenn R. Smith, Jr.

A Thesis
Submitted in partial fulfillment of the requirements of the Master of Arts Degree Technology Education in the Graduate Division of Rowan University
April, 1997

Approved by: Professor

Date Approved: 4/16/97
ABSTRACT

Glenn R. Smith, Jr.


1997

Thesis Advisor: Dr. Lili Levinowitz

Master of Arts: Technology Education
Graduate Division of Rowan University

The purpose of this study was to investigate the comparative effects CAD and manual drafting have on the effectiveness of teaching technical drawing techniques to secondary students. The problem of the study was to compare CAD and manual methods using the sectional view and auxiliary view techniques of Technical Drawing on second level Mechanical Drawing students.

The researcher, as the teacher, taught the concepts of the two technical drawing techniques, sectional view and auxiliary view drawings. During each section of the study, one group was assigned to complete drawings using the computer assisted drafting method and the other group used the manual tools and methods. The groups switched methods as the drawing technique changed from sectional views to auxiliary views.

An ANOVA was used to calculate data on the drawing tests, the written test, and on total time to complete drawings and the written test for the respective methods of each section. Based on the data obtained from this study, it can be concluded that both manual and CAD are acceptable methods of teaching sectional view and auxiliary view drawings.
MINI-ABSTRACT

Glenn R. Smith, Jr.


1997

Thesis Advisor: Dr. Lili Levinowitz

Master of Arts: Technology Education
Graduate Division of Rowan University

The problem investigated in this study was the comparative effects of manual drafting and computer assisted drawing on secondary students through the use of sectional and auxiliary view drawing techniques.

There is no significant difference in either the CAD or manual methods of teaching sectional view or auxiliary view drawings to secondary students.
ACKNOWLEDGEMENTS

The writer wishes to thank two people who have been a great help, support and inspiration.

Dr. Lili Levinowitz, my advisor, who encouraged, inspired, and who's teaching made Educational Research an interesting and enjoyable learning experience.

Joyce P. Smith, my wife, if it wasn't for her perseverance, inspiration, help, encouragement, and support of my goal, this project would have not been attempted let alone completed.

I thank you!
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Chapter One

Introduction

Drawing is one of the oldest forms of communication, dating back further than verbal communications. 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.  

“Drawings have been developed along two distinct lines; artistic and technical. The artistic line has artists using drawings to express aesthetic, philosophic, or other abstract ideas. The technical has people using drawings to represent the design of objects to be built or constructed.”  

This study will deal with the technical drawing.

The first written evidence of the use of technical drawing was in 30 B.C. when the Roman architect Vitruvius wrote a treatise on architecture in which he said, “The architect must be skillful with the pencil and have a knowledge of drawing so that he readily can make the drawings required to show the appearance of the work he proposes to construct.”

In order to achieve these drawings a universal graphic language is used. This language is commonly referred to as drafting. Within the drafting language there are many

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subcategories which include (but are not limited to) the following: technical sketching, mechanical drawing, engineering drawing, technical drawing, engineering graphics, descriptive geometry and computer graphics. One may see many of these terms used interchangeably with the overall term of drafting.

The basic principles of drafting are common to both traditional and computer-aided drafting. In traditional drafting, pencil skills for lettering and line weights are essential. The proper use of hand-held tools and supplies are necessary and vital to good results. Computer Aided Drafting (CAD) is an automated process that replaces drafting tables and hand-held tools. It automatically produces consistent lettering and regulates line work.\(^4\)

Over the last 20 years, CAD systems have grown steadily in use in architecture, engineering, construction and other fields. The need for skilled CAD operators is forcing changes in the drafting curriculum to include computer aided drafting. Education in drafting has been slow to follow the trend of industry due to the prohibitive cost of the equipment and software. Recently, costs have become more reasonable. Subsequently, software has become increasingly more powerful, affordable and adaptable to educational use. This has had a revolutionizing effect on the teaching of drafting. Many drafting programs may now invest in computers and software which at one time were priced out of reach.

Although the instruction of the basic principles of drafting are needed for both manual drafting and computer aided drafting, a debate is currently underway within the drafting community as to whether to concentrate solely on teaching the new computer aided drafting skills or whether a curriculum including both methods would be best.

As CAD technology has become an essential part of the design process in industry and education, a debate has also arisen among the concerned trainers as to how students

can learn and visualize differently with CAD than with traditional methods. 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.

This study will try to answer this question by teaching the principles of sectional views and auxiliary views to secondary students using manual and CAD tools.

The Problem

Can drafting techniques and skills such as section view and auxiliary view drawings be comprehended and utilized more effectively by manual or computer assisted drafting methods of training?
Chapter Two

Related Research

The Kashef Study

In 1993, Kashef investigated the effectiveness of computer aided drafting techniques versus traditional drafting techniques as a method of teaching pictorial and multiview drawings. The subjects of the study were thirty-seven full and part-time, male and female undergraduate students who volunteered to be part of the study in which they would be assigned to either the computer aided drafting or traditional drafting section in an industrial technology course at Montclair State College, New Jersey.

The entry level technical drawing course stipulated no prerequisites and focused on the study of multiview and pictorial view drawings. This class met for three hours each week. Two of three intact classes were randomly assigned to either the CAD group or the traditional drafting section of the study. One class with seventeen students was assigned to computer aided drafting and the other with twenty students was assigned to traditional drafting. The same instructor was assigned to both classes. Prior to the experimental session, each class was given time (six weeks) to learn their respective tools without exposure to the concept of pictorial and multiview drawings.

The purpose of the study was to determine the effectiveness of two different methods of teaching multiview and pictorial view drawings. The researcher had six questions in the study. They are as follows:

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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 between students who were instructed in beginning technical drafting using CAD and those instructed using traditional drafting methods?

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

A pre-test was developed and validated by a panel of experts which consisted of three educators of technical drawing and three industry representatives with work experience in both CAD and traditional drawing. The pre-test was given at the beginning of the seventh week to determine if the two intact groups were equal as to the dependent variable at the beginning of the instructional program.

The two part instrument consisted of twenty-five questions each. The first part was designed to measure two dimensional (multiview drawing) to three dimensional (pictorial drawings) perception and the second part was designed to measure three
The pre-test was given in the seventh week with a similar post test (questions were reordered) being administered at twelve weeks.

The researcher found no statistically significant mean differences for problems 1-4. That is, it was not determined that CAD technique is better than the traditional method or vice versa. The following Pearson correlation coefficients were used to determine the relationships between time to complete the test and score obtained for both the CAD and traditional classes ranged between 1.) .1930 & .3795 for the traditional drafting pretest, 2.) .3254 & .4333 on the CAD pretest, 3.) -.03215 & .2959 for the traditional drafting post test, and 4.) -.0832 & .2393 for the CAD post test. That is, little practical significance can be attributed to time to complete a drawing task and pedagogy. Therefore the two different teaching methods, CAD and traditional, were assumed to be equally effective for teaching pictorial and multiview drawing.

Comparison between the Kashef study and the present study.

The subjects in the Kashef study were college students in an introductory technical drawing course. In the present study, the subjects were secondary students in a second level mechanical drawing course proficient at not only matching multiview drawings to pictorial drawings and vice versa, but at drawing both methods of technical drawing. The Kashef study used two separate classes while the present study included one class and divided the class into two groups.

In both studies, students experienced the same instruction without regard to the tool (computer or drawing instruments) to be used as the same instructor and textbook were used for both groups.
Both studies were designed for understanding differences that could occur due to pedagogical technique. The Kashef study used a pre-test and post-test to measure correct answers and time as the factors for matching a given multi-view drawing (two dimensional) to a pictorial drawing (three dimensional) to see if the tool enables the students to better visualize an object. The present study concentrated on two techniques commonly used in Technical Drawing (sectional views and auxiliary views) to determine if the tools of the trade enabled students to better process the information that is needed. A written and drawing test on the information was used for evaluation in the present study. The Kashef study only had students visualize the different drawings and choose the correct drawing which best depicts the given view. There were no manual drafting or CAD skills involved. This type of visualization skill could and is commonly taught, at the secondary level, using simple sketching techniques.

The Becker Study

In this 1991 survey study, Becker researched the content and strategies for teaching computer aided drafting. The primary purpose of the study was to determine whether selected drafting content should be taught at the secondary level using traditional methods, computer aided methods or both methods.

The Delphi research technique was used in conducting the study. "It is a method of forecasting that uses a panel of experts within a field to gather consensus on future opportunities, and value judgment." The Delphi technique consists of a series of questionnaires. A three round Delphi was adopted and used for this study.

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The results of the study were unclear due to the following: 1) The goal of secondary drafting programs were not common, 2) Programs have little in common in both content and equipment, 3) Variations in time showed there are no general agreement on the time needed to master CAD.

The study did, however, show a need for a curriculum to be developed to teach CAD. Facilities varied so much that research is needed to establish the optimum hardware and software to teach CAD in at the secondary level.

*Comparison between the Becker study and the present study.*

The Becker study uses a survey of experts in the teaching of CAD with a focus on strategies and content of the secondary curriculum. The present study was designed to understand differences that exist between two aspects of pedagogy for a secondary mechanical drawing curriculum.

Although the study did not directly influence the present study, some very important concepts for teaching technical drawing were discussed in the Becker study and used in the present study. The following concepts are important to any technical drawing program. When teaching CAD, traditional lectures, demonstrations, discussions, and problems/practices are all effective methods of conveying the information to the students. CAD instruction should stress concepts and know-how rather than quality and motor skills. The basic components of sketching, orthographic projection, pictorial projection, and dimensioning should be taught. CAD and traditional drafting should be complementary in current drafting programs.

The Becker study and the present study both show that there is a need for CAD in the curriculum, and also needed is a standardized curriculum, hardware, software, and facilities in the secondary schools.
Chapter Three

Design and Analysis

Sample

In this study a random sampling of the mechanical drawing students at Triton Regional High School, Runnemede, New Jersey, was used. The second period class of 17 students was divided into two groups. The students were second year mechanical drawing students consisting of sophomores, juniors, and seniors, all of whom have successfully completed the level one course which included the basics of manual drafting tools and techniques. The students were from a suburban, middle class, blue-collar socioeconomic area. The ethnic make-up of the group was as follows: one student is Asian male, two are white females, the remaining 14 are white males.

Procedure

The students in a second level mechanical drawing course were required to begin the course with a review of manual orthographic projection for the month of September. An orthographic projection is a system of views of an object formed by projectors from the object perpendicular to the desired planes of projection, this is also referred to as multiview projection. This system of required views provides for the shape description of the object. During this time students completed approximately six drawings using the orthographic projection method. A written test and a drawing test was given at the end of this four week period.

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At the culmination of this review, the instructor began a tutorial demonstrating the use of the computer assisted drafting equipment and software. The first two weeks of this six week curriculum consisted of lectures and demonstrations with the only manipulations done by the student being strictly guided by the instructor. The students were introduced to program menus, the different screens, the multitude of function key operations and the various control operations. The final four weeks of instruction required the students to complete the following: 1.) six drawings on their own, 2.) written scantron type test consisting of sixty questions and 3.) a drawing test graded by the instructor culminating this section.

The second marking period, which began in early November, the students were introduced to sectional views; this is a technique of drawing internal parts clearly. The first lesson involved a discussion on the types of sections as follows: full, half, removed, revolved, broken-out, offset, and aligned. Each type of section was drawn on the board and discussed. A piece of fruit was utilized to graphically show the cutting plane and how the material is to be removed to show the internal parts. The second day started with a review of the types of section views. Multiview drawings with one view missing were distributed. The students completed the drawing. A discussion of the procedure followed. The third day reviewed and reinforced the new drawing technique. At the beginning of the fourth day, the class was randomly divided into two groups. The groups were chosen to proceed in the Manual-CAD group (1) or the CAD-Manual group (2) for the data collection section of this study. For the next four weeks, until the winter recess, group one completed the assigned section view drawings using the manual tools and technique. Group two used the computers loaded with Cadkey version 7 to complete their section drawings. During the fourth week, students were given a written test on section views. The written test for this section was a scantron test of forty questions. The test is presented in Appendix A. The following week, a drawing test consisting of
full section, half section, and an offset section was given to the students over a two day period. These drawings are presented in appendix B. The drawing test was evaluated using a point system criteria sheet. This criteria sheet presented in Appendix C. Scores from both the multiple choice test and the drawing test served as criterion scores. The completion times, in minutes, were also taken on both the written and drawing tests.

After completion of the evaluations, (early January) the assigned work continued on section views, however, Manual-CAD group (1) now used the computers and CAD-Manual group (2) used the manual tools. This allowed the students to complete section drawings using both techniques as well as reacquaint the student with the tools he/she had not been using for the past six weeks.

The next topic to be studied during the last week of January was auxiliary views. An auxiliary view is a technique used to show the true size and shape of an oblique surface. "The definition is a view obtained by a projection on any plane other than the horizontal, frontal, and profile projection planes." The first week involved the teacher discussing the classifications, explaining the definition, outlining the process of construction, and facilitating guided practice of students who sketched auxiliary views. Each sketch was constructed by the students individually, while two or three randomly selected students created the view at the board for further clarification by the teacher. The second week was the start of the individual classwork. The students were assigned six drawings to be completed on their own during class time. The Manual-CAD group (1) worked on their auxiliary views using the computer and the CAD-Manual group (2) used the manual tools to complete their drawings. At the end of the fourth week, students were given a scantron test of forty multiple choice questions on auxiliary views. This test is presented in Appendix D. The following week a drawing test.

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consisting of three auxiliary views was given. Each group completed this section of test using the equipment which they had been using. The drawing test is presented in Appendix E. The drawing test was evaluated using a point system criteria sheet. This criteria sheet is presented in Appendix F. Scores from both the multiple choice test and the drawing test served as criterion scores. Completion time, in minutes, were also taken for both tests.

After completion of the evaluations, (early March) the assigned work continued on auxiliary views, however, CAD-Manual group (2) now used the computers and Manual-CAD group (1) used the manual tools. This allowed the students to complete auxiliary drawings using both techniques as well as reacquaint the student with the tools he/she had not been using for the past six weeks.

The criterion measure sheets used to grade the drawing tests was validated by a panel of experts. The experts consisted of a college professor and three technology teachers all of whom have taught section views and auxiliary views.

The judges for both drawing sections consisted of two Technology teachers and the researcher, all of whom have experience in teaching Technical Drawing. Before the judges started the judging, the researcher reviewed the drawings and explained the criterion measure sheet with both judges. During the judging, each student drawing was compared to a perfect example, Appendix G, prepared by the instructor. The instructor also modified the criterion measure sheet by marking the areas not applicable to each drawing. The judging averaged one hour per judge to complete.

During the manual drawing portion of the study students used a 24"x 24" drawing board, 24" T-square, 30-60 triangle, 45 triangle, flat scale, 5mm leadholders, compass, eraser, eraser shield, brush, French curves, and 11" x 17" vellum. The CAD section had students using CADKEY version 7.02 software, 486 PC, 33mhz, 16MB ram CPU, super VGA monitors, and a three button mouse. Output was on 11" x 17" white plotter paper printed from a Hewlett Packard 300XL Paintjet printer.
Analysis

An interjudge reliability was calculated using a Pearson-Product moment correlation coefficient. A least squares one way analysis of variance was used to determine differences existing in these two one-dimensional designs for differences; one for the multiple choice test and one for the drawing test.
Chapter 4
Results & Interpretations

Sectional Views.

Interjudge Reliabilities. Interjudge reliabilities among the three judges for each drawing for sectional views are presented in Table 1. Those interjudge reliabilities range between .733 - .927. Overall, there is substantial agreement among all three judges but in particular between judges 2 & 3.

Table 1
Interjudge Reliabilities of Sectional View Drawings

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<tr>
<th>Drawing Test 1</th>
<th>Judge 1</th>
<th>Judge 2</th>
</tr>
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<tbody>
<tr>
<td>Judge 2</td>
<td>0.843</td>
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<tr>
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<td>0.873</td>
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<td>Judge 3</td>
<td>0.733</td>
<td>0.899</td>
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<td>Judge 3</td>
<td>0.828</td>
<td>0.927</td>
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Summary of the Analysis of Variance

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<td>225.540</td>
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Drawings Sectional Views. Means, Standard Deviations, and ANOVA summary data for Sectional view drawings are presented in Table 2. The researcher failed to find a
statistically significant mean difference between the CAD and manual groups. The observed mean for the CAD group, however, was higher than the mean for the manual group.

Table 2
Means, Standard Deviation, and ANOVA Summary for Students Sectional View Drawings

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<td>100.444</td>
<td>14.196</td>
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<tr>
<td>Manual</td>
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<td>95.875</td>
<td>1.905</td>
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Summary of the Analysis of Variance

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<td>Error</td>
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<td>1838.800</td>
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Written Test Sectional Views. Means, Standard Deviations, and ANOVA Summary for Sectional View Written test are presented in Table 3. The researcher failed to find statistically significant mean difference between the CAD and manual groups.

Table 3
Means, Standard Deviation, and ANOVA Summary for Students Sectional View Written Test.

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Summary of the Analysis of Variance

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<td>Error</td>
<td>313.500</td>
<td>15</td>
<td>20.900</td>
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</table>

Total Time to Complete Sectional View Drawings and Test. Means, Standard Deviations, and ANOVA Summary data for the Sectional View Written test is presented in Table 4. The researcher found a statistically significant mean difference between the amount of time needed to complete the drawings and test for the CAD and manual groups. The manual group took less total time to complete the drawings and test.

Table 4
Means, Standard Deviation, and ANOVA Summary for Students Sectional View Total Time to complete drawings and test.

<table>
<thead>
<tr>
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<td>35.095</td>
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<tr>
<td>Manual</td>
<td>8</td>
<td>88.226</td>
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Summary of the Analysis of Variance

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<td>758.136</td>
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*p<.05

Auxiliary Views.

Interjudge Reliabilities. Interjudge reliabilities among the three judges for each drawing for auxiliary views are presented in Table 5. Those interjudge reliabilities range between .860 and .986. Overall, there is substantial agreement among all three judges but in particular between judges 2 & 3.
Interjudge Reliabilities of Auxiliary View Drawings

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<th>Judge 2</th>
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<tr>
<td>Judge 3</td>
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<td>0.942</td>
<td></td>
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<tr>
<td>Judge 3</td>
<td>0.945</td>
<td>0.986</td>
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</table>

<table>
<thead>
<tr>
<th>Drawing Test 3</th>
<th>Judge 1</th>
<th>Judge 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judge 2</td>
<td>0.916</td>
<td></td>
</tr>
<tr>
<td>Judge 3</td>
<td>0.912</td>
<td>0.85</td>
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</table>

Summary of the Analysis of Variance

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<tr>
<th></th>
<th>SS</th>
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<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>88.432</td>
<td>1</td>
<td>88.432</td>
<td>0.392 a.s.</td>
</tr>
<tr>
<td>Error</td>
<td>3383.097</td>
<td>15</td>
<td>225.54</td>
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</tbody>
</table>

Drawings Auxiliary Views. Means, Standard Deviation, and ANOVA summary data for Auxiliary view drawings are presented in Table 6. The researcher failed to find a statistically significant mean difference between the CAD and manual groups. The observed mean for the manual group, however, was higher than the mean for the CAD group.

Table 6
Means, Standard Deviation, and ANOVA Summary for Students Auxiliary View Drawings

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD</td>
<td>8</td>
<td>85.5</td>
<td>48.125</td>
</tr>
<tr>
<td>Manual</td>
<td>9</td>
<td>117</td>
<td>37.699</td>
</tr>
</tbody>
</table>
Summary of the Analysis of Variance

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1957.765</td>
<td>1</td>
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<td>1.065 n.s.</td>
</tr>
<tr>
<td>Error</td>
<td>27582</td>
<td>15</td>
<td>1838.8</td>
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</tr>
</tbody>
</table>

Written Test Auxiliary Views. Means, Standard Deviations, and ANOVA Summary data for Auxiliary View Written test is presented in Table 7. The researcher failed to find statistically significant mean difference between the CAD and manual groups.

Table 7
Means, Standard Deviation, and ANOVA Summary for Students Auxiliary View Written Test.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD</td>
<td>8</td>
<td>29.125</td>
<td>4.086</td>
</tr>
<tr>
<td>Manual</td>
<td>9</td>
<td>28.444</td>
<td>3.005</td>
</tr>
</tbody>
</table>

Summary of the Analysis of Variance

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>DF</th>
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<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>1.962</td>
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<td>0.156 n.s.</td>
</tr>
<tr>
<td>Error</td>
<td>189.097</td>
<td>15</td>
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<td></td>
</tr>
</tbody>
</table>

Total Time to Complete Drawings and Test Auxiliary Views. Means, Standard Deviations, and ANOVA Summary data for Auxiliary View Drawings and Written test is presented in Table 8. The researcher failed to find a statistically significant mean difference between the CAD and manual groups.
Table 8
Means, Standard Deviation, and ANOVA Summary
for Students Auxiliary View Total Completion Time for Drawings and Written Test.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD</td>
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<td>13.475</td>
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<tr>
<td>Manual</td>
<td>9</td>
<td>14.494</td>
<td>3.400</td>
</tr>
</tbody>
</table>

Summary of the Analysis of Variance

<table>
<thead>
<tr>
<th></th>
<th>SS</th>
<th>DF</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
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<td>1</td>
<td>4.402</td>
<td>566 n.s.</td>
</tr>
<tr>
<td>Error</td>
<td>116.742</td>
<td>15</td>
<td>7.783</td>
<td></td>
</tr>
</tbody>
</table>

Interpretation

Interjudge reliabilities were high for both the Sectional Drawings and Auxiliary Drawings. The Sectional View interjudge reliabilities had an overall lower range (0.733 to 0.927), than the Auxiliary View interjudge reliabilities (0.860 to 0.936). Therefore, the criterion measure which was created and used looks to be a good instrument for the judging of these drawings. Judges two and three rated the drawings in both sections with similar ratings. This may be due to the fact that judges two and three are currently teaching the first two levels of Mechanical Drawing at Triton High School and that judge one has not taught Mechanical Drawing for at least two years.

The researcher failed to find a mean difference which was statistically significant in the drawing tests for sectional views and auxiliary views, although, the researcher noticed that the same group of students had higher means scores in both drawing tests. The
researcher feels these data indicate that either method, CAD or manual, is an effective method of teaching technical drawing.

The researcher did detect mean differences that were statistically significant in the amount of total time required to complete the drawings and test in the sectional view section of the study. The time was noted as to the time required to complete the drawing and test only. The time needed to print out a hard copy of each drawing was not included for the CAD drawings, due to the researcher only having one printer. The time required to setup the computer to the printer and create a hard copy output was six minutes per drawing. If this time was added to both the sectional views and auxiliary view drawings, the time required to complete each drawing would have been overwhelmingly in favor of the manual method.

For both drawing analyses, the researcher detected mean differences that were not statistically significant, that could be because the number of students in the experiment were few, hence contributing to the possibility of a type II error.
Chapter 5

Summary and Conclusions

The Problem

Can drafting techniques and skills such as section view and auxiliary view drawings be comprehended and utilized more effectively by manual or computer assisted drafting methods of training?

Design and Analysis

The sample used for this investigation consisted of the second level Mechanical Drawing class at Triton Regional High School, Runnemede, New Jersey. The second period class of 17 students was randomly divided into two groups. The students were sophomores, juniors, and seniors, all of whom have successfully completed the level one course which included the basics of manual drafting tools and techniques. The student population is primarily white, middle social-economic level.

The researcher, as the teacher, taught the concepts of the two technical drawing techniques, sectional view and auxiliary view drawings. During each section of the study one group was assigned to complete drawings using the computer assisted drafting method and the other group used the manual tools and techniques. The groups switched methods as the drawing technique changed from sectional view to auxiliary view. Each group was also given the opportunity to use the CAD or manual method for a week after the testing was completed for the technique (sectional or auxiliary) being investigated.

Testing for each technique consisted of a written scantron test and a drawing test which had students complete three missing view style drawings. Completion times were
recorded for written and each drawing test. The researcher designed a criterion measure which was validated by four professionals who teach Technical Drawing. The criterion measure was used by three judges, the researcher and two other Technology teachers at the school. The judges were trained and provided correct examples of each drawing. The combined ratings of the three judges for each technique served as the measure for the data in the drawing section. The students raw score was used for the written scantron test. A Pearson correlation was calculated on each of the techniques to determine the interjudge reliability for the criterion measure. An ANOVA was calculated for the written test, drawing tests, and completion times of each drawing technique to compare the differences between the CAD and manual drawing methods.

Results

Interjudge reliabilities for both the sectional view and auxiliary view drawings were very reliable the scores ranged between .733-.927 and .860-.986, respectively. Only the ANOVA for total time was found to be statistically significant. The other five designs revealed that there is no difference between manual and CAD methods of pedagogy for teaching second year technical drawing students.

Conclusions and Recommendations

Based on the data obtained from this study, it can be concluded that both manual and CAD are acceptable methods of teaching sectional view and auxiliary view drawings. The researcher also concludes that the time needed to complete a CAD drawing will take longer, however, drawings may be revised at a much faster rate.

Typically technical drawing courses assign a drawing which is completed by the student and then graded by the teacher. Unfortunately, the student moves on to the next drawing is never given the opportunity to make the revisions to the drawing for a sense of
completion, due to the time constraints of the curriculum. The CAD method would allow the student to load the saved drawing, make the revisions quickly, and achieve a sense of closure for each drawing.

All research points toward the use of CAD for the future. Aerospace engineering and designers who have historically been one of the first to use computers as a design tool have currently created the new Boeing 777 widebody jetliner totally using CAD. The program called CATIA (Computer Aided Three Dimensional Interactive Application) not only allows designers to create the parts in CAD but CATIA also allows the parts to be assembled within the computer by a computer generated humanoid figure.10

Future studies should not dwell on whether manual or CAD should be used but on how to better utilize the CAD software and equipment we have now so we can better understand how CAD of the future can be implemented to better our society.

Section Views

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
</table>
| 1. Section views are the method of showing internal parts?              | a. with hidden lines  
b. clearly  
c. together                  |
| 2. Section lines are?                                                   | a. Thick dark lines  
b. Thin dark lines  
c. Medium thin lines       |
| 3. Cutting plane lines are?                                             | a. Thick dark lines  
b. Thin dark lines  
c. Medium thin lines       |
| 4. A section view which shows a quarter of the object removed.          | a. Removed section  
b. Full section  
c. Half section             |
| 5. Arrowheads on the cutting plane line indicate                        | a. the section lines.  
b. the view of the hidden lines.  
c. the way you view the object. |
| 6. Section lines should be drawn                                       | a. parallel.  
b. perpendicular.  
c. horizontal or vertical. |
| 7. The computer refers to section lines as                              | a. X-hatch  
b. X-crossing  
c. X-view                       |
| 8. The most common spacing of a section line is                         | a. 1/16"  
b. 1/8"  
c. 1/4"                        |
| 9. A section line can be drawn at angle?                                | a. 30 degrees  
b. 60 degrees  
c. 45 degrees                 |
10. If two materials are to be sectioned it is indicated by

11. The cutting plane line indicates

12. A drawn cutaway view of an object can be called a

13. Hidden lines are needed in a sectional view

14. How many arrow heads will a Half-section drawing contain?
   a. one
   b. two
   c. three

15. How many arrow heads will a Full-section drawing contain?
   a. one
   b. two
   c. three

16. How many arrow heads will a Revolved-section drawing contain?
   a. one
   b. two
   c. three

17. How many arrow heads will an Offset-section drawing contain?
   a. one
   b. two
   c. three

18. The type of section view where the interior and exterior are exposed?
   a. half section
   b. revolved section
   c. removed section

19. The type of section view where the cutting plane line is shown and labeled but the section is on another page?
   a. half section
   b. revolved section
   c. removed section
20. The type of section view where the cutting plane line has only one arrowhead?
   a. half section
   b. revolved section
   c. removed section

21. The type of section view where the cutting plane line has right angles but the section does not show it?
   a. full section
   b. aligned section
   c. offset section

22. The type of section view where the section view has been altered to clearly show the internal parts?
   a. full section
   b. aligned section
   c. offset section

23. The type of sectional view where the object is rotated around the center axis?
   a. revolved section
   b. aligned section
   c. offset section

24. Which objects should not be sectioned?
   a. nuts
   b. webs
   c. shafts

25. When drawing section lines care should be taken to make sure the lines are
   a. evenly spaced.
   b. consistent thickness
   c. same angle.

26. Section views
   a. are treated as hidden views.
   b. should be dimensioned as normal.
   c. use special dimension techniques.

27. The most common type of section view in engineering drawing?
   a. half
   b. full
   c. removed

28. The most common type of section view in architectural drawing?
   a. half
   b. full
   c. removed

29. In a full section drawing the arrowheads usually point toward the ____________.
   a. left
   b. right
   c. it depends on the view

30. Sectional views can be drawn in
   a. oblique projection
   b. isometric projection
   c. orthographic projection
Carefully look at the following drawings and read the questions below to each drawing.

31. Choose the correct section view for the pivot lug.

32. Choose the correct section view.

33. What type of section view is the above?
   A. Removed  B. Revolved  C. Offset  D. Aligned  E. Full

34. Choose the correct section view.

35. What type of section view is the above?
   A. Removed  B. Revolved  C. Offset  D. Aligned  E. Full

36. Choose the correct section view.

37. What type of section view is the above?
   A. Removed  B. Revolved  C. Offset  D. Aligned  E. Full

38. Choose the correct section view.

Using the drawing on the right answer the following.

39. What type of sectional view is it?
   A. Removed  B. Revolved  C. Offset  D. Aligned  E. Full

40. Which section view is correct for section A-A?

41. Which section view is correct for section B-B?

42. Which section view is correct for section C-C?
Create a full section of the block support.
Create an offset section of the wheel support.
Create a half section view of the guide.
Sectional View Drawing Test

Students Name:

Criteria Question
If yes to the following questions assign three points per question. If no assign zero points. N/A if not applicable to the drawing.

Is a sketch included?

Is the view drawn correctly?

Is the view sectioned correctly?

If yes to the following questions give two points.

Are section lines thin and dark?

Are section lines properly spaced 1/8”?

Are section lines at the proper angle (not parallel or perpendicular to the object line)?

Are the arrowheads on the cutting plane line drawn correctly?

If yes to the following questions give one point.

Are object lines thick and dark?

Are hidden lines thin and dark with the proper 1/16” space 1/8” dash?

Are center lines thin and dark with the proper spacing?

Are center lines in the correct position?

Is there proper spacing between views?

Circle the method used: Manual or CAD

Drawing 1  Drawing 2  Drawing 3

Total number of points achieved.

Total number of possible points.

Completion Time.
APPENDIX

D

36
Auxiliary Views

Carefully read each question and chose the best answer. If none of the answers are correct chose letter (D) none of the above. If all of the answers are correct chose letter (E) all of the above.

1. We construct auxiliary views to show the ___ size and ___ of an object.
   A. true, construction  
   B. true, shape  
   C. correct, dimensions

2. Auxiliary views are also known as __________ views.
   A. common  
   B. other  
   C. helper

3. The front view is also known as the
   A. horizontal view  
   B. profile view  
   C. Frontal view

4. The top view is also known as the
   A. horizontal view  
   B. profile view  
   C. Frontal view

5. The right side view is also known as the
   A. horizontal view  
   B. profile view  
   C. Frontal view

6. Auxiliary views are classified according to
   A. Length of the incline.  
   B. which plane they project from.  
   C. whether the whole object is created or just the incline.
7. The line of sight
A. is perpendicular to the incline surface.
B. should be labeled.
C. has an arrowhead that points toward the incline surface.

8. The view which contains the inclined surface
A. reference view
B. primary view
C. auxiliary view

9. The view which contains the third dimensions
A. reference view
B. primary view
C. auxiliary view

10. The line used to transfer measurements and points.
A. object line
B. section line
C. line of sight

11. Another name for an incline surface
A. oblique
B. slanted
C. angled

12. All objects contain these measurement
A. length
B. width
C. height

13. When only the incline surface is shown in the auxiliary view
A. half
B. full
C. partial

14. The profile view contain these measurement
A. length, width
B. width, height
C. height, length

15. The horizontal view contain these measurement
A. length, width
B. width, height
C. height, length
16. The frontal view contain these measurement
A. length, width
B. width, height
C. height, length

17. The type of auxiliary view where the whole object is drawn
A. whole
B. normal
C. full

18. The type of auxiliary view where only the incline surface is drawn
A. half
B. partial
C. normal

19. Hidden lines should be omitted except to show
A. another surface
B. foreshortened view
C. Counter-sink holes

20. The type of auxiliary where the incline is in the frontal view
A. Depth
B. Height
C. Width

21. The type of auxiliary where the incline is in the Horizontal view
A. Depth
B. Height
C. Width

22. The type of auxiliary where the incline is in the profile view
A. Depth
B. Height
C. Width

23. If a plane is not true size and shape it is called
A. foreshortened
B. forelonged
C. forgotten

24. When two halves are exactly the same it is called
A. non-symmetrical
B. symmetrical
C. A-symmetrical
25. How far should the reference line in the auxiliary view be from the inclined surface.

A. two inches  
B. any convenient distance  
C. same as reference view.

Using the statements below organize them in the correct order needed to construct an auxiliary view.

Questions 26-30
A. Label the primary and reference views.  
B. Place an arrowhead on the line pointing toward the incline surface.  
C. Examine the views for the incline surface.  
D. Label this line the line of sight.  
E. Construct a line perpendicular to the incline surface.

Questions 31-35
A. Construct projection lines from all points labeled on the primary view perpendicular to the incline surface.  
B. Label the points in the primary view.  
C. Construct a reference line in the reference view.  
D. Label the points in the reference view.  
E. Construct a reference line parallel to the incline surface in the primary view.

Questions 36-40
A. Label the points using the primary and reference views.  
B. Darken in the drawing as needed.  
C. Transfer measurements to the auxiliary view.  
D. Connect the points in the proper order.  
E. Measure third dimension measurements in the reference views.
Complete a full auxiliary view.
Complete a full auxiliary view.
APPENDIX

F
## Auxiliary View Drawing Test

### Criteria Question

If yes to the following questions assign three points per question. If no assign zero points. N/A if not applicable to the drawing.

<table>
<thead>
<tr>
<th>Students Name:</th>
<th>Criteria Question</th>
<th>Drawing 1</th>
<th>Drawing 2</th>
<th>Drawing 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Is the auxiliary view drawn correctly?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Are all points labeled correctly?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>If yes to the following questions give two points.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Are the Reference lines present?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Are the Reference lines in the correct place?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Is the Line of Sight present?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Is the Line of Sight drawn correctly (arrowhead &amp; labeled)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Is the auxiliary view parallel and perpendicular to the incline surface?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Is the primary view labeled correctly?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Is the reference views labeled correctly?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>If yes to the following questions give one point.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Are object lines thick and dark?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Are hidden lines thin and dark with the proper 1/16&quot; space 1/8&quot; dash?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Are center lines thin and dark with the proper spacing?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Are center lines in the correct position?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Total number of points achieved.

### Total number of possible points.

### Completion Time.
APPENDIX

G
Create a full section of the block support.
Create an offset section of the wheel support.
Create a half section view of the guide.
Complete a full auxiliary view.
Complete a full auxiliary view.
CONSTRUCT THE HORIZONTAL AUXILIARY VIEW
Bibliography


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