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A simulation program for electronics skill knowledge instruction at a selected community college in Taiwan

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A SIMULATION PROGRAM FOR ELECTRONICS SKILL KNOWLEDGE INSTRUCTION AT A SELECTED COMMUNITY COLLEGE IN TAIWAN

A Dissertation

Submitted

In Partial Fulfillment

Of the Requirements for the Degree

Doctor of Industrial Technology

Approved:

Dr. John T. Fecik, Advisor

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An Abstract of a Dissertation

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ABSTRACT

Since computers came into existence, simulations have been associated with it as the two inseparable media simulations and computers have had a mutually beneficial effect. With the advent of the flexible microcomputer, simulation has been widely used. In recent years of computer technology has infiltrated every sector in society especially the educational system and industrial operations where simulations are essential for satisfying both instructional and industrial needs. Simulation effectiveness research has been mixed in both the educational system and industries. Therefore, it is still necessary to evaluate how effective computer simulation is as an instructional method or strategy.

This study was designed to compare and evaluate the effectiveness of computer simulated laboratory instruction versus traditional laboratory instruction for educating community college students requisition skills and knowledge for understanding combination logic circuitry. In order to compare the achievement between the two groups, the researcher utilized classroom examination scores. The students were given four exams in the course, one as a pretest, one on each of two contents and a comprehensive final.

A pretest was given in order to ascertain whether the groups matched at the start of the study. The topics in the laboratory were taught in one of two ways: by lecture and simulation, or by lecture and traditional laboratory. Post-tests were administered as dependant variable measures. The data were analyzed statistically by ANCOVA. Conclusions will be drawn and recommendations will be made on the basis of the findings of the study. It was founded that both instructional methods were effective and there were no significant differences between them.

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TABLE OF CONTENTS

LIST OF TABLES

`CHAPTER I

INTRODUCTION

Since computers came into existence, simulations have been associated with them as the two inseparable media (Crookall, 1988). Simulations and computers have had a mutually beneficial effect. With the advent of the flexible microcomputer, simulation has been used widely in education.

In recent years the integration of computer technology has infiltrated every sector in society (Milner & Wildberger, 1974), especially into the educational system and industrial operations. Simulations are essential for meeting many instructional needs, and they are especially important in classroom tasks. Simulation also focus on the learning environment without usurping control from the learner, and they offer unique learning opportunities in nearly every subject area. As a result, simulations permit the attainment of learning goals which are beyond traditional ones and are more feasible than other computer-based instructional methods. For this reason, simulation are more prefer than computers in both the classroom, and laboratory situations. Furthermore, they provide more advantages over natural events, creating a sense of immediacy to the learning tasks; they challenge the students to participate more actively in the tasks (Bushnell & Allen, 1967). There is also evidence showing that the instructional potential of laboratory simulations is substantial (Hughes, 1974). Simulation activities have been adopted by many industrial companies. For example, the complexity of electronic circuitry has made computer simulation a necessity in modern electronics industrial operations (Banzhaf, 1991). Although there were few studies for the electronics instruction, Chen and Miller (1997) compared student achievement resulting from learning the minimization of Boolean algebra by computer tutorial/simulation program versus traditional lecture/practice methods. Chen and Miller found that the average time spent for the computer tutorial/simulation program in the experimental group was much less than for the control group.

In summary, simulations are essential for satisfying both instructional and industrial needs. For this reason, simulation research has been proven worthwhile for its unique roles in both the educational system and industries. Therefore, it is necessary to evaluate how effective computer simulation is as an instructional method or strategy.

Statement of the Problem

This study is designed to compare and evaluate the effectiveness of computer simulated laboratory instruction versus traditional laboratory instruction (utilizing actual electronics components) for educating community college students in skills and knowledge of combination logic circuitry.

Purposes of the Study

The purposes of this study were to show the differences between computer simulated laboratory instruction and traditional methods of laboratory instruction, and to determine their different influences on students in the study of logic circuitry. Specifically.

1. The study intended to compare the achievement levels of community college students who are receiving the computer simulated laboratory instructions with students who receiving the traditional from of laboratory instruction.

2. The study intended to evaluate the effectiveness of computer simulated laboratory instruction in educating college students in combination logic circuitry.

3. The study intended to compare which instructional method helps students to have a better understanding of the underlying concepts applied in combination logic circuitry.

4. The study intended to evaluate the effectiveness between computer simulated laboratory instruction and the traditional method on a final comprehension exam over all concepts taught in the course.

Needs of the Study

The traditional teaching methods of lecture and laboratory practice have long been used in teach logic circuitry in Taiwan. Large costs are necessary to support such a course. The costs are involved in purchasing modular equipment, instruments and parts. Due to the high damage rate of equipment, instruments and parts, school administrations require an extra maintenance fee to keep the laboratory work functioning continuously. Moreover, with the rapid development in technology, equipment and instruments need to be updated every two or three years. Therefore, there is a heavy financial burden on the private community college.

Some studies have been conducted in an effort to improve the environment in which students learn digital circuits. Some software packages for digital simulations can be very easily implemented and maintained. It is hoped that this study may provide further empirical evidence to guide the teaching of logic circuitry in digital technology by using computer simulation programs at the community college level in Taiwan.

Hypotheses of the Study

The hypotheses for this study are shown as below. The null hypotheses are necessary for four measures (a pretest, a first posttest, a second posttest, and a final examination) that compared the mean scores of an experimental and control group of students.

Hypotheses 1

There is no significant difference between the Pretest mean scores of the experimental and control groups.

Ho : $U_{E,pre}=U_{C,pre}$.

Ha : $U_{E,pre}\neq U_{C,pre}$.

Hypotheses 2

There is no significant difference between the mean scores of the adjusted experimental and control groups as measured by a Post-test I with the Pre-test as the covariate.

Ho : $U_{E,post1}=U_{C,post1}$.

Ha : $U_{E,post1} \neq U_{C,post1}$.

Hypotheses 3

There is no significant difference between the mean scores of the adjusted experimental and control groups as measured by a Post-test II with a Post-test I covariate.

Ho : $U_{E,post2}=U_{C,post2}$.

Ha : $U_{E,post2} \neq U_{C,post2}$.

Hypotheses 4

There is no significant difference between the mean scores of the adjusted experimental and control groups as measured by a final exam with a pre-test covariate.

Ho : $U_{E,final}=U_{C,final}$.

Ha : $U_{E,final} \neq U_{C,final}$.

Assumptions of the Study

One of the assumptions of this study is that students should be divided evenly between the experimental and control groups, with the effect of the teacher being the same for both classes. Secondly, the presence of the experimental and control groups has the identical effect on each of the two groups. In addition, the experiments set up during the entire study should keep the content of the course the same, showing no differential factors in manner so as not to affect the experiment except for the difference in laboratory experiments. Besides, the interaction among students outside of class should not affect the study.

In summary, all the laboratory experiments for both of the groups surveyed are required to be identical in content. In addition, this study will be based upon the following assumptions:

1. Students are randomly and independently distributed in both the experimental and control groups. (Complete, intact classes participated in this research.)

2. The effect of the teacher is the same on the experimental and the control groups. The same teacher taught both classes.

3. The presence of experimental and control groups in the same buildings has no differential effect on either group.

4. The activities set up during the entire study do not differ in any manner, thus not affecting this study.

5. No interaction occurs among students outside of the experimental setting which affects the results of the study.

6. All the laboratory experiments are the same for both the experimental and the control groups.

Delimitations of the Study

The delimitation of this study are specified as follows:

1. The students participating in this study are enrolled in the fall semester of 2000 in Logic Circuit Design in the Department of Electronics Engineering at Chun-Chou Institute of Technology in Taiwan.

2. The length of the semester is restricted to 12 weeks in the experiment,

3. The simulation software is delimited to a selected existing software.

4. Due to scheduling complexities, the same instructor was required to teach both groups. The instructor was not the author, but was a colleague and personal acquaintance of the author.

5. The list of content will consist of the following:

   a. Digital logic.
   b. The number system.
   c. Digital codes, operations and logical gates.
   d. Boolean function.
   e. Function simplication.
   f. Rules and laws of Boolean Algebra.
   g. Function minimization.
   h. Combination logic and Functions of combination logic.
   i. Assembly logic design procedure, compulsion or gate design.
   j. Combination logic circuit.
   k. Binary counter circuit experiment.
   l. BCD counter circuit experiment.
   m. Decoder circuit design and multiplexer circuit.

Procedures of the Study

The procedures necessary for this study are specified in the following segment. First, the researcher conducted a review of the literature in order to identify and isolate the problems to be studied. Next the researcher identified the population; then the researcher formulated a pretest and posttests and verified the validity of the instruments. Afterwards, all test instruments were submitted to the dissertation committee for approval.

A pretest was given in order to match the groups for the study. The topics in the laboratory were taught in one of two ways: by simulation, or by traditional laboratory. Post-tests were administered to facilitate data collection. The data were analyzed statistically in order to compare the results of the pretest and the post-tests. The findings were identified, interpreted, and discussed. Conclusions were drawn and recommendations were made on the basis of the findings of the study. The following procedures pursued in the study were (a) Identify and isolate the problems, (b) Conduct a review of the related literature, (c) Identify the population, (d) Select and formulate the pretests and post-tests. The tests were written as a cooperative effort by the author and the instructor, (e) Administer the pretest, (f) Teach the topics, (g) Administer the post-tests, (h) Collect data, (i) Implement the statistical analysis, (j) Analyze the results of pretests and post-tests, (k) Identify the findings, and (l) Interpret and discuss the proper conclusions and recommendations and prepare the final report.

Data Collection Instruments

In order to compare the achievement difference between the two groups, the researcher utilized examination scores. The students were given a pretest and three exams in the course. The score of the four exams supplied the data for analyses.

1. Pretest: Prior knowledge, including electronics theory and electrical theory.

2. Post-test I: Digital logic, the number system. Digital codes, operations and logical gates, Boolean function, Function simplication.

3. Post-test II: Rules and laws of Boolean Algebra, function minimization Combination logic and functions of combination logic.

4. Final exam: Over all topics taught in the course.

Research Design

First of all, subjects were selected from the students who were enrolled in the fall semester of 2000 in the Department of Electronic Engineering at Chun-Chou Institute of Technology in Taiwan. The students were divided randomly into two groups, each group consisting of a minimum of 40 students. The subjects were randomly chosen from each group and matched with individuals of similar score levels, in the other group based on their pretest scores. One group received computer simulation laboratory experiments and the other group received the traditional laboratory experimental instruction.

See Table 1 for the results of the achievement of the two groups were compared on the basis of group means.

Table 1

Research Design

Classes	Control Group	Experimental Group
	Pre-Test	
C1	40	42
	Post-Test I	
C2	40	42
	Post-Test II	
C3	40	42
	Final Test	
Final	40	42

Research Procedures

This study was a quasi-experimental research design developed in order to determine the effects of type of instruction on variables combination logic circuit.

The pretest-posttest control group design was used in the experiment, as is schematically illustrated.

Control : R_1 T O_1 T O_2 T F

Experimental : R_1 S O_1 S O_2 S F

Where R = Pretest

O_1~O_2 = post-test I -- post-test II

F = Final examination

T = lecture and laboratory practice

S = lecture and simulation

Variables of the Study

There is one independent variable in this study, type of instruction, and it has two levels. The first level of the independent variable involves using actual components in laboratory instruction, which is commonly known as the traditional laboratory instruction. The second level of the independent variable involves using computer simulation in laboratory instruction, which is refer to as computer simulated laboratory instruction.

The dependent variable consists of Post-test I, Post-test II and final examination scores during this study. The covariate is the pre-test of different prior knowledge about electronics theory and electrical theory of the students or the Post-test I or II as appropriate.

Independent variables: Teaching methods (lecture and practice, lecture and simulation).

Dependent variables: Post-test I-II and final exam scores.

Covariates: Pretest score, post-test I or post-test II as appropriate.

Budget

All equipment, materials, instruments, and faculty staff needed for this research project were completely provided by the school within its normal teaching operation, except that US$1200 was spent on 40 computer simulation software packages.

Table 2

Time Line

Activity	2000	2001	2001
Complete literature review	Nov	Jan	
Prepare teaching and testing instrument	Dec	Feb	
Instructional experiment are testing.		May	June
Collect data and complete test.		June	July
Analyze test and exam results		July	August
Interpret and discuss the proper conclusions.		August	Sept

Definition of Terms

The following terms directly relate to this study. Definition of these terms helps to clarify their use in the context of this research.

Simulation: Simulation is a representation of a system by a device that imitates the behavior of that system.

Experimental treatment: The computer simulated laboratory instruction used in this study as one level of the independent variable.

Traditional treatment: Actual laboratory equipment and electronics components (bread boarding) used in this study as a second level of the independent variable.

Bread boarding: The term bread boarding refers to the process of installing components on a circuit board and interconnecting them to form a specified circuit.

Computer Assisted Learning (CAL): Using a computer to aid in the learning improvement process.

Computer Assisted Instruction (CAI): Using a computer to aid in the teaching improvement process.

Practice: In laboratory, employs hands-on experiments with usage of actual components.

SAS: Statistical Analysis system computer statistical package.

SPSS: Statistical package of the Social Science computer package. Used to compute the reliability of the instrument.

Summary

This chapter consisted of stating the problem and purposes of this study, the hypotheses, the procedures, the organization for data collection, identification of variables, and the time line.

CHAPTER II
REVIEW OF LITERATURE

In this chapter the author will review and discuss literature related to computer applications in education, the definition of computer simulation instruction and its strength, the types of software for computer simulation instruction, and the application of computer simulation software in the education of science and engineering.

Computer Applications in Education

Classification of Computer Application in Teaching

In the traditional teaching system, a teacher must handle many students simultaneously. He must guide the students to learn and acknowledge individual differences among students. Educators and experts have tried their best to develop various instructional tools to coordinate with teaching needs improve both teaching effectiveness and the learning efficiency of students.

Computer-Assisted Instruction (CAI) was developed under such conditions. Computers have made great impacts on teaching as a result of the rapid development of information technology. In the past, many scholars tried to classify computer software applications in education from different angles, including the characteristics of the computer software, application scopes of the software, etc. Taylor (1987) made a classification in 1980 based on the connection between computer software and the user. Taylor considers computer software plays three roles in education: tutor, tool and tutee. The following is a brief illustration of the related research on the roles of computer software application in education.

Tutor, when the computer acts as a tutor, the teacher set up computer to control the learning content and schedule. For example he set the specific learning software for students to practice on the computer, make available various auxiliary learning software in the market, or sets up simulation learning software or free learning software samples in textbooks. Analyzed recent studies on CAI and recorded the following results:

1. Regarding the learning achievement of students, CAI is more effective than traditional methods.

2. With respect to the application method, CAI achieves good results if used as a supplementary instrument; if we replace the teacher with CAI, learning results are unknown.

3. CAI can reduce learning time.

4. Regarding learning attitude, students who are in lower grade, have lower scores or are in special education show more interest in CAI.

Tool, when the computer acts as a tool, it contains various software such as word processors, electronic spread sheets and data base management systems, which can be helpful for students to do data processing, sorting, calculations and analysis. It is also time-efficient and allows students to concentrate on analysis and inference.

Tutee, when the computer acts as a tutee, students use various programming languages to learn how to make computers follow instructions. Computer scholars have long been arguing whether the teaching of programming languages is able to enhance student's thinking ability. Papert (1980) agreed that teaching programming languages indeed enhances students' ability to think. However, Vockell (1992) held an opposing opinion. It is necessary to include programming languages in elementary and junior high school education? After several investigations, it was found that teachers and administrators undervalue the importance of learning programming languages. Computer educators view it as one part of the necessary knowledge a teacher should have.

<u>The Effect of Computer Applications on Teaching</u>

Role transformation between instructor and student and its process. In the traditional teaching environment, the teacher plays the role of conveying knowledge. The teacher has to handle many students at the same time and guide their learning direction, as well as instruct each student in accordance with their individual differences. He is the center of the entire learning activity. In such a learning environment, students spend most of their time passively accepting the knowledge conveyed from the teacher. Since the dissemination of information technology, computer software and hardware have been gradually introduced to schools to play the important role of auxiliary tool. The role of the teacher is also gradually transformed from knowledge-conveyor to learning-facilitator. In addition to sometimes passively accepting knowledge passed on from teachers, students can now start to process individual self-learning, small-grouped collaborative learning or project-based learning through the assistance of computer software and hardware. The major task of the teacher in this kind of learning environment is to raise assorted learning topics and then guide students in choosing plans to solve problems in the process of learning. The center of learning gradually shifts from teacher to student, students become more active learners and the teacher plays the role of learning-facilitator.

Research found that in the process of the introduction of computer software and hardware to the campus, the transformation of the roles of teachers and students generally experienced five stages. They are the entry stage, application stage, adaptation stage, familiarization stage and innovation stage. It takes about four to six years to go from the first stage to the fifth stage. The entry stage is the most frustrating stage because the teacher has just begun to use computer software and hardware, often needing to undergo various technique training and faces problems on the management of computer resources. During the second, or application, stage, the teacher begins trying to use computer software and hardware as an auxiliary tool to the traditional teaching. He encounters the challenges of setting new teaching strategies and managing the teaching environment. In addition, students must also face the challenge of new learning conditions. During the third, or adaptation, stage, the teacher spends more time on computer teaching. He spends about one third of the time teaching students how to use word processors, database software, graphic software and other auxiliary teaching software. In this stage the learning speed of students accelerates and learning efficiency increases. Both the teacher and students grad usually adapt to the new teaching and learning conditions. During the fourth, or familiarization, stage, the teacher demonstrates confidence in computer teaching strategies, computer resource management and the new teaching environment, and students are able to do independent work more efficiently. Thus, the teacher has transformed from being a traditional one-way knowledge-conveyor into a learning-assistant. Consequently, new models of teaching and learning appear, thus generating group teaching, inter-disciplinary project-based teaching and individualized teaching. Students show high levels of learning motivation and learning ability increases. The learning model changes from competition among students to collaboration. During the fifth, or innovation, stage, there are more interactive relationships between the teacher and students. The familiarity with computers of the teacher and students results in more innovative learning activities.

Impact on Teaching Methods

Computerized instruction focuses on software and hardware in the early stages. The largest concern regarding the software is the problem of "Computer-Assisted Instruction." The most researched are training and drill and practice, and next is the emphasis on programming languages and computer simulation instruction. Before 10 years ago, computer educators began to notice the three most significant elements affecting the success of computerized instruction – instruction, student tasks and assessment, and beginning systematic research on these three factors, such as the long-term joint research projects like MIT's Structural Thinking Experiential Learning Laboratory with Animation (STELLA) program in 1980, Apple Tomorrow of Computer (ATOC) in California in 1986 and Harvard's

System Thinking and Curriculum Innovation (STACI) research in 1987. These research projects are still in progress, ATOC publishing research results most frequently.

Definition of Computer Simulation Instruction and its Strengths

Definition of Computer Simulation Instruction

Computer simulation has a variety of definitions. To simulate means to imitate or pretend to do something. According to Webster's collegiate dictionary, to simulate, is "to feign, to attain the essence of without the reality." Chambers and Sprecher (1983) indicated that computer simulation provides a model in which the student plays a role and interacts with the computer. Alessi and Trollip (1985) stated that computer simulation is the use of a computer to simulate objects or phenomena and is a powerful tool in industry to test out new products without actually producing them. Dennis and Kansky (1984) consider simulation a design to duplicate real circumstances or phenomena. This design allows learners to judge and make decisions based on their own logic, observations and understanding of reality. Simulation computer instruction is the most creative kind of computer software, but the definition of computer simulation varies. Dennis and Kansky (1984) believed that computer simulation is using the computer to execute replication. Thus, computer simulation is to apply computers to the operation of variables and observe the entire process of change in the simulation. Alessi and Trollip (1985) pointed out that computer simulation is using the computer to imitate concrete objects or their phenomena. It is a very effective tool for testing new products without producing any real products.

Simulations have been used most often in higher education to model scientific processes. They are applicable to any field, and can be of significant help in illustrating concepts, in helping students to develop problem-solving techniques, or in allowing students to explore complex interactions.

Simulation allows a student to learn about an aspect of the world by imitating or replicating it. Students are not only motivated by simulations but also learn by interacting with them in a manner similar to the way they would react in real situations. In almost every instance, a simulation also simplifies reality by omitting or changing details. In this simplified world, the student solves problems, learns procedures, comes to understand the characteristics of phenomena and how to control them, or learns what actions to take in different situations (Dennis, 1979).

Computers can be used to simulate laboratory situations. An experimental situation can be represented by a set of questions programmed into the computer. The student enters a set of initial values. The computer generates data similar to data the student would have collected in an actual laboratory experiment. The simulation program can be written so that the data generated by the computer reflect uncertainties corresponding to the experimental errors. The magnitude of these uncertainties can be varied from trial to trial through the use of the computer's random number generator.

In a laboratory experiment, the student would manipulate the laboratory experiment or apparatus to obtain the data required. In a computer simulated experiment, the student would manipulate the input and output data through the use of a computer terminal. Once the data are obtained, whether by laboratory equipment or by computer, the objective is to determine relationships from the data by curve plots and data analysis (Hughes, 1974).

Bushnell and Allen (1967) suggested that computer simulation offers many advantages over natural events in that simulation brings a sense of immediacy to the learning task and challenges the student to participate more actively. Boblick (1972) noted that computer simulations of laboratory environments enable physics students to experiment with environments which are unattainable in any other form.

There is evidence to suggest that the instructional potential of laboratory simulations is substantial (Hughes, 1974). Simulations differ from interactive tutorials which help the student learn by providing information and using question-answer techniques. In a simulation, the student learns in a context that is similar to the real world (Alessi & Trollip, 1985). The CAI model of teaching has four phases: (a) presenting the student with information; (b) guiding the student in acquiring information or skill; (c) providing practice to enhance retention and fluency; and (d) assessing learning. Tutorials generally engage in the first two of these instructional phases. Simulations, in contrast with tutorials, may be used for any of the four phases of teaching. Initial presentation, grievances and practice, and assessment of learning are all capabilities of a simulation (Alessi & Trollip, 1985).

The general definition of computer simulation instruction is: to present various simulations of actual objects or phenomena on screen so that the learners are able to learn and practice along with the simulation and use the computer to analyze possible variations in different experiments and receive instant results. In brief, computer simulation instruction is one strategy of computer supplementary instruction. Hopefully the goal of supplementary instruction can be achieved by the combination of computer simulation technology and software. This also means we can present actual objects or phenomena that are difficult to observe for the learners, using computer simulation to achieve similar instructional goals as when observing the true conditions.

Strengths of Computer Simulation Instruction

Alessi and Trollip (1985) compared computer simulation instruction with traditional Tutorials and Drills CAI, and noted three merits of computer simulation instruction.

Initiation of learning motivation: Students are more active in learning under the learning conditions of computer simulation instruction. Active involvement is more effective than passive learning in initiating students' learning motivation.

Accessible shift in learning: Computer simulation instruction offers an excellent shift in learning. It allows students to shift knowledge learned from computer simulation instruction to real conditions. Textbooks or traditional computer-assisted instruction provide general knowledge or information and tell students how to do certain things. Students are able to expect better learning results when applying computer simulations.

Higher learning efficiency: Students are able to achieve a high level of efficiency for the learning shift of knowledge and skills.

Models of Computer Simulation Instruction Software

Scholars have conducted research on various computer simulation instruction methods since the 1970s. The research categorized four models: experiencing, information, reinforcing and integrating. Below is a brief description of the relevant research.

Experience Simulation Instruction

Experience simulation instruction software provides a complete knowledge structure or examples to induce learning motivation. Students are able to present a concept or situation, or discuss incorrect concepts through the software. Examples were found in the following sources.

Cox (1974) found in the economy simulation instruction that higher or lower level students most benefited from computer simulation instruction, while intermediate level students do not show any outstanding benefits.

Taylor (1987) compared the learning effects of computer simulation scheduled before instruction with those scheduled after instruction. In researching social science computer simulation instruction, Taylor found that students had better learning attitudes and values when scheduled before instruction. However, there was no significant difference on test results.

Brant, Hooper, and Sugrue (1991) applied computer simulation in the study of genetics and found that when computer simulation was arranged before instruction, students achieved better learning than when arranged after instruction, or no simulation at all.

Hooper and Thomas (1991) applied computer master memory operation simulation software in a programming instruction experiment, and the results showed simulation instruction enhanced student's capability to infer and deduct. However, there were no significant difference on test scores and programming.

Gokhale (1989) conducted research on the learning effects of different instruction methods and sequences. Students were divided into two experimental groups, computer simulation and traditional circuit experiment, to learn digital logic circuit. Results showed different instruction methods made no significant differences in either group. However, different instruction sequences had different learning effects. Both computer simulations and traditional circuit experiments had more satisfactory effects if scheduled prior to the instruction.

Information Simulation Instruction

Information simulation is mainly used to convey knowledge to the students. This software applies different teaching strategies to introduce instruction content, and then conduct the tests; it can replace the textbooks or instruction. It is a tool to introduce knowledge.

A simulation instruction on qualitative analysis, was performed by Hollen, Bunderson, and Dunham (1971). The results showed that the experimental group learned faster, but there was no difference in the test scores for either group.

Emery and Enger (1972) made a comparison between lecture instruction and simulation instruction and found that the simulation instruction group had a better performance on analyzing problems than the lecture instruction group, but there was no significant difference in the recognition ability of either group.

A simulation instruction experiment on Archimede's theory, was conducted by Choi and Gennaro (1987). Students were divided into three groups in this experiment; computer simulation, experimental instruments and control group. Performance of the first two groups was superior, but there was no significant variance between the first two group in test results. In analyzing test results and instruction preferences from the aspect of gender, male students had better performance than female students. Male students preferred experimental instruction and female students preferred computer simulation instruction.

Berlin and White (1986) did an experiment on the learning of geometry graphics. Students were divided into three groups; hand-drawing, computer simulation and hand-drawing plus computer simulation. Results showed there was no difference in performance. The research also showed rural white female students and suburban black male students were better using hand-drawing than computer simulation; rural white male students and suburban black female students were better using computer simulations than hand-drawing. For those who used both methods there was no significant difference in learning results.

The effects of tutorial instruction was compared by Schloss (1986) with simulation instruction and found there was no difference in the test scores for either group. The simulation group took a longer time to finish practice and preferred tutorial learning.

Alperson and O'Neil (1990) did a study on psychology instruction and found tutorial groups had superior performances compared to simulation groups. In addition, students preferred tutorial learning.

Reinforcing Simulation Instruction

Reinforcing simulation is mainly for enhancing student's learning ability in a specific area of knowledge. The most common software is Drill and Practice. In this learning environment, the computer must give the learner a test and analyze the results in order to understand the level of the learner. Then, it provides a series of practices for students and records the learning conditions, keeping track of student's progress.

Munro, Fehling, and Towne (1985) did an experiment on the influence of interrupted simulation instruction on the learning. One group of students received immediate responses from the computer when a mistake was made; the second group was allowed to decide on the computer's response time. The purpose was to reduce the computer's interference of the student's thoughts. Results showed the first group of students made more mistakes than the second group of students. Based on the above research, the researchers proposed interrupted reinforcing simulation instruction was not suitable for complex simulation instruction. In addition, it would also be unfitting for simulation instruction in which students can not easily find their own mistakes during the simulation instruction process.

The simulation instruction and learning manuals design by Rivers and Vochell (1986) were intended to promote students' problem-solving ability. Students were divided into three groups; the traditional group applying tradition instruction, the discovering group applying simulation instruction with learning manuals and the guided discovery group applying simulation instruction with problem-solving strategies. Results showed there was no variance in test scores among the three groups. Yet, on the problem-solving skills, the guided discovery group performed the best, next was the discovery group, with the traditional group performing the worst.

Woodward, Carnine, and Gersten (1988) did an experiment on simulation instruction combined with instructor's supervision. One group of students received traditional instruction, while the other group received the simulation instruction with the instructor being responsible for supervising and judging the learning process. Results showed students of the simulation instruction group were superior in memorizing and understanding facts and oncepts.

Also, there was an especially significant difference on the problem-solving skills between these two groups.

Integrating Simulation Instruction

Integrating simulation instruction is mainly for assisting students to integrate relevant information. Students are able to integrate unit information after independent learning though the integrating simulation software. Hughes (1974) did an experiment on physics simulation instruction. Three groups were involved in the experiment. The first group used physical experimental equipment, the second group collected data by experimental equipment as well as controlled variables and collected the remaining information by computer simulation. The third group analyzed data with the computer. Results showed the second group had the best performance.

Diedrick and Thomas (1997) did a simulation experiment on trouble-shooting of the internal combustion engine. Evaluation was based on the student's performance. All students learned the internal combustion engine system and how to use an oscilloscope. Students were divided into two groups; one diagnosed problems through computer simulations and the other was given lectures and demonstrative instruction. Both groups then diagnosed real automobile problems. It was found that the computer simulation group out-performed the lecture group.

A simulation instruction to diagnose reading disabilities, was developed by Boysen, Thomas, and Mortenson (1979). The experiment focused on students majoring in education. One group of students applied simulation instruction that was able to diagnose students' reading weaknesses. The other was the control group. They found the experimental group was better of analyzing problems.

Krahn and Blanchaer (1986) did a research on medical diagnosis by the medical school students. One group diagnosed with computer simulations and the other one without.

Results showed the group with computer simulation was able to analyze problems immediately after diagnosis.

Thompson and Wang (1988) did research on sixth grade students learning the general theory of equations by Descartes. After completing the learning of traditional mathematics equivalent theory students were divided into two groups. One group received simulation instruction and the other received traditional instruction. The results showed that students who received simulation instruction had achieved superior mathematical knowledge and transformation.

Thomas and Hooper (1991) conducted many analyses on computer simulation instruction and found that the effect on learning via the information and reinforcing systems is not necessarily superior to other instruction methods. However, the computer simulation instruction method using the experiencing and integrating methods is absolutely better than other instructions methods. From the review of author has:

1. The most effective computer simulation instruction methods among the four types are the experiencing and integrating simulation instruction. It also means computer simulation instruction is applicable both before and after instruction. If applied before instruction, it initiates learning motivation and provides a complete knowledge structure. If applied after instruction, it integrates knowledge and enhances the ability of reasoning and problem-analysis.

2. Computer simulation is not effective for learning activities emphasizing memorization, yet, it is very effective for developing inference ability.

Application of Computer Simulation Software in the Instruction of Science and Engineering

Computer simulation software reveals its distinguishing features when applied to the teaching of science and engineering. Compared with actual object experiments, computer simulations possesses the following merits:

1. Cost savings--When errors taken place in actual experiments, experimental equipment might be damaged and new equipment purchased, thus increasing the costs.
In addition, costs are higher on experimental materials when the same or similar experiments are conducted repeatedly.

2. Time savings--It takes more time to install experimental facilities when conducting an identical or similar actual experiment many times; computer simulations can easily duplicate and modify an identical or similar simulated experiment.

3. Self--detection of errors--Actual experiments depend on people to check if there are any installation errors; computer simulations are able to self-detect and indicate the errors of sequence, loading effect and any other possible errors neglected by the designers.

4. Improved safety--Actual experiment defects might cause personal injury or facility damage, while computer simulations merely indicate experimental errors, resulting in a higher level of safety.

Among the research on the application of computer simulation software to the instruction in science and engineering departments, Roy (1968) was the first to apply CAI to the study of logic circuit design. Roy used IBM650 to teach engineering majors to learn the simplification of Boolean algebra and logic circuit design. The research results showed, comparing students of the CAI group with those of the traditional instruction group, students of the CAI group were able to maintain concept memorization for longer period of times.

However, Roy concluded that CAI was not applicable to engineering instruction due to the restriction of software functions.

Gokhale (1989) conducted research on the instruction of logic circuit design to discuss whether computer simulation software or actual experiments provided better results on logic circuit design. Gokrale did further research on the influence of the different instruction sequences on instruction effects. Results showed there was not a significant difference between the two factors. Yet teaching effectiveness on the exercise practices was significantly better when arranged by computer simulation prior to the circuit experiment.

Carren (1990) applied computer simulation software in the instruction of digital electronics and concluded there was no significant difference on the final test scores between computer simulation instruction and traditional, actual wiring experiment instruction. It also showed those students who used computer simulation software were less interested in the experiment content and had lower desire to learn compared with those who did not use computer simulation software.

Goldberg and Subbarao (1990) thought the advantage of computer simulation software to the digital logic circuit design was the ability to obtain results without actual operation and tests.

Shankar, Freytag, and Alon (1991) discovered computer simulations were capable of indicating the sequence and loading effect possibly neglected by the designers. Microcomputer products often come from ideas, and CAD can complete circuit design quickly. Manufacturers use CAD to do various simulations and sequence analysis to test product reliability before they actually start production.

Gokhale (1989) used Apple II and HIGH WIRE LOGIC simulation software to compare the learning of electronic digital logic by computer simulation and traditional circuit experiment. The results of the teaching of different instruction methods and instruction sequences was discussed in his research. Results showed there was no obvious difference on the learning effect of the teaching methods. However, different teaching sequences resulted in different results. Whether computer simulation or traditional circuit experiment, students learned more effectively by those scheduled before instruction.

Nejad (1992) did an experiment of solid electronic circuit instruction on two groups of college students. The experimental group applied electronic parts and computer simulation software PSPICE, while the control group applied actual electronic parts. Though there was no significant difference on the test scores, students of the experimental group had a higher level of understanding of the solid electronic circuit.

Wilson (1993) applied computer simulation software to teach experimental groups to analyze logic circuits, applying traditional illustration and letting students do the actual connecting of parts and tests. Testing was done after completion of the learning process and it showed no significant difference between the two groups.

Chu (1994) pointed out that in engineering instruction, it would be very difficult for students to conduct complex experiments without educational simulation software. Although they could connect circuit boards with breadboards, the process proved very tedious and time consuming. Furthermore, they could have connected the wrong wires and had to spend more time on checking. If original design was modified, the students must waste a remarkable amount of time on wire connecting.

Moslehpour (1995) also did an experiment on college students for an entire semester. The experimental group applied both traditional instruction and the computer simulation software PSPICE, while the control group applied traditional instruction only. A series of exercises and learning tests were given to both groups and they found the group with a combination of traditional instruction and the computer simulation software PSPICE had better performance on the application of complex circuits.

Chen (1995) applied PC and Electronics Workbench to design a set of instructional software focusing on the simplification of logic circuits. This software recorded the entire learning process of the experimental group. The control group used lectures and practicing on connecting actual parts. Although test results showed no difference, the experimental group only spent half the time on this unit compared to the control group. This also means that computer simulation saves time and minimizes human errors.

Wang Chow-Jen (1995) compared the instructional effects from computer simulation and traditional circuit experiments in electronic engineering. He also did a comparison on instructional sequence by comparing computer simulation instruction prior to traditional circuit experiment instruction with traditional circuit experiment instruction prior to computer simulation instruction. Results showed the results of computer simulation instruction were more satisfactory than that of traditional circuit experiment instruction. Computer simulation instruction prior to traditional circuit experiment instruction was superior than traditional circuit experiment instruction prior to computer simulation instruction.

Drawing conclusions from the above literature, we know there is much research discussing the application of computer simulation software to the instruction of electronic engineering and electronics, mainly in the field of electronics and circuits. However, research on the instruction of logic circuit design is limited. Demand for computer software used in college-level engineering has existed in Taiwan for a period of time, yet research on the applications of computer simulation software to logic circuits is extremely insufficient. In the literature, the author found that the results of the application of computer simulation software to engineering instruction was not necessarily superior to that of traditional lecture or actual experimentation. Different computer simulation software did not demonstrate significant influence on instruction. However, different instruction strategies (different instruction sequences) indeed had certain levels of influence on learning. In addition, computer simulation software instruction possesses several advantages that can not be found in actual experiments. This review of literature supports the contention that further research regarding the application of computer simulation software to engineering instruction should continue.

CHAPTER III
THE PROCEDURES AND METHODS OF RESEARCH

The objective of this chapter is the description of the teaching experiment, in order to investigate the influence of different teaching strategies to the college students in the area of the combinational logic design. The students were divided into two groups, one labeled as the experimental groups and one recognized as the control group. The elements of this experiment are (a) experiment sample, (b) tool of measurement, (c) the execution of the teaching experiment, (d) the design of the experiment, (e) data processing, (f) the hypotheses of the research, and (g) simulation program, which will be explained as below.

Experiment Sample

The population of this study consisted of all college students who enrolled in the fall semester of 2000 in the Department of Electronic Engineering at Chun-Chou Institute of Technology in Taiwan. A total of 87 students enrolled and participated in this study. All the students had taken related courses such as circuits theory and electronics before they joined this experiment. All students were randomly assigned to one of the two groups randomly as stated above (one called experimented group and one control group).

Tools of Measurement

The measurement methods of this experiment was divided into (a) pre-test; (b) achievement Post-test I; (c) achievement Post-test II; and (d) final examination. The tests were written and administered in Chinese. The English translations are located in Appendix A to D.

Pre-Test

The pre-test instrument was designed by the researcher with the electronics instructor. All the students were tested before they joined the experiment. The pretest was a paper and pencil test which consisted of 30 multiple choice and 10 true/false. This test was designed to be used as a covariate to control for initial differences in the students' background and knowledge of electronics and their ability to evaluate, compute, and analyze the responses to the test questions.

Achievement Post-Test I

After four weeks of the experiment, all the students took the achievement Post-test I. There were 40 multiple choice items in this test, also designed by the researcher. The test covered two areas of content: logic gates and Boolean function simplification. The test was used to judge the performance of the two groups of students who were subjected to different teaching strategies.

Achievement Post-Test II

After eight weeks of the experiments, all the students took the achievement Post-test II. Almost the same as the procedure of the achievement Post-test I, there are also 40 multiple choice items in this test. This test covered two areas of content: the design and the practice of combinational logic circuits. The test was used to judge the performance of the two group of students who were under different teaching strategies.

Achievement Final Examination

After 12 weeks of the experiment, all the students took the achievement final examination. The content of this test was 20 items from logic gates to Boolean function, simplification and 20 items from the design and practice of combinational logic circuits. The final exam was a paper and pencil test which consisted of 40 multiple choice items. This comprehensive final exam instrument was developed by the researcher.

The Execution of the Teaching Experiment

As the author mentioned in an earlier section, the students were divided into two groups, i.e., one experimental groups and one control group. The experimental group was taught through computer simulation and lecture, and the control group instruction has the same lecture but experienced traditional laboratory practice. In order to eliminate the irrelevant factors, all the groups used the same textbooks, the same course materials and the same practice content. Additionally, the teacher was the same. All materials and instruction were presented in Chinese.

The students took the 3-hour logic design course every week. Because of the inflexibility of the course hours for those college students, the courses were assigned to the afternoon of Friday and the morning of Saturday. The first hour was used to describe the logic circuits and the practice items, and for the next two hours the students are separated into the appropriate group for the computer simulation or practice laboratory for procedures as required in the experiment, depending on to which group the student belonged. Table 3 specifies the teaching date and the lower case content or activity on that date.

Table 3

Schedule and Unit

Date	Content of Teaching
Feb 21-22	Group division and pretest
Feb 28 Mar 1	Digital system, basic logic gate and real value table, introduction to 74 series of logic gate, logic gate output characteristics
Mar 7-8	Logic gate output characteristics, logic gate interchange, Brule function and logic circuit, maximum and minimum values of Brule function
Mar 14-15	Boolean Algebra, rules and laws of Boolean Algebra. DeMorgan lows.
Mar 21-22	Boolean function simplication
Mar 27-28	Post achievement assessment test (1)
	Youth's Day and Spring Break
Apr 11-12	Assembly logic design procedure, compulsion or gate design
Apr 18-19	Half adder design
Apr 25-26	Full adder design, comparator design
May 2-3	Combination logic circuit
May 9-10	Post achievement assessment test (2)
	Functions minimization
May 16-17	Decoder circuit design, multiplexer circuit,
May 23-24	Binary counter circuit experiment and BCD counter circuit experiment
May 30-31	Demultiplexes circuit experiment, Logic gate application.
June 6-7	Final examination

The Design of the Experiment

This study used a two groups experimental design in order to determine the effects of the independent variable on the dependent variable. This type of design involves comparisons between the two groups to which subjects have been randomly assigned (Mason & Bramble, 1978). Random assignments were used to establish equivalency between the two groups in the study.

The flow of the experiment and the design for the test are described as follows :

Control : R T O1 T O2 T F

Experimental: R S O1 S O2 S F

where

R : pre-test

O1 : achievement post-test I

O2 : achievement post-test II

F : achievement final-test

S : lecture and computer simulation

T : lecture and traditional practice

For the dependent variable measures, this experiment can be divided into achievement Post-test I, achievement Post-test II, and final exam. The independent variable is the different teaching strategies with two level, one level is lecture plus simulation, and the second is lecture and traditional laboratory. The pre-test is a control measure for prior knowledge of the subject in the experimental. In this study, the researcher randomly assigned subjects to particular groups. The experimental group received the pretest, experimental treatment, Posttest I, experimental treatment, Posttest II, experimental treatment, and the final exam, while the control group received the pretest, traditional treatment, Posttest I, traditional treatment, Posttest II, traditional treatment, and final exam (the posttests). The variables of the study are described as follows:

Levels of the Independent Variable:

The following levels of the independent variable were studied:

1. Lecture plus computer simulated laboratory instruction.

2. Lecture plus traditional laboratory instruction.

Dependent Variables:

The following dependent variable measure were used: Posttest I, Posttest II, and Final exam scores.

Data Processing

After the pre-test, achievement Post-test I and achievement Post-test II and final test, we started the coding and computer program writing. The analysis work was accomplished by SPSS/Windows for PC. In order to achieve the goal of this research, we appropriately took the t-test and ANCOVA; and employed the .05 significant standard.

The Hypotheses of the Research

The hypotheses for this study are noted as below. The null hypotheses are necessary for four measures: a pretest, a first posttest, a second posttest, and a final examination, that will compare the mean scores of an experimental and control group of students.

1. There is no significant difference between the pretest mean scores of the experimental and control groups. There is no obvious difference in the knowledge background about the basic electrical engineering between the students of the two groups. This assumption is to test if there is any difference between the prior basic logic circuits knowledge of the two groups.

Ho : UE,pre = UC,pre.

Ha : UE,pre $\neq$ UC,pre.

2. There is no significant difference between the mean scores of the adjusted experimental and control groups as measured by a post-test I. There is no obvious difference between the achievement post-test score of the students in the two groups. Here the covariate is the pre-test scores. This hypothesis is to test the achievement of the students for basic logic gate and Boolean simplification after 4 weeks of instruction in the content one.

Ho : UE,post I = UC,post 1.

Ha : UE,post I $\neq$ UC,post 1.

3. There is no significant difference between the mean scores of the adjusted experimental and control groups as measured by a Post-test II. There is no obvious difference between the achievement Post-test II score of the students in the two groups. Here the covariate is the achievement post-test I scores. This assumption is to test the achievement of the students for combinational logic circuit design with 4 weeks instruction in the content.

Ho : UE,post 2 = UC,post 2.

Ha : UE,post 2 $\neq$ UC,post 2.

4. There is no significant difference between the mean scores of the adjusted experimental and control groups as measured by a final exam with a pre-test covariance. There is no obvious difference between the final score in the two groups. Here the covariate is the pre-test scores. This assumption is to test the achievement of the students of the two groups for combinational logic design after 12 weeks.

Ho : UE,final = UC,final.

Ha : UE,final $\neq$ UC,final.

Simulation Programs

The computer simulation program that was used in this study is a schematics capture program called Schematics (the evaluation version of the 5.1 release of The Design Center) distributed by the MicroSim Corporation.

Schematics is a schematic capture program with a direct interface to the PSpice circuit simulator and the Probe waveform analyzer. Schematics' editing capability provides a simple way to create and edit circuit diagram, as well as create new parts. This integrated system provides a complete environment for designing and using Probe, all can be run without leaving the Schematics environment.

Schematics provides pull-down menus and dialog boxes for specifying analysis parameters and running simulations directly from the schematic. There is no need to exit the system and invoke another software package to perform a circuit analysis. If device simulation parameters need adjustment after a simulation is run, they can be easily modified and the simulation rerun. Netlists for PSpice are generated automatically and can be examined on the screen. The electrical rule checker inspects the electrical connections on the schematic before the simulation is run. Probe may also be activated through the Schematics environment. Schematic pins and net name are used instead of arbitrary node numbers.

PSpice and its options form an integrated package for analyzing electronic and electrical circuits. That is, PSpice will calculate a circuit's voltages and currents and in some cases, derived quantities such as group delay. Think of PSpice as a "software breadboard." You can perform the same measurements that you would do with an actual circuit and many others that would not be feasible with a breadboard.

Probe is the waveform analyzer for PSpice. Using high-resolution graphics, Probe allows you to view the results of a simulation both on the screen and on hard copy. In effect, Probe is a "software oscilloscope." Running PSpice corresponds to building or changing a breadboard, and running Probe corresponds to looking at the breadboard with an oscilloscope (MicroSim Corporation, 1992).

Summary

The object of this chapter is the description of our teaching experiment, in order to investigate the influence of different teaching strategies to the college students in the area of the combinational logic design. The students were divided into two groups, one labeled as the experimental groups and one recognized as the control group. The contents of this experiment are (a) experiment sample, (b) tool of measurement, (c) the execution of the teaching experiment, (d) the design of the experiment, (e) data processing, (f) the hypotheses of the research, and (g) simulation programs.

CHAPTER IV

DATA ANALYSES AND DISCUSSIONS

In this chapter discussions on research data have been conducted according to the analysis of variance (ANOVA), analysis of covariance (ANCOVA), reliable data test, and the Kuder-Richardson reliability (KR-20) for the classroom tests. The results of this study will be presented and discussed as they relate to the hypotheses of the study as presented in Chapter I. Each of the four hypotheses is presented and the relevant results are discussed, in order to understand the differences between the said teaching methods in the assembly logic circuit design course. Here is a description of the results of data analysis.

Sample Description

The population of this study consisted of college students who enrolled in the fall semester of 2000 in the department of electronic engineering at Chun-Chou Institute of Technology in Taiwan. A total of 87 students participated in this study, 5 students dropped out from the program, and 82 students have completed the entire program. Students were divided into two groups: 40 students (49%) were assigned to the traditional teaching method group; and 42 students (51%) were assigned to the computer simulation teaching method group. See Table 4.

Table 4

Sample Distribution of Experiment

Basic Data	Number of Students	Percentage
Traditional Teaching Method	40	49%
Computer Simulation	42	51%

Measuring Tool

The measurement method of this experiment was divided into (a) Pretest of achievement assessment; (b) post achievement assessment test I; (c) post achievement assessment test II; and (d) final examination, in order to collect the experiment results.

Pretest of Achievement Assessment

The researcher designed this pre-test instrument; all the students were tested before they joined the experiment. The pre-test was a paper and pencil test, which consisted of 30 multiple choice and 10 false/true items. This test was designed to be used as a covariate to control for initial differences in the students' background and knowledge of electronics and their ability to regard analysis and design of problems related to logic design. The KR-20 reliability factor of the test was .74, score mean was 44, and standard error was 1.762 as shown in Table 5 (refer to Appendix A).

Table 5

Analysis on Pretest

Number of Questions	Mean	Standard Error	KR-20
40	44	1.762	.74

Post Achievement Assessment Test I

After four weeks of the experiment, all the students took the achievement Post-test I. There were 40 multiple-choice items in this test. The test covers two contents: logic gates and Boolean function simplification, which is used to judge the performance of the two group of students who are under different teaching strategies.

The score mean was 68.93, standard error was 1.688, and the reliability factor was .82, as shown in Table 6 (refer to Appendix B).

Table 6

Analysis on Post Achievement Assessment Test I

Number of Questions	Mean	Standard Error	KR-20
40	68.93	1.688	.82

Post Achievement Assessment Test II

After eight weeks of the experiment, all the students took the achievement Post-test II. Almost the same as the procedure of the achievement Post-test I, there are also 40 multiple-choice items in this test. This test covers two areas of content: the design and the practice on the field of combinational logic circuits, which is used to judge the performance of the two group of students who are under different teaching strategies and the score mean was 84.90, standard error was 1.008, and the reliability factor was .85, as shown in Table 7 (refer to Appendix C).

Table 7

Analysis on Post Achievement Assessment Test II

Number of Questions	Mean	Standard Error	KR-20
40	84.90	1.008	.85

Final Test

After 12 weeks of the experiment, all the students took the achievement final examination at the end of the study. The final exam was a paper and pencil test which consisted of 40 multiple choice items, and the score mean was 78.65, standard error was 1.612, reliability factor was .80, as shown in Table 8. The comprehensive final exam consisted of 20 items from logic gates to Boolean function simplification and 20 items of the design and the practice of combinational logic circuits (refer to Appendix D).

Table 8

Analysis on Final Test

Number of Questions	Mean	Standard Error	KR-20
40	78.65	1.612	.80

Analysis of Differences to Achievement Assessment

The hypotheses for this study are shown as below. The null hypotheses necessitated four measures: a pre-test, a first post-test, a second post-test, and a final examination, that were used as appropriate to compare the mean scores of an experimental and control group of students.

Analysis on Pretest of Achievement Assessment

Hypothesis 1: No significant difference was found in the pretest score mean in two groups regarding background knowledge in basic electricity and electronics. (There is no significant difference between the pre-test mean scores of the experimental and control groups).

This assumption is to test if there is any difference between the basic logic circuits knowledge both the two group.

Ho : $\mu E,pre = \mu C,pre.$

Ha : $\mu E,pre \neq \mu C,pre.$

Results of Table 9 show, $t = 4.78$, $p<.05$, which was higher than the significance level and therefore reject the null hypothesis, i.e., there is a significant difference in the pretest scores of two groups. In other words, there was a significant difference in circuit knowledge, background, and abilities to analyze, calculation and assessment of related problems of two groups. The traditional method was superior to simulation, consequently, all subsequent tests were done through ANCOVA procedures.

Table 9

The t-test Between two Groups on the Pretest

Group	N	Mean	SD	t Value
Control	40	48.48	13.24	4.78*
Experiment	42	35.14	11.88	

Analysis of Teaching Methods Through Post Achievement Assessment Test I

Hypothesis 2: No significant difference in score mean of post achievement assessment test I of two groups under the influence of the covariate (pretest score). (There is no significant difference between of the adjusted experimental and control groups as measured by a Post-test I).

This assumption is to test the achievement of the students of the two groups for basic logic gate and Boolean simplification after 4 weeks.

Ho : μE,post I = μC,post 1.

Ha : μE,post I $\neq$ μC,post 1.

Results of the regression and homogeneity test show in Table 10, that F = 1.68, p = .198 >.05, which are below the significance level and suggest that the inclination rate of all methods is similar and complies with the basic assumption of homogeneity in inside group regression factors, then we moved on to the ANCOVA.

Table 10

Summary of Regression and Homogeneity Test on Scores of Post-test I of Two Groups

Source	SS	DF	MS	F Value
Regression	264.28	1	264.28	1.685
Residual	12254.57	78	157.11	

Table 11 shows the results of ANCOVA, after removing the covariance of 'influences of pre-test, it reaches the significant level, $F = .09$, $p = .77 > .05$, i.e., there is no significant difference in scores of post-test I. Either method produced similar achievement.

Table 11

ANCOVA on Scores of Post Achievement Assessment Post-test I of Two Groups. Covariant is the Pre-test.

Source	SS	DF	MS	F Value
Treatment	13.38	1	13.38	.086
Error	12519.25	79	158.47	

The comparison of the results of Table 12 shows, after removing the covariance of 'pre-test, the scores of post-test I in two groups are: control group (mean 65.96), and computer simulation teaching method (mean 65.04).

Table 12

Adjusted Mean of Scores in Post-test I of Two Groups

Group	N	Means	SD	Adjusted means
Control	40	71.27	10.08	65.96
Experiment	42	62.24	16.32	65.04

Analysis of Teaching Methods Through Post Achievement Assessment Test II

Hypothesis 3: No significant difference in score mean of Post Achievement Assessment Test II of two groups under the influence of the covariance (Post-test I). (There is no significant difference between the mean scores of the adjusted experimental and control groups as measured by a Post-test II).

This assumption is to test the achievement of the students of the two groups for combinational logic design after 8 weeks.

Ho : $\mu E,post\ 2 = \mu C,post\ 2$.

Ha : $\mu E,post\ 2 \neq \mu C,post\ 2$.

Results of the regression and homogeneity test shown in Table 13, that $F = .33$ $p = .57 > .05$, which are below the significance level and suggest that the inclination rate of all methods is similar and complies with the basic assumption of homogeneity in inside group regression factors. Then we moved on to the ANCOVA .

Table 13

Summary of Regression and Homogeneity Test on Scores of Post-test II of Two Groups

Source	SS	DF	MS	F Value
Regression	26.63	1	26.63	.328
Residual	6335.92	78	81.63	

Table 14 shows the results of ANCOVA, after removing the covariance of influences of post achievement assessment test I. The reaches the significance level, $F = .39$, $p = .538 > .05$, i.e., there is no significant difference in scores of post-test II .

Table 14

Results of the ANCOVA on the Post-test II.

Source	SS	DF	MS	F Value
Treatment	30.80	1	30.80	.385
Error	6362.55	79	80.59	

Note: The covariant is post-test I.

The comparison of the results of Table 15 shows, after removing the covariance of 'post achievement assessment test I, the scores of post-II in two groups are control group (mean 82.54), and computer simulation teaching method (mean 81.27).

Table 15

Adjusted Mean of Scores in Post-test II of Two Groups

Group	N	Means	SD	Adjusted means
Control	40	83.25	8.48	82.54
Experiment	42	80.60	10.13	81.27

Analysis of Teaching Methods Through the Final Examination

Hypothesis 4: No significant difference in score mean of final achievement assessment test of two groups under the influence of the covariance (pre-test). (There is no significant difference between the mean scores of the adjusted experimental and control groups as measured by a final exam with a pre-test covariate).

This assumption is to test the achievement of the students of the two groups for combinational logic design after 12 weeks.

Ho : $\mu E, final = \mu C, final$.

Ha : $\mu E, final \neq \mu C, final$.

Table 16 shows, $F = 1.110$, $p = .295 > .05$, which is below the significance level and suggests that the inclination rate of two groups is similar and complies with the basic assumption of homogeneity in inside group regression factors. The author moved on to the ANCOVA.

Table 16

Summary of Regression and Homogeneity Test on Score Mean of Post-test of Two groups

Source	SS	DF	MS	F Value
Regression	165.29	1	165.29	1.11
Residual	11613.26	78	148.89	

Table 17 shows the results of ANCOVA, after removing the covariance of influences of post-test II scores, it reaches the significant level, F=.415, $p = .521 > .05$, i.e., thus there was no significant difference in score means of post achievement assessment tests.

Table 17

ANCOVA on Score Mean of Final Test of Two Groups

Source	SS	DF	MS	F Value
Treatment	61.89	1	61.89	.415
Error	11778.55	79	149.10	

Note. The covariant is pre-test.

The Table 18 shows, after removing the covariance of influence of post-test II, the score mean of post achievement assessment tests in two groups are: control group mean (75.60), and computer simulation teaching method (mean 77.36). The difference is not statistically significant.

Table 18

Adjusted Mean of Scores in Final Test of Two Groups

Group	N	Means	SD	Adjusted means
Control	40	76.15	14.04	75.60
Experiment	42	76.88	11.30	77.36

Verification of Assumptions

In this section, assumptions of the research are examined and statistical results are produced. Here are the conclusions of simple reduction done on the four assumptions of research:

Hypothesis 1: There was significant difference found in the assembly logic pretest for year 3 electrical engineering students of junior college.

Results show that there was significant difference in the pretest score of students of two groups. In other words, there are significant differences of all samples regarding circuit knowledge, background, and abilities to analysis, calculation and assessment. The finding necessitated using ANCOVA procedures for all further hypotheses.

Hypothesis 2: No significant difference in score means of Post-test I of two groups under the influence of the covariance (pretest score).

Data analysis of Hypothesis 2 shows, after removing the pretest covariance, found no significant difference of the score mean of post-test I of two groups, i.e., the efficacy of both two methods is similar.

Hypothesis 3: No significant difference in score mean of Post-test II of two groups under the influence of the covariance (Post Achievement Assessment Test I).

After eight weeks of the experiment, results are similar from hypothesis 2. Examination of Hypothesis 3 shows, after removing covariance post-test I, there is no significant difference between the two groups.

Hypothesis 4: No significant difference in score mean of final-test of two groups under the influence of the covariance (pretest score).

Examination of Hypothesis 4 shows, there was no significant difference in score means of final-test after removing the covariance of the pretest .

Summary

In this chapter, analysis and discussions on research data have been conducted according to the t-test, analysis of covariance (ANCOVA), and the Kuder-Richardson reliability (KR-20). Each of the four hypotheses is presented and the relevant results are discussed in order to understand the differences between the said teaching methods in the assembly logic circuit design course. The experimental and control groups were significantly different on prior knowledge of basic electricity and electronics, the students learned under both teaching methods, but there were no significant differences in achievement between the two teaching methods.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The earlier portion of this study dealt with the introduction of the study, a review of the literature, the procedures and methods of research, date analysis and discussion. The purpose of this chapter is to summarize the preceding chapters, draw conclusions based on the findings, and present recommendations.

Summary

This study was designed to evaluate the effectiveness of computer simulated laboratory instruction and compare it versus traditional laboratory instruction (utilizing actual electronics components) for educating community college students in skills and knowledge of combination logic circuitry.

The purposes of the study were to show whether there are differences between computer simulated laboratory instruction and traditional methods of laboratory instruction. Specifically, this study was concerned with answering the following combined objectives:

1. Compare the achievement levels of community college students who are receiving the computer simulated laboratory instructions with students who are receiving the traditional from of laboratory instruction.

2. Evaluate the effectiveness of computer simulated laboratory instruction in with traditional laboratory instruction educating college students in combination logic circuitry.

The computer simulation program that was used in this study was a schematic capture program called Schematics (the Evaluation version of the 5.1 release of The Design Center) distributed by the MicroSim Corporation.

The population of this study consisted of college students who enrolled in the fall semester of 2000 in the Department of Electronic Engineering at Chun-Chou Institute of Technology in Taiwan. A total of 87 students participated in this study, 5 dropped out and 82 completed assigned phases. The researcher randomly assigned subjects to one of two groups. A pretest-posttest experimental and control groups' design was used in this experiment.

A total of four measuring instruments were used to collect data in this study. The experimental group received the pretests, experimental treatment, Posttest I, experimental treatment, Posttest II, experimental treatment, and final examination. The control group received the pretests, traditional treatment, Posttest I, traditional treatment, Posttest II, traditional treatment, and final examination. It should be noted that the sequences for the two methods were not the same for both groups.

The pre-test instrument was designed by the researcher. All the students were subjected to a pre-test before they participated in the experiment. The pretest was a paper and pencil test that consisted of 30 multiple choice and 10 true/false items. This test was designed to be a covariates to control for initial differences in the students' background and knowledge of electronics and their ability to evaluate, compute, and analyze the responses to the test questions. The pre-test determined prior knowledge for electronics theory and electrical theory. The KR-20 reliability coefficient was .74.

After four weeks of the experiment, all the students completed the achievement Post-test I. There were also 40 multiple choice items in this test which was used to judge the performance of the two groups of students who were under different teaching strategies. The content which was Boolean Algebra, rules and laws of Boolean Algebra, function and Karnaugh maps, combination logic and functions of combination logic. The KR-20 reliability coefficient was .85.

After 12 weeks of the experiments, all the students took the achievement final examination at the end of the study. The final exam was a paper and pencil test that consisted of 40 multiple choice items, that was also developed by the researcher. The final exam content was comprehensive since all topics from Post-test I and Post-test II were included. The KR-20 reliability coefficient for comprehensive content was .80.

Research Findings

The findings of this study eminated from scrutinizing the statistical data and interpreting those results. The researcher determined the following five research findings.

1. There is a need to repeat this study but use higher reliability coefficient instruments constructed to better reflect the course objectives and to better measure higher order thinking skills. The research results noted in the literature agree with such a finding, similar results found in earlier research are noted in the following sentences.

More complex problem solving and a higher order of integrated thinking skills if required, would perhaps have yielded additional significant differences. Also, the computer-based learning program could be used in an integrating mode rather than in the experiencing mode as it was in this study. In an integrating mode, the computer program is used to provide an opportunity to apply previously learned material to new situations as well as to associate previously unconnected ideas (Thomas & Boysen, 1984).

Chuang (1990) found a significant difference between simulation and traditional instruction in the time it took students to troubleshoot and repair color T.V. sets.

Hwang (1989) found that students who worked on computer simulation with a partner scored as well as those who were provided traditional instruction, however, they asked the teacher fewer questions in carrying out their laboratory assignments.

Diedrick and Thomas (1977) found that high school students in automotive mechanics who used the computer simulation method of instruction performed significantly better than the traditional instructional group in diagnosing ignition problems.

Thomas and Hooper (1991) reported that simulation may be useful for reinforcing complex sequences. In using these simulations, the authors maintained, that the learner is forced to assume responsibility for executing the process whereas in alternative methods, the learner responds to external questions or instructions.

2. The review of literature shows the efficacy of computer simulation in instruction of engineering courses may not be better than traditional oral briefing or use of physical electronic components; and the variety of computer simulation software does not have major influences on efficacy of engineering course instruction; while different teaching strategies (i.e., different sequence process) have considerable influence on teaching efficacy.

3. There is no direct relation between teaching efficacy of logic circuit design and variety of computer simulation software; while the correlations among strategy, content and practical unit is considerably important.

4. Practice of logic circuit of two education methods of computer simulation and traditional teaching. In computer simulation at the initial stage, students must spend more time to be come familiar with the software because it is not as close to real circuitry as before. But after few days, they can adequately use the software. Besides, one point we must notice and improve on, is that after finishing practice, both groups of students did not use the laboratory time well.

5. Future research should focus on diagnosis, synthesis of complex concepts and evaluation of consequences of practical problems in assessing the effectiveness of computer simulation instruction.

Conclusions of Research

The following conclusions address the problem of the study and the result from analyzing and interpreting the date. No attempt is made to generalize to other groups or content areas. With the data, we summarized the major hypotheses of the study and their testing results as follows:

Hypotheses 1

Since the calculated t-value was 4.78, which is significant at 0.05 level, Null Hypothesis 1 was rejected. There is a significant difference between the pretest mean scores of the experimental and control groups. (There is an obvious difference in the knowledge background about the basic electrical engineering between the students of the two groups). This conclusion implies that the random assignment of the subjects produced differences in groups. This knowledge necessitated the use of covariate analysis on all other hypothesis evaluated.

Hypotheses 2

There was no significant difference between the adjusted group mean scores of the two groups in Posttest I as indicated by an F-value of 0.09. Therefore, the Null Hypothesis 2 was not rejected. There is no significant difference between the mean scores of the adjusted experimental and control groups as measured by a Post-test I with a pretest covariance. This conclusion suggests that both methods of instruction produced similar results.

Hypotheses 3

There was no significant difference between the adjusted group mean scores of the experimental and control groups as indicated by an F-value of 0.38, which is not significant at 0.05 level. Therefore, Null Hypothesis 3 was not rejected. There is no significant difference between the mean scores of the adjusted experimental and control groups as measured by a Post-test II with a Pre-test I covariance. This conclusion suggests that both methods of instruction tended to produce similar effects.

Hypotheses 4

There was no significant difference between the mean scores of the adjusted experimental and control groups as measured by a final exam with a pre-test covariance. The F-value was .415, which is not significant at 0.05 level. Therefore, Null Hypothesis 4 was not rejected. There is no significant difference between the mean scores of the adjusted experimental and control groups as measured by a final exam with a pre-test covariance.

By the testing results of these four hypotheses, the following conclusions are drawn up according to the experiment and scores of achievement assessment.

1. Results of analysis on experiment and statistics show that the student's performance in achievement assessment (1) and (2) on teaching method after 4 weeks and 8 weeks do not have significant superiority between traditional and computer simulation teaching methods.

2. However, the student's performance in achievement assessment (final test) on the teaching method group after 12 weeks showed higher mean scores for computer simulation compared to traditional teaching methods. So we may foresee the efficacy might be improved after a longer period of time and further study is warranted. At the very least, cost benefits alone would warrant switching to computer simulation for laboratory practice as traditional methods proved better.

3. Computer simulation has many advantages in circuit design, such as, convenience, rapidity, and cost saving so that computer simulation is applicable for most circuit programs. However, computer simulation can not realize operational experience and information of interaction in practical formats. So, traditional practice should still be existed in necessity.

4. If a combined method can be used in assembly logic design and related programs of engineering colleges might be able to enhance teaching efficiency.

<u>Suggestions for Future Research</u>

The following future works are recommended based upon the findings of this study and the experiences gained from conducting this experiment.

1. This study should be replicated to verify its results and findings.

2. There is a need to expand the number of items to 60 or 80 in order to improve the reliability of the test items.

3. There is a need to conduct research with a larger group of students, the use of simulation on more complex concepts of circuitry and applications requiring actual analysis, troubleshooting, evaluation, and repair.

4. There is a need to extend the period of instruction to a longer period to at least 16 weeks.

5. One instructor should provide all phases of instruction to each group, the treatment as well as control group, in order to eliminate instructor bias.

6. Student learning style should be used as an independent variable to determine what effects simulation does produce.

7. The assembly logic design programs shoud be adaptable to the following concerns:

a. Longer period of time and more units

This research focused only on assembly logic design, and future researches should cover serial logic design, in order to explore various practical teaching strategies and the differences in efficacy of such strategies.

b. Increasing of number of samples.

Though the experiment of this research has been carried out on 87 samples divided into 2 groups, the number of valid samples were insufficient one way or another to conclude the efficacy experiment on all engineering students taking assembly logic design program. Therefore, if we can remove the problems regarding lab facilities and time for class, we may increase the number of samples in future research.

8. The remaining variables should be expanded.

Considering factors affecting efficacy, such as ability to logical thinking, learning sequence, and cognitive pattern. It is further suggested that follow-up research should consider related variables or adopt dual-factor experiment design to make in-depth exploration as reference for teaching methods of engineering or technical subjects at the college level.

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APPENDIX A

PRE-TEST

PRE-TEST

DIRECTIONS: Select the letter of the choice for each statement below which best completes the statement or answers the question. Circle the letter of your choice for each item number.

Students name:

FALSE / TRUE : (1-10)

( ) 1. Putting a resistance of 3Ω, a electric capacity impedance of 3Ω, electric inductance impedance of 7Ω become series, then its total impedance is 5Ω。

( ) 2. If a battery of 1.5V can supply maximum current is 3A, then when we put 4 batteries series, the maximum current it can supply is 12A。

( ) 3. The value that common AC voltmeter point out is wink value。

( ) 4 At a CE transistor circuit, emitter current is 5mA, base current is 1mA. Then current gain in this circuit is 500

( ) 5. If a transistor's α=0.99, then β = 86。

( ) 6. If putting a resistance of 12Ω, a impedance of 5Ω series, its total impedance is 13Ω。

( ) 7. The LSI means how many logic gates at least does a wafer have 100。

( ) 8. At an oscilloscope we measure a waveform, its period is 50μs, then we can know its frequency is 20KHz。

(   ) 9.   At n-type semiconductor, conduction current's carry almost is hole。

(   ) 10.   If at diode , P end connect to negative voltage, N end connect to positive voltage, then the current it produced call reward current。

CHOICE : (11-40)

(   ) 11.   Which work does the diode can't do ? ①commutation ②galvanoscopy ③amplify ④cut wave。

(   ) 12.   When a transistor works as a switch, which kind of range does a transistor work at ? ①cut off ②linear ③broken down ④saturation。

(   ) 13.   At bipolar transistor state, which one have lower input impedance?

①common base (CB)   ②common correct (CC)

③common emitter (CE)   ④no difference between them。

(   ) 14.   The relation between AC frequency (f) and period (T) is

① proportional   ② inverse proportional   ③ geometric ratio

④no relation。

(   ) 15.   Electron Volt is what kind of physics unit ?

①electric potential ②electric field intensity ③energy ④voltage。

( ) 16. Twp 60W light bulbs when them are series connection, the power that each light bulb consumes is ①120W ②60W ③30W ④15W。

( ) 17. Putting a DC source 50V and three resistors 2Ω、3Ω、5Ω to become a series circuit , then the voltage between 3Ωresistance is ① 15V ② 30V ③ 10V ④ 20V。

( ) 18. The light bulb resistance of 100V/100W is ①smaller than ②larger than ③equal to ④can compare 100V/200W light bulb resistor。

( ) 19. A conducting wire pulls 3 times at its length, its resistance will become ? times compare to the original ① 3 ② 9 ③ 1/3 ④1/9。

( ) 20. At common circuit, when the temperature increases, its isolated resistance will become? ① decrease ② increase ③ no change④unstable。

( ) 21. A 300V voltmeter, its inside impedance is 34,000Ω. Now we want measure 600Voltage, the outside resistors we need to put it series is ① 17,000Ω ② 34,000Ω ③ 51,000Ω ④ 68,000Ω。

(   ) 22. A 150V DC voltmeter with inside impedance is 12,000Ω. When we put a resistor of 36,000Ω series, its measure range can expand to ① 300V ② 450V ③ 600V ④ 750V。

(   ) 23. A ammeter with full scale is 1mA, inside resistance of 50Ω. If we want to expand to 0~100mA, it resistor of shunt should be ? ① 1 ② 0.5 ③ 0.505 ④ 0.3Ω。

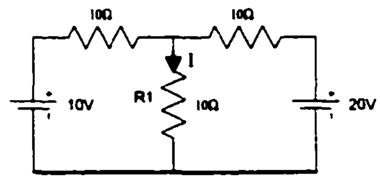
(   ) 24. An ammeter with inside resistance of 0.5Ω, resistor of shunt is 0.1Ω. If we read ammeter is 2A, then the total current of this circuit is ① 2 ② 6 ③ 12 ④ 120A。

(   ) 25. An RC series circuit , C=0.05μF, R=100K, its time constant is ①$2\times10^3$sec ② 10^3sec ③ 0.5m sec ④ 5m sec。

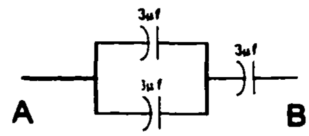
(   ) 26. A motor-driven machine connect to a AC source of 220V,60Hz, its pass current is10A, current lag behind voltage60°, the average power is ① 0.5KW ② 1KW ③ 1.1KW ④ 1.2KW。

(   ) 27. After putting n the same resistors series, add DC voltage to each end, its consume power is P_1 ; if put n the same resistors parallel, add DC voltage to each end, its consume power is P_2。 Then the ratio of P_1/P_2 is ① n ② 1/n ③ n^2 ④ $/n^2$。

( ) 28. The current pass R1 is ① 0.5A ② 1A ③ 2A ④ 4A。



( ) 29. The capacity between A、B is ① 3μf ② 9μf ③ 6μf ④2μf。



( ) 30. Putting 4 resistances of 1.5V with inside impedance is1Ω series, the power of the load can supply is① 2.25W ② 9W ③ 1.5W ④ 4.5W

( ) 31. After put three resistances 20Ω、30Ω、50Ω series, we connect it to a DC source of 110V, then the power dose the resistance of 50Ωconsume is① 20W ② 30W ③ 50W ④ 100W。

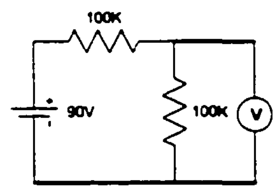
( ) 32. When the power factor is 1, the phase difference between voltage and current is ① 90° ② 60° ③ 30° ④ 0°。

( ) 33. After a sine wave through a full-wave rectification, we measure the peak to peak voltage is 100V, then its root mean square (rms) is ① 14.14V ② 28.28V ③ 70.7V ④ 282.8V。

( ) 34. At AC circuit, AC voltage and current value are : e=50cos(ωt+30°) V, i=2sinωt A, then the phase relation between each other is ① voltage current 120° ② voltage gets behind of current120°③ voltage gets ahead of current30° ④ voltage gets behind of current30°。

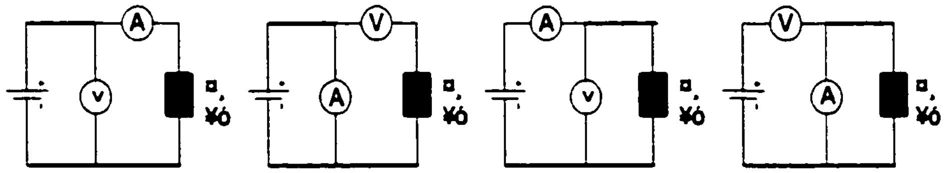
( ) 35. A resistor of 5Ω add a voltage $v=100\sqrt{2}$ sinωt V, then the effective value of current that through the circuit is① 20 ② $20/\sqrt{2}$ ③ 40 ④ $40\sqrt{2}$ A。

( ) 36. As the figure shows, if inside resistance is 100KΩ, its reading on voltmeter is ①30V ② 45V ③ 60V ④ 90V 。



( ) 37. If we want use voltage and ammeter at the same time to measure "low impedance "device's current and the end voltage, we should use what kind of style measurement so that it has the smallest mistake.

① ② ③ ④



(   ) 38. We can measure AC100V at home by an oscilloscope, its peak value is

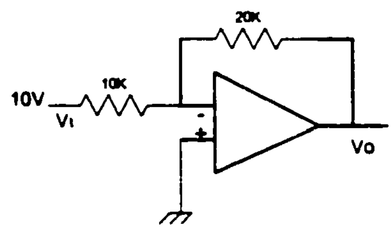
① 110V ② 141.4V ③ 70.7V ④ 55V 。

(   ) 39. Input waveform is squall wave, if we want output waveform is tangential wave, what kind of circuit we should choose?

① differential circuit ② integral circuit ③ commutate circuit

④ cut off circuit

(   ) 40. As the figure shows, operation amplify output voltage is ① 5V ② 0V ③ -5V ④ -20V。



APPENDIX B

POST-TEST I

POST-TEST I

DIRECTIONS: Select the letter of the choice for each statement below which best completes the statement or answers the question. Circle the letter of your choice for each item number.

Students name:

1. ( ) In the decimal system $79_{(10)}$ which in the binary system is ①01001111②01111001 ③01101011 ④01101101

2. ( ) Some number in the binary system is $01011010_{(2)}$, if it in the decimal system is①58②72 ③90 ④91 。

3. ( ) As the figureits symbol is what kind of logic gate ? ①AND gate ②OR gate③NAND gate④NOR gate

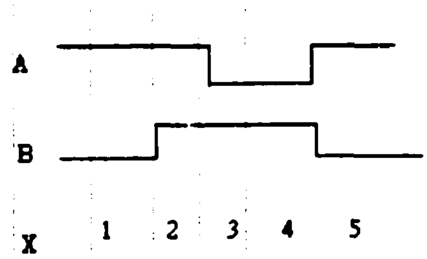
4. ( ) In the decimal system $32_{(10)}$ change to BCD number is①00110010 ②00100000 ③00100001 ④11011111。

5. ( ) In the decimal system $3_{(10)}$, its 2's complement should be ①1100 ②1101 ③1110 ④1101 。

6. ( ) 74 series digital logic is belong to what kind of logic circuit ? ①TTL ②ECL ③CMOS ④ I^2 L。

7. ( ) In 74 series TTL logic clan IC (ex:7400), its range in using source voltage is①3~5 V ②4.75~5.25 V ③-5~5 V ④-12~12 V 。

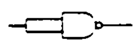
8. ( ) A、B and X is NAND gate input,output end, its input waveform is as the figure,in which time,X output will be 0 ?

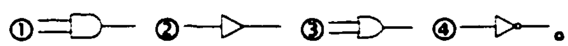


① time 1 ② time 2 ③ time 3and 4 ④time 5

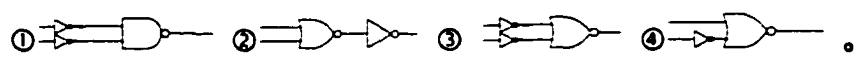
9 ( ) In the digital logic gate if, the input signal at least has one is "1". what kind of logic gate its output signal is"1" ①AND gate ②OR gate③NAND gate④NOR gate。

10. ( ) In the digital logic gate,if its input is all "1", what kind of logic gate its output signal is only "1" ①AND gate ②OR gate③NAND gate④NOR gate。

11. ( ) Logic circuit as the figure  equal to which circuit ?



12. ( ) Logic circuit as the figure  which gate's function is equal to it?

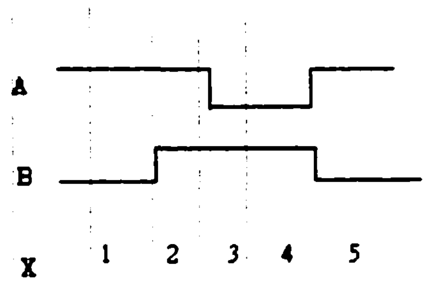


13. ( ) In Boolean function, the symbol as AND is ①X ② + ③• ④÷ 。

14. ( ) $f=\overline{A}$ mean ①AND gate ②OR gate ③NOT gate ④XOR gate 。

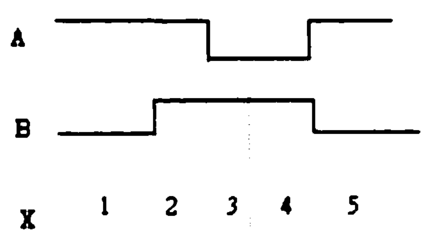
15. ( ) To simplify Boolean function $A+\overline{A}B$, then we can get ① $\overline{A}+B$ ② $A+B$ ③ $\overline{A}+\overline{B}$ ④ $A+\overline{B}$ 。

16. ( ) A、 B and X is NOR gate input, output end, is input waveform is as the figure, in which time, X output will be 1 ?



① time 1 ② time 2 ③ time 3and 4 ④impossible

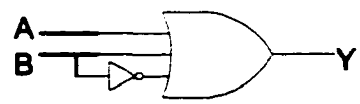
17. ( ) A, B and X is AND gate input, output pin, it input waveform is as the figure, in which time, X output will be 1 ?

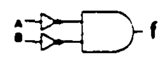


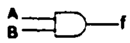
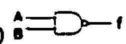
① time 1 ② time 2 ③ time 3and 4 ④time 5

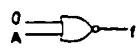
18. ( ) CMOS logic circuit, its input floating, which situation will occur? ①this input is high electric potential ② this input is low electric potential ③input floating has on effect to the circuit ④output will become unstable。

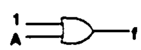
19. (　　) Logic circuit as the figure, if it connects only 5V. when its input A and don't connect to any signal, then the output Y= ? ①1 ②0 ③A ④B 。



20. (　　) Logic circuit as the figure  , which gate has the equal value ?

①  ②  ③  ④  。

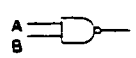
21. (　　) Logic gate as the figure  , its Boolean function equation is ① f =1 ② f =0 ③ f =A ④f= $\overline{A}$ 。

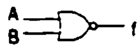
22. (　　) Logic gate as the figure  , its Boolean function equation is ① f =1 ② f =0 ③ f =A ④ f =$\overline{A}$ 。

23. (　　) X Brule function is $CD+EF+EGX$. If it has 2 input pins logic gate, how many AND gates does it need ? ① 2 ② 3 ③ 4 ④ 5

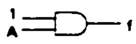
24. (　　) The same as 23, If it has 2 input pins logic gate, how many OR gates it need ? ① 2 ② 3 ③ 4 ④ 5

25. (　　) According to Boolean function rule, if $A = B = C = D = 1$, then which following is wrong ①$AB+CD$=1 ② $\overline{ABC}$=0 ③ $\overline{ABCD}$=1④ $\overline{A+B+C}$=0 。

26. (　　) Logic gate as the figure  , the Boolean function equation is① f =$\overline{A}+\overline{B}$ ② f = $A+B$ ③ f = $\overline{A}+B$ ④ f= $A+\overline{B}$ 。

27. ( ) Logic gate as the figure 

, the Boolean function equation is ① f = A . B ② f= $\overline{A+B}$ ③ f=$\overline{A}+\overline{B}$ ④ f=$A+B$ 。

28. ( ) Logic gate as the figure 

, the Boolean function equation is ① f =1② f=0 ③ f =A ④f=$\overline{A}$ 。

29 ( ) The Boolean function equation is X=AB+CD. If we use logic gate to connect lines then which following gate is its output ? ① OR gate ② AND gate ③ NOR gate ④ NAND gate

30. ( ) A 3 inputs NOR gate which inputs at what situation, its output is1(high electric potential i.e.5V) ?

① any one input connect to high electric potential ② any two inputs connect to low electric potential (i.e.0V) ③ 3 inputs all connect to high electric potential ④ 3 inputs all connect to low electric potential (i.e. 0V)

31. ( ) To simplify Boolean algebra is f = $A+\overline{A}$, then we can get ① f = A ② f = $\overline{A}$ ③ f =1 ④ f = 0 。

32. ( ) To simplify Boolean algebra is f = $\overline{\overline{A}}$, then we can get ①f = $\overline{A}$ ② f = A ③ f = 1 ④ f = 0 。

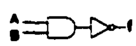
33. ( ) To simplify Boolean algebra is f = $X+XY$, then we can get ① f = X+Y ② f = Y ③ f = XY 。

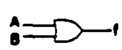
34. ( ) To simplify Boolean algebra is f = (A+B)C, then we can get ① f = $AC+BC$ ②f = $A+B$ ③ f = $AB+AC$ ④f=C 。

35. ( ) Boolean algebra is f = $\overline{X+Y}$. according to DeMorgans' law to make it simple, which following can get the same function ? ①f=XY ②f= $\overline{X}\ \overline{Y}$ ③f= $\overline{XY}$ ④f=$X+Y$ 。

36. ( ) Which following is Boolean algebra min item ? ① f = $A+B+C$ ② f= $AB+C$ ③ f = $\overline{A}BC$ ④f=$A+\overline{B}C$ 。

37. ( ) Which following is Boolean algebra max. item ? ① f = $\overline{A}+B+\overline{C}$ ② f = $A\overline{B}+C$ ③ f = ABC ④f = $\overline{AB}+\overline{C}$ 。

38. ( ) Logic circuit as the figure  , the max. item can express as ①f= $\overline{A+B}$ ②f= $\overline{AB}$ ③f= $\overline{A}+\overline{B}$ ④f=AB 。

39. ( ) Logic circuit as the figure  , the mix. item can express as ①f=$A+B$ ② $\overline{\overline{AB}}$ ③f=AB ④ f= $\overline{AB}$ 。

40. ( ) To simplify Boolean algebra is f = A+0, then we can get ① f = A② f = $\overline{A}$ ③ f = 1 ④ f = 0 。

APPENDIX C

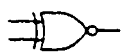
POST-TEST II

POST-TEST II

DIRECTIONS: Select the letter of the choice for each statement below which best completes the statement or answers the question. Circle the letter of your choice for each item number.

Students name:

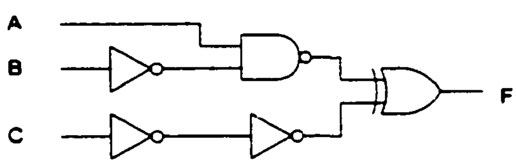
1. ( ) Point out which following is the symbol of XOR①  ② 

③ ④ 

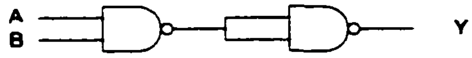
2. ( )  when A≠B, output Y is1 ; when A=B, output Y is 0 , then this logic gate should be①AND gate ②OR gate ③XOR gate ④NXOR gate 。

3. ( ) The change function of XOR is ① $\bar{A}$B+A$\bar{B}$ ② $\bar{A}$B+AB ③ AB+$\bar{A}\,\bar{B}$ ④ ($\bar{A}+\bar{B}$)(A+B)。

4. ( ) As the figure B=0 , C=1 then①Y=$\bar{A}$BC ②Y=A ③Y=B ④Y=C 。

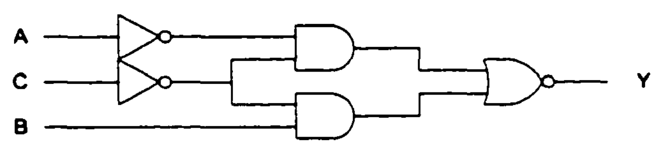


5. ( ) 2 NAND gates connect as following figure, it output Y = ①A+B ② $\overline{AB}$ ③AB ④A+$\bar{B}$。

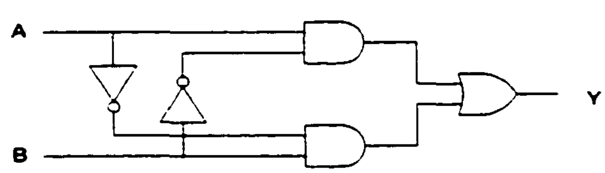


6. ( ) How many kinds of situations when Y output is "1" ? ①6 ②5 ③4 ④3。

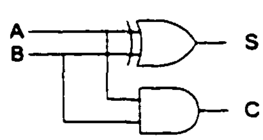
7. ( ) As the figure show, if we want to make output Y only "1", then input relation between A and B is ①A=0,B=0 ②A=0,B=1 ③A=1,B=0 ④A=1,B=1。



8. ( ) As the figure show, which following is right ? ①A=0,B=0 then Y=0 ②A=0,B=1 then Y=1 ③A=1,B=0 then Y=1 ④upword is right。



9. ( ) As the figure, Half adder S means ①sum ②different ③accumulate ④carry。



10. ( ) As the above figure, C means①sum ②different ③accumulate ④carry。

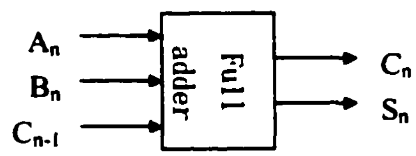
11. ( ) Half adder S equal to① A+B ② AB ③ A⊕B ④ $\overline{A \oplus B}$。

12. ( ) Half Adder C equal to ① A+B ② AB ③ A⊕B ④ $\overline{A \oplus B}$。

13. ( ) Half Adder input both "1", it θ and S output is ① 1 ② 0 ③ 1 and 0 ④ unstable。

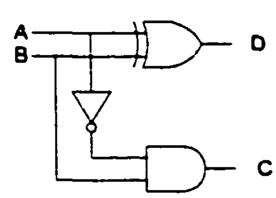
14. ( ) About Half Adder , which following is right ① only can sum in the binary system ② can sum in any system ③ can do multiplication in the binar system ④ can do sum, subtraction, multiplication, division, and operation。

15. ( ) As the figure is an full Adder . If $A_n=B_n=C_{n-1}=1$ then ① $S_n=0,C_n=0$ ② $S_n=1,C_n=0$ ③ $S_n=0,C_n=1$ ④ $S_n=1,C_n=1$。



16. ( ) Putting several Full Adders abreast, which kind of function it can do ? ① become a series adder ② become a multi-bit adder ③ only can do no carry adder ④ because using ripple carry adder, there is no time delay。

17. ( ) As the figure show A·B is inputs, C·D is outputs, then this circuit is using as ① Full Adder ② Half adder ③ Full Subtractor ④ Half Subtractor。



18. (　) If X,Y and Z is all inputs of Full Adder , its Boolean relation of carry output is

①$X+Y+Z$ ②$ZY+XZ+YZ$ ③XYZ ④$X\oplus Y\oplus Z$。

19. (　) A Full Adder consists two Half Adder and a ①OR ②AND ③NOR ④NAND。

20. (　) A Full Adder's carry bit can express as which kind of logic equation。

①$AC_{in}+BC_{in}+\overline{AB}$ ②$AB+AC_{in}+BC_{in}$ ③$AB+\overline{AB}+AC_{in}$ ④$\overline{A}B+BC_{in}$

(E)$\overline{B}C_{in}+AC_{in}$。

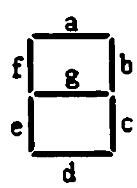
21. (　) Inputs of a Full Adder are A、B、C, then its Boolean function of carry C_{out} is

①$B\odot B\odot C$ ②$A\oplus B\oplus C$③$AB+BC+CA$ ④$\overline{A}B+\overline{A}C+\overline{BC}$。

22. (　) Inputs of a Full Adder are A、B、C, then its Brule function of sum S_{out} is ① $A\oplus B\oplus C$ ② $A\odot B\odot C$ ③$AB+BC+CA$ ④$\overline{A}B+\overline{A}C+BC$。

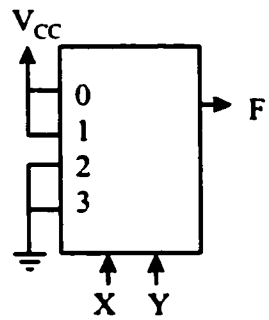
23. (　) The figure is Common Cathode seven segment displayer .If when

gfedcba=1100110, the displayer will show①3②4 ③ 5 ④ 6。

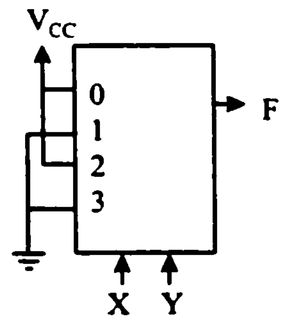


24. (   ) Assume there is s Boolean algebra $F(X,Y)=\overline{XY}+XY$ use 4:1 multiplexer to make this function, which figure does it should be ?

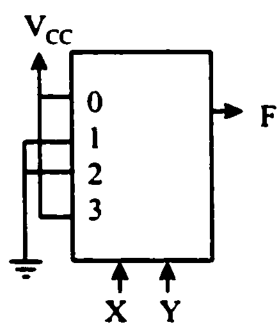
①



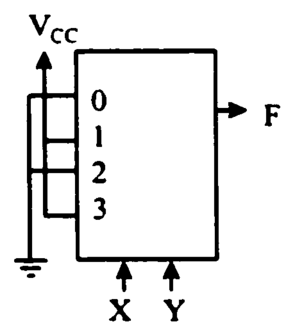
②



③



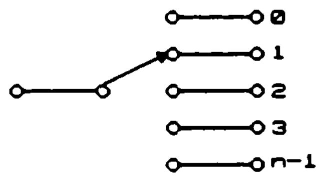
④



25. (   ) About multiplexer. It has many inputs. How many outputs does it have? ①1 ②2 ③3 ④as many as input

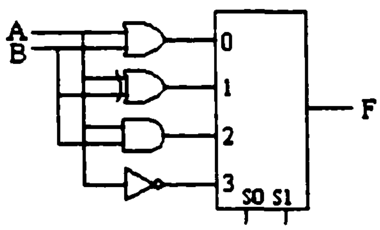
26. (   ) As the figure is a multiplexer circuit. If $S_1=1$, $S_0=1$, then it enforce output function is①F=A+B ②$F=A\oplus B$ ③F=AB ④$F=\overline{A}$。

27. ( ) As the circuit , what system does it belong to ? ①decoder②multiplexer ③demultiplexer ④encoder。



28. ( ) Accept m line inputs, then changes it into several bits of binary system output combination circuit is①multiplexer ②encoder ③demultiplexer ④decoder。

29. ( ) As the figure is a multiplexer circuit. If S_1 =1,S_0 =1, then it enforce output function is①F=A+B ②F=A⊕B ③F=AB ④F= $\overline{A}$。



30. ( ) How many lines does a multiplexer output have?①1 ②2 ③3 ④4 。

31. ( ) How many lines does a 16 v.s1 multiplexer have ? ①1 ②2 ③3 ④4 。

32. ( ) Two computer want to transmit 8 bits data. If system use even parity check circuit to detector mistakes, then how many bits does the transmission data have ? ① 7 ② 8 ③ 9 ④ 10 。

33. ( ) At 8 bits parallel connection transmission system ,what kind of mistake does Even parity checker can check out ? ①a bit's mistake ②two bit's mistake ③ a bit's mistake and then revise ④ two bit's mistake and then revise 。

34. ( ) We want to design a Half Adder inputs are A、 B, output are S(sum)、 C(carry)then its truth table is?

①

A	B	C	S
0	0	0	0
0	1	0	0
1	0	0	0
1	1	1	1

②

A	B	C	S
0	0	0	0
0	1	1	1
1	0	1	1
1	1	1	1

③

A	B	C	S
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

④

A	B	C	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

35. (   ) The same as 34, it Boolean function at output S and C are ?

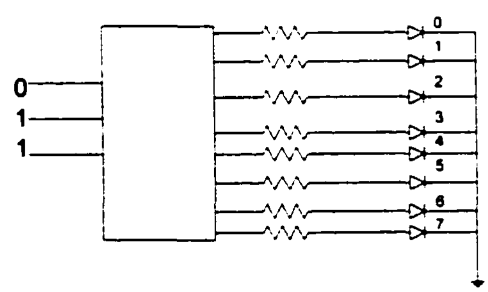
①C=AB , S=AB

②C= $\overline{A}B+A\overline{B}+AB$, S= $\overline{A}B+A\overline{B}+AB$

③C= $\overline{A}B+A\overline{B}$, S=AB

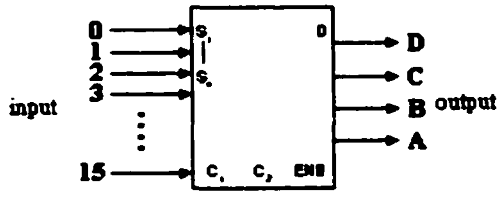
④C=AB , S= $\overline{A}B+A\overline{B}$

36. (   ) As the figure LED adopt common cathode connections, when input data is "001", then the fifth LED is bright, U1 is what kind of device?



①encoder
②decoder
③multiplexer
④ demultiplexer

37. (   ) What kind of circuit do the figure show?①multiplexer ②encoder ③ demultiplexer ④decoder。

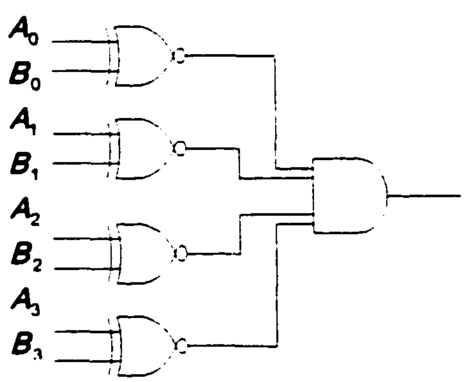


38. ( ) If we want to design some logic circuit, it input is A, B, C, output is Y. We can know its truth tables is the list table, then what is output Boolean function ?

A	B	C	Y
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

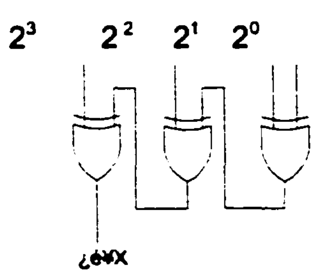
① $\overline{AB}C + \overline{A}B\overline{C} + A\overline{BC}$
② $\overline{AB} + \overline{AC} + \overline{BC}$
③ ABC
④ A⊕B⊕C

39. ( ) As the figure shows, this circuit works as a ?



① parity generator
② comparator
③ encoder
④ multiplexer

40. ( ) Try to determine what kind of circuit does the figure belong to ?



① multiplier ② adder ③odd parity generator ④even parity generator

APPENDIX D

FINAL-TEST

FINAL TEST

DIRECTIONS: Select the letter of the choice for each statement below which best completes the statement or answers the question. Circle the letter of your choice for each item number.

Students name:

1. ( ) Boolean algebra is f = $\overline{X\,.\,Y}$. according to DeMorgans' law to make it simple, which following can get the same function ? ①f= $\overline{X}+\overline{Y}$ ②f=X+Y ③f=XY ④f= $\overline{X+Y}$ 。

2. ( ) Boolean algebra (A+B)(A+C) in simple term is①B+AC ②C+AB ③A+BC ④ABC 。

3. ( ) Boolean algebra $A+\overline{A}B$ in simple term is ① $A+\overline{B}$ ②$A+B$ ③ $\overline{A}+\overline{B}$ ④$A+\overline{B}$ 。

4. ( ) Boolean algebra F=X+ $\overline{X}$ +Y in simple term is ①Y ②X ③ $\overline{X}$ ④1 。

5. ( ) A logic circuit, its output Y equation is Y= $\overline{A}\,\overline{B}C+\overline{A}B\overline{C}+AB\overline{C}+A\overline{B}C$ ①B⊕C ②AC+$\overline{B}$C ③A$\overline{B}$C+C (D) ④ $\overline{B}$C+A$\overline{C}$ 。

6. ( ) Boolean algebra X+ $\overline{X}$ +Y in simple term is ①Y②X ③ $\overline{X}$ ④1 。

7. ( ) The same as 48.Karnaugh map show, the symbol "01" means ① $\overline{A}\,\overline{B}$ ② A$\overline{B}$ ③ $\overline{A}$B ④AB 。

8. (   ) As the following table show, this function f is ① $ABC+A\overline{B}C+\overline{A}BC$ ② $AB\overline{C}+\overline{A}BC+A\overline{B}C$ ③ $ABC+\overline{A}\,\overline{B}\,\overline{C}+\overline{A}\,\overline{B}C$ ④ $ABC+\overline{ABC}+\overline{AB}C$ 。

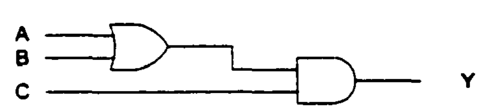
C \ AB	00	01	11	10
0	X		1	
1		1		1

9. (   ) f(A,B)=Σ(0,1,2,3) using Karnaugh map to make it simple, f is ①0 ②1 ③A ④B

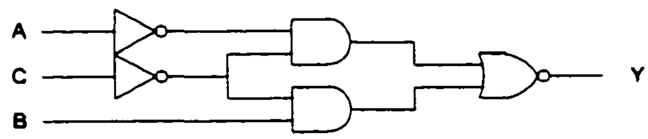
10. (   ) As the following table show, f(AB,C,D) in algebra simple equation is ① $\overline{A}$BD+CD ②B$\overline{C}\,\overline{D}$+CD ③ $\overline{B}$CD+AC ④ $\overline{A}$BC+$\overline{C}$D 。

CD \ AB	00	01	11	10
00	0	0	0	0
01	0	1	0	0
11	1	1	1	1
10	0	0	0	0

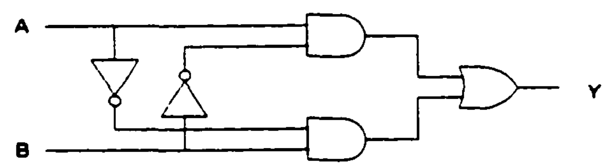
11. (   ) How many kinds of situations when Y output is "1" ? ①6 ②5 ③4 ④3。



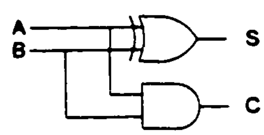
12. (   ) As the figure show if we want to make output Y only "1", then input relation between A and B is ①A=0,B=0 ②A=0,B=1 ③A=1,B=0 ④A=1,B=1。



13. (   ) As the figure show, which following is right ? ①A=0,B=0 then Y=0 ②A=0,B=1 then Y=1 ③A=1,B=0 then Y=1 ④upword is right。



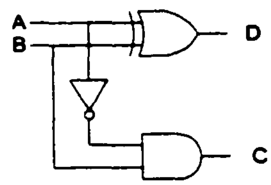
14. (   ) As the figure, Half Adder S means ①sum ②different ③accumulate ④carry。



15. (   ) As the above figure, C means①sum ②different ③accumulate ④carry。

16. (   ) Putting several Full Adders abreast, which kind of function it can do ? ①become a series adder ②become a multi-bit adder ③only can do no carry adder ④because using ripple carry adder, there is no time delay。

17. (　　) As the figure show A·B is inputs, C·D is outputs, then this circuit is using as ①Full Adder ②Half Adder ③Full Subtractor ④Half Subtractor。



18. (　　) If X,Y and Z is all inputs of Full Adder, its Boolean relation of carry output is ①X+Y+Z ②ZY+XZ+YZ ③XYZ ④X⊕Y⊕Z。

19. (　　) A Full Adder consists two Half Adder and a ①OR ②AND ③NOR ④NAND 。

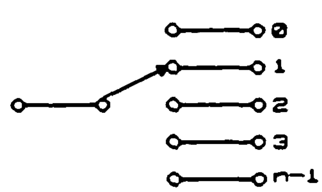
20. (　　) A Full Adder's carry bit can express as which kind of logic equation。

①$AC_{in}+BC_{in}+\overline{AB}$ ②$AB+AC_{in}+BC_{in}$ ③$AB+\overline{AB}+AC_{in}$ ④ $\overline{A}B+BC_{in}$

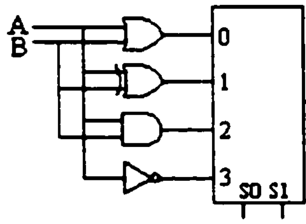
(E) $\overline{B}C_{in}+AC_{in}$。

21. (　　) About multiplexer. It has many inputs. How many outputs does it have?①1 ②2 ③3 ④as many as input

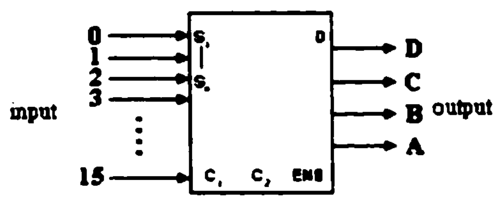
22. (　　) As the circuit , What system does it belong to ? ①decoder②multiplexer ③demultiplexer ④encoder。



23. ( ) As the figure is a multiplexer circuit. If S_1 =1,S_0 =1, then it enforce output function is①F=A+B ②F=A⊕B ③F=AB ④F= $\overline{A}$。



24. ( ) What kind of circuit do the figure show?①multiplexer ②encoder ③ demultiplexer ④decoder。



25. ( ) If we want to design some logic circuit, it input is A, B, C, output is Y. We can know its truth tables is the list table, then what is output Brule function ?

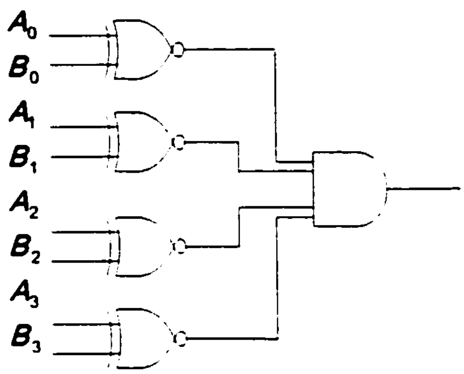
A	B	C	Y
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

①ℵ $\overline{A}\overline{B}C+\overline{A}B\overline{C}+A\overline{B}\overline{C}$
②ℑ $\overline{A}\overline{B}+\overline{A}\overline{C}+\overline{B}\overline{C}$
③ℜ ABC
④℘ A⊕B⊕C

26. ( ) As the truth table shows at 25, it works as a ?

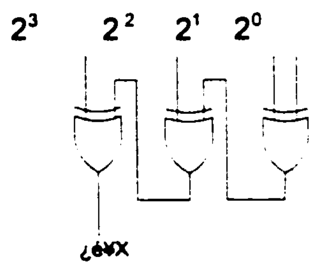
① parity generator
② comparator
③ multiplier
④ divider

27. ( ) As the figure shows, this circuit works as a ?



① parity generator
② comparator
③ encoder
④ multiplexer

28. ( ) Try to determine what kind of circuit does the figure belong to ?



① multiplier ② adder③odd parity generator ④even parity generator

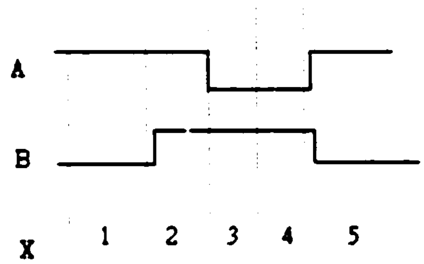
。

29. ( ) 74 series digital logic is belong to what kind of logic circuit ? ①TTL ②ECL

③CMOS ④ I^2L。

30. (　　) In 74 series TTL logic clan IC (ex:7400), its range in using source voltage is①3~5 V ②4.75~5.25 V ③-5~5 V ④-12~12 V。

31. (　　) A、B and X is NAND gate input, output end, its input waveform is as the figure, in which time，X output will be 0 ?

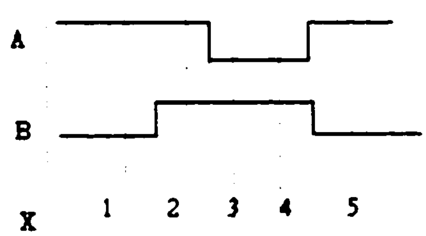


① time 1　② time 2　③ time 3and 4 ④time 5

32. (　　) In the digital logic gate, if the input signal at least has one is "1". what kind of logic gate its output signal is"1" ①AND gate ②OR gate③NAND gate④NOR gate。

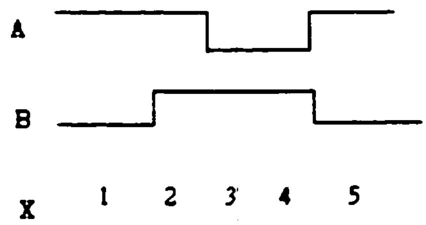
33. ( ) In the digital logic gate, if its input is all "1", what kind of logic gate its output signal is only "1" ①AND gate ②OR gate③NAND gate④NOR gate。

34. (　　) A、B and X is NOR gate input, output end, is input waveform is as the figure in which time, X output will be 1 ?



① time 1　② time 2　③ time 3and 4 ④impossible

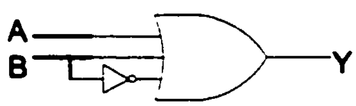
35. ( ) A、B and X is AND gate input, output pin, it input waveform is as the figure, in which time, X output will be 1 ?

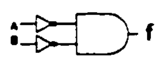


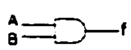
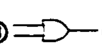
① time 1 ② time 2 ③ time 3and 4 ④time 5

36. ( ) CMOS logic circuit, its input floating , which situation will occur?①this input is high electric potential ② this input is low electric potential ③input floating has on effect to the circuit ④output will become unstable。

37. ( ) Logic circuit as the figure, if it connects only 5V. when its input A and B don't connect to any signal, then the output Y= ? ①1 ②0 ③A ④B 。



38. ( ) Logic circuit as the figure  , which gate has the equal value ?

①  ②  ③  ④  。

39. ( ) Boolean function equation is X=AB+CD . If we use logic gate to connect lines then which following gate is its output ? ① OR gate ② AND gate ③ NOR gate ④ NAND gate

40. ( ) A 3 inputs NOR gate which inputs at what situation, its output is1(high electric potential i.e.5V) ?

① any one input connect to high electric potential ② any two inputs connect to low electric potential (i.e.0V) ③ 3 inputs all connect to high electric potential ④ 3 inputs all connect to low electric potential (i.e. 0V)

APPENDIX E

THE TEST SCORE FOR THE CONTROL AND EXPERIMENTAL GROUPS

The test score for the control and experimental groups

CG					EG				
Stude#	Pretest	Post 1	Post 2	Final	Stude#	Pretest	Post 1	Post 2	Final
1	52	56	89	60	1	40	80	75	71
2	48	76	95	87	2	48	68	88	71
3	60	88	79	70	3	36	76	92	83
4	60	72	90	95	4	44	72	71	86
5	68	76	98	85	5	28	68	84	79
6	48	60	85	95	6	24	24	89	81
7	48	72	89	97	7	60	84	77	84
8	48	64	93	83	8	24	76	95	72
9	36	72	80	86	9	44	72	81	90
10	64	76	76	91	10	28	84	97	84
11	44	72	72	74	11	20	64	87	65
12	56	60	76	65	12	40	44	82	79
13	52	84	95	79	13	40	64	72	87
14	36	68	80	74	14	28	56	75	65
15	36	80	71	62	15	44	60	74	68
16	20	56	84	95	16	44	68	92	64
17	32	60	84	81	17	48	72	90	93
18	24	76	84	69	18	20	48	90	83
19	28	72	90	74	19	52	48	64	73
20	48	80	91	82	20	36	56	82	75
21	56	58	90	81	21	50	80	80	72

CG					EG				
Stude#	Pretest	Post 1	Post 2	Final	Stude#	Pretest	Post 1	Post 2	Final
22	50	80	92	77	22	44	68	85	90
23	80	88	79	92	23	32	76	90	93
24	68	72	88	83	24	42	72	80	82
25	66	76	92	60	25	30	68	84	88
26	46	60	88	64	26	30	24	90	92
27	48	72	84	25	27	62	84	80	82
28	60	64	96	72	28	30	76	95	96
29	40	72	80	80	29	44	82	81	81
30	64	76	76	60	30	40	84	97	92
31	42	46	79	50	31	34	62	71	80
32	58	76	85	77	32	18	74	87	74
33	50	78	69	60	33	10	54	77	55
34	50	62	80	85	34	30	34	72	69
35	58	66	88	75	35	30	54	62	77
36	38	50	65	85	36	18	46	65	55
37	38	62	79	86	37	34	50	64	58
38	38	54	83	73	38	34	58	82	54
39	26	62	70	76	39	38	62	80	83
40	54	62	66	81	40	10	38	80	73
41					41	42	38	54	63
42					42	26	46	72	65