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ABSTRACT

With the advent of the microcomputer has come an increase in the use of educational simulations. Distinct from software used for drill and practice, tutorials, or problem-solving, simulation software recreates events, devices, or phenomena and can provide the student with a scientific experience which might otherwise be too expensive, dangerous, or time-consuming. This paper reports the results of an experimental study (n=28) designed to measure the effectiveness of computer simulations in a solid state electronics circuitry course in an industrial technology program. The study treated age and college grade point average (GPA) as independent variables and learning outcome, based on posttest scores, as the dependent variable. Findings revealed that neither age nor GPA had a significant impact on learning via simulation technology, although the researcher recommends replicating the study with a larger sample size over a longer duration. Three tables offer a glimpse of the data. (Contains 17 references.) (Author/BEW)

Running head: Computer Simulation

Affects of Age and GPA on Learning Electronics via Computer Simulation-Based and Traditional Instruction

by

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Abstract

This paper reports the results of an experimental study (N=28) designed to measure the effectiveness of computer simulations in a solid state electronics circuitry course in an industrial technology program. The study treated age and college grade point average (GPA) as independent variables and learning outcome as the dependent variable. The findings indicate that age nor GPA is a factor in learning electronics via computer simulation-based or traditional breadboard instruction.

Introduction

Simulation is the application of computer techniques to create models of either objects or processes to explore alternative solutions (Biekert, 1993). Simulations focus on the learning environment without usurping control from the learner, offering unique learning opportunities in nearly every subject area. As a result, simulations permit the attainment of learning goals which are beyond traditional and other computer-based instructional methods (Thomas & Hooper, 1991).

Simulations existed long before computers were invented, but the two factors have been associated ever since computers came onto the scene (Crookall, 1988). First, computers were appended to simulation, mainly as number crunchers. Then, in the late 1970s, simulations were designed explicitly for the computer; their shape was determined by the capabilities of the computer. More recently, especially with the advent of the personal computer, there has been a movement back to using the computer more as a peripheral aid, as one among numbers of components, in simulation.

Simulations and computers have had a mutually beneficial effect. There is little doubt that the advent of the microcomputer has conferred a greater legitimacy upon, and promoted a more widespread use of simulation. This is not to say that computers determine, or should determine, simulation characteristics; rather, it is an indirect commentary on the fact that just as other educational media (e.g., paper, video) have their limitations, so do computers.

History of Computers in Education

Computer-assisted instruction basic methods and vocabulary appeared early in the 1960s during a period in which educators were using mainframe computers to conduct research and do their projects. It was during this period that the computer's potential as an educational tool was noticed, however, inaccessibility and cost prevented adoption on a wide scale (Berg & Bramble, 1983).

In approximately 1977, microcomputers were introduced in schools. Public schools began to purchase microcomputers for educational purposes as they became inexpensive as well as powerful. Three phases of educational computing are proposed by Berg and Bramble (1983). The experimental phase of the 1960s was the first of these phases. The second phase proposed was the popularization phase which began with microcomputers in 1977. This phase is characterized by the low level educational use of computers. Schools purchased computers and teachers received inservice education about the computers. The third phase proposed by Berg and Bramble was the transition phase which began in the mid-1980s. It is during this phase that educators have had the opportunity to improve and transform public education through technology. The transformation has accelerated due to the decreasing cost of powerful microcomputers, digitalized voice, high quality classroom management software, and more sophisticated instructional software.

Current Uses of Computers in Education

Currently, instructional software is most commonly classified in one of four categories. The first of these categories is drill and practice. When using drill and practice software, the computer provides the students with a series of questions to respond, offers immediate feedback, and a summary evaluation of performance.

The second classification of software used in instruction is tutorial. Tutorial software presents the instructional material and asks the user questions over the material. Depending on the student's responses to the questions tutorial software branches to new material or remediation.

The third category of instructional software is problem solving. Problem solving software allows the user to solve specific problems. It provides answers to problems and/or performs calculations. Problem solving software can perform statistical calculations such as t-scores on data.

Simulation software is the fourth classification of educational software being used currently. This type of software places the student in a simulated realistic setting. Simulation software may teach a student to fly a plane, drive a car, or other psychomotor and academic skills. When utilizing simulation software, a student is confronted by situations that require active participation in initiating and carrying through a sequence of inquiries, decisions, and actions (McGuire, 1976). In assessing the educational importance of simulations in computer-based instruction Crookall (1988) stated, "One might say simulation has come to the rescue of computer use in the classroom" (p. 3).

Taylor (1980), proposes a classification scheme that allows an instructional computing view based on the learner's association with the computer rather than the software characteristics. In Taylor's classification, the computer is used as a tutor, a tool, or a tutee. The computer presents information, and reacts to feedback from the learner as a tutor. As a tool, the computer performs a function for the user such as database management or word processing. The computer is programmed by the learner in its role as a tutee.

A Taxonomy of Education Software

Several other taxonomies of educational computing have also been suggested. Thomas and Boysen (1984) believe that the traditional classification schemes have major deficiencies.

Older schemes fail in guidance on how a particular application should be used in the educational setting, or how they focus the teacher's attention on a student's weakness. Thomas and Boysen (1984) offer a classification that focuses on the needs of the learner. The new scheme provides guidance for the development of lessons and their instructional use and facilitates the design and communication of research studies. This classification places the focus on the students. Their taxonomy consists of the following five categories.

1. Experiencing – sets the cognitive and affective stages for future meaningful learning.
2. Informing – provides new information to the learner.
3. Reinforcing – develops mastery of new information.
4. Integrating – new material is associated with existing long term memory via meaningful learning.
5. Utilizing – using the computer as a tool to perform a task.

Each category of the taxonomy represents a step in the learning process with experiencing being the first step and utilizing being the last. If the learner uses the program prior to learning to set the stage for learning, the program is said to be an experiencing program. If the program is used to acquire information, it is said to be an informing program. Informing and reinforcing applications are usually computer-directed. Experiencing applications are learner-directed as are integrating and utilizing applications. It is through these type of applications that the highest levels of learning and computer literacy are achieved, and the greatest degree of teacher competence and deepest philosophy are required (Thomas & Boysen, 1984).

Computer Simulations

The purpose of a simulation is to recreate various events, devices, or phenomena via computers. A computer simulation can provide the students with a scientific experience that might otherwise be considered too expensive, too dangerous, too time-consuming, or simply impractical. Simulations take advantage of one of the powerful features of the computer - its ability to be interactive. When a student makes a choice or decision within a simulation, the computer generates a response based upon that choice. In a well-designed simulation, the response closely approximates what might happen in real life. Simulations require the students to build mental models of processes or events. Students can then see how a process or an event is altered by making different choices (Alessi & Trollip 1985). A well-designed computer simulation can allow a science teacher to conserve expensive equipment and materials while still teaching the concept or procedure. Another advantage in simulations is that students' mistakes or errors are more easily rectified: if a mistake is made, the simulation is generally salvageable, unlike in real experiments where one error can ruin the entire project. Also, it is usually easier to control variables in a computer simulation than in an actual laboratory experiment, where the risk of contamination from outside factors constantly looms. Finally, a computer simulation can provide a sound basis for further experiments (Weaver, 1986).

An excellent way for students to use computer simulations is by assigning them to work in cooperative learning groups. Based on the work of Johnson and Johnson (1985) of the University of Minnesota, cooperative learning has received increasing attention recently for its potential to allow students to learn from each other and to learn group process skills. The key to cooperative learning is "positive interdependence," students working together toward mutual goals in such a way that the labor is shared and members of the group must depend upon each other. Skills such as leadership, conflict resolution, and decision making are taught and practiced in a cooperative learning situation (Langhorne, Donham, Gross, & Rehmke, 1989).

Summary

Over the past few years computer simulations have become more popular in the classroom. They have been proven to be safe, economical, and perhaps most importantly, have shown the ability to stretch or compress time according to student's needs (Carlson, 1989). Several researchers, including Hartley (1988), stressed the importance of being able to use the simulations to simplify the design of a physical system by "stripping off extraneous or elaborate features while still retaining validity. Hence, students are able to focus on the main attributes of the model" (p 60).

For simulations to be the most effective, the students must be able to use them at the proper time in their training. According to Thomas and Boysen (1984), computer-based instruction can lay a foundation for proper student schemas prior to formal classroom instruction on a concept. In the above authors' view, a model of the concept should be introduced, usually by means of a computer simulation, and the student should be guided through sets of problems with the specific goals of the formal instruction in mind. All this is done with the simulation before the student receives the formal classroom instruction. This "pre-instruction" helps the student gain an intuitive feel for the concept, thus building a cognitive framework for the formal instruction. Thomas and Boysen (1984) emphasize that this kind of simulation is rarely "stand alone" and should be used as a foundation for the instruction to follow.

Purpose of the study

The purpose of this study was to compare and evaluate the affects of age and college grade point average (GPA) on learning electronics via computer simulation-based and traditional instruction for educating college students about solid state electronics circuitry.

Characteristics of the Subjects

The population of this study consisted of undergraduate students who enrolled in Fundamentals of Electronics class at Iowa State University. The prerequisite for the course was a one semester course in Basic Electronics.

A ten-item questionnaire was used to collect demographic data of the participant's educational background and extent of previous electronics and computer experience.

The average age of the subjects were twenty-two years with a range of twenty to thirty-two years. The subjects were industrial education and technology majors. The mean grade point average was 2.60 on a four-point scale, ranging from 1.90 to 3.90.

The subjects were classified as age-group I if they were under 22 years of age and as age-group II if they were 22 and over. They were also divided into two groups based on their overall grade point average. Group I was made of students with GPA under 2.5 and group II consisted of students with GPA of 2.5 and over.

Methods of Procedure

Pretest

The pretest instrument was developed by the author. The pretest was administered during the first meeting before the teaching began. The pretest consisted of forty multiple-choice items, ten items for each experimental circuit. This test was designed to be used as a covariate. The pretest items were selected from the tests and quizzes given to basic Electronics and Fundamentals of Electronics students in previous semesters. The KR-20 reliability estimate of those tests and quizzes ranged from 0.73 to 0.79.

Posttest

The posttest instrument was also developed by the author. The posttest was administered at the end of the study and consisted of forty multiple-choice items, ten items for each experimental circuit. This test was similar in content to the pretest. Scores on the posttest ranged from 15 to 37 out of a total of 40 possible, with the mean score of 28.59. The KR-20 reliability estimate of this test was 0.77.

Statistical Analysis of Data

All scores were coded by the researcher and provided as a data file for running statistical analyses by applying the Statistical Package of the Social Science (SPSS) computer package. The statistical methods chosen for analyzing the data in this study was two-way analysis of variance.

Simulation Program

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

Research Procedures

A pretest-posttest control group design was used in the experiment. The design is schematically presented by the following.

Group I	R	O_1	T	O_2	S
Group II	R	O_1	S	O_2	T

R stands for random assignment of subjects.

O stands for observation, O_1 is the pretest and O_2 is the posttest.

S stands for experimental treatment.

T stands for traditional treatment.

In this study, the researcher randomly assigned subjects to particular groups. The experimental group received the pretest, experimental treatment, traditional treatment, and the posttest, while the control group received the pretest, traditional treatment, experimental treatment, and the posttest (Table 1).

Classroom Procedures

Both the experimental and control groups received theoretical instruction together from the same instructor. Both the experimental and control groups also received the same in-class quizzes and homework problems.

Laboratory Procedures

In order to become familiar with the use of computer and software simulation, all the subjects had three weeks of computer simulated laboratory activity before this study began. Both the experimental and control groups were supervised by different laboratory instructors at different times and locations. In a typical laboratory session, the instructor would first briefly review the objectives or the experiment plan and comment on special problems or safety precautions.

The treatment (experimental) group used the computer simulation as the means of conducting laboratory experiments. Students were provided instructions on the use of the computer, both through demonstration and in a written format. Students were monitored by the researcher during the computer simulation activities. The assistance given to students during laboratory activity consisted of instruction on the use of the computer, software simulation program, and step by step written laboratory procedures.

The control group used the traditional breadboarding (use of actual components) as laboratory experiments. The assistance given to students during laboratory activity consisted of instruction on the use of various equipment, components, and step by step written laboratory procedures.

Data Collection Procedures

At the beginning of the study, a general information sheet was administered in order to gather demographic information on each subject. At this time students were given the opportunity to participate in the study. Prior to instruction, the forty item pretest was administered to all subjects to assess student's background and knowledge of electronics, and their ability to analyze, compute, and evaluate the responses to the test questions.

After completion of the pretest, the subjects were randomly assigned to the experimental treatment group and the control treatment group (traditional treatment group).

After two weeks of experiments, the experimental group switched with the control group.

At the conclusion of the study, the posttest was administered to all subjects to measure treatment effects (Table 1).

Table 1. Experimental design

Group #1 (N1 = 14)	Group #2 (N2 = 14)
Pretest	
Control Group #1	**Experimental Group #1**
Traditional Method Instructor #1 Week #1 Meeting #1 (n1=7) Meeting #2 (n3=7)	Computer Simulation Method Instructor #2 Week #1 Meeting #1 (n2=7) Meeting #2 (n4=7)
Traditional Method Instructor #2 Week #2 Meeting #1 (n1=7) Meeting #2 (n3=7)	Computer Simulation Method Instructor #1 Week #2 Meeting #1 (n2=7) Meeting #2 (n4=7)
Experimental Group #2	**Control Group #2**
Computer Simulation Method Instructor #1 Week #3 Meeting #1 (n1=7) Meeting #2 (n3=7)	Traditional Method Instructor #2 Week #3 Meeting #1 (n2=7) Meeting #2 (n4=7)
Computer Simulation Method Instructor #2 Week #4 Meeting #1 (n1=7) Meeting #2 (n3=7)	Traditional Method Instructor #1 Week #4 Meeting #1 (n2=7) Meeting #2 (n4=7)
Posttest	

Hypothesis I

There is no significant difference between age-group I pretest mean score and age-group II pretest mean score.

Ho: $\mu_{age\ I} = \mu_{age\ II}$

Ha: $\mu_{age\ I} \neq \mu_{Age\ II}$

Hypothesis II

There is no significant difference between GPA-group I pretest mean score and GPA-group II pretest mean score.

Ho: $\mu_{GPA\ I} = \mu_{GPA\ II}$

Ha: $\mu_{GPA\ I} \neq \mu_{GPA\ II}$

Hypotheses I and II were analyzed by two-way analysis of variance where age and GPA were the factors and pretest was the dependent variable. Age and GPA were not found to be significant factors of pretest score. Additionally, there was no interaction effect between age and GPA. The results are displayed in table 2.

Table 2. Tests of Significance for Pretest using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Within+Residual	646.91	24	26.95		
T_{AGE}	25.50	1	25.50	0.95	0.340
T_{GPA}	45.60	1	45.60	1.69	0.206
T_{AGE} by T_{GPA}	3.32	1	3.32	0.12	0.729
(Model)	56.80	3	18.93	0.70	0.560
(Total)	703.71	27	26.06		

R-Squared = 0.081
Adjusted R-Squared = 0.000

T_{AGE}: Under 22 (N = 14)
22 & over (N = 14)

T_{GPA}: Under 2.5 (N = 12)
Over 2.5 (N = 16)

Hypothesis III

There is no significant difference between the age-group I posttest mean score and age-group II posttest mean score.

Ho: $\mu_{age\,I} = \mu_{age\,II}$

Ha: $\mu_{age\,I} \neq \mu_{Age\,II}$

Hypothesis IV

There is no significant difference between the GPA-group I posttest mean score and GPA-group II posttest mean score.

Ho: $\mu_{GPA\,I} = \mu_{GPA\,II}$

Ha: $\mu_{GPA\,I} \neq \mu_{GPA\,II}$

Hypotheses III and IV were analyzed by two-way analysis of variance where age and GPA were the factors and posttest was the dependent variable. Age and GPA were not found to be significant factors of posttest score. Additionally, there was no interaction effect between age and GPA. The results are displayed in table 3.

Table 3. Tests of Significance for Posttest using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
Within+Residual	526.41	24	21.93		
T_{AGE}	0.49	1	0.49	0.02	0.882
T_{GPA}	27.81	1	27.81	1.27	0.271
T_{AGE} by T_{GPA}	3.38	1	3.38	0.15	0.698
(Model)	31.44	3	10.48	0.48	0.701
(Total)	557.86	27	20.66		

R-Squared = 0.056
Adjusted R-Squared = 0.000

T_{AGE}: Under 22 (N = 14)
22 & over (N = 14)

T_{GPA}: Under 2.5 (N = 12)
Over 2.5 (N = 16)

Summary

This study was designed to compare and evaluate the affects of age and GPA on the learning electronics via computer simulation-based and traditional instruction for educating college students about solid state electronics circuitry. Results indicate that age nor GPA is a factor in learning electronics via computer simulation-based or traditional breadboard instruction. This may be viewed as a positive finding concerning the use of computer simulation-based instruction. Failing to reject the null hypothesis could also be due to sample size (n = 28) or the restriction in range of the age or GPA variables. It is tenable that extremes in age or GPA would be related to achievement utilizing computer simulation-based or traditional instruction. Replications of this study are warranted. Specific recommendations include the following.

1. Replicate the study with a sample that exhibits greater variance in age and GPA.
2. Replicate the study with a larger sample size.
3. Further research utilizing gender and other demographic data as variables.
4. Further research using more complex circuits and applications requiring actual analysis, troubleshooting, evaluation, and repair.
5. Additional research of a longer duration, for example eight weeks, instead of the four weeks used in this study.
6. Further research that considers student learning style.

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