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ALEX: an analysis of a learning system

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ALEX: An analysis of a learning system

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INTRODUCTION OF THE PROBLEM

Prior to 1970, teaching media for accounting courses was little known or used, partially as a result of the problem-based approach used by most accounting instructors in the teaching process. Commercially produced transparencies accompanying basic accounting texts were available, and these were frequently supplemented by individuals creating media for their own selective needs.

Since 1973, at least three commercially produced multi-media systems have been developed for national distribution. The dollar investment required to purchase these systems, plus the potential teaching and learning advantages, seem to suggest the need for scientific analysis of each system's effectiveness. At the time of this writing, there existed no formal evaluation of any of the three systems, nor was this author aware of any study in progress.

The purpose of this study is to attempt a formal analysis of the effectiveness of one of the three above-mentioned multi-media learning systems, specifically, A Learning EXperience (ALEX), published by Prentice-Hall, Inc., Englewood Cliffs, New Jersey, authored by Dempsey Dupree, Matthew Marder, and Forest Carter, copyright 1973. A complete copy of the ALEX system was purchased for use at Lincoln Land Community College, Springfield, Illinois, in mid-1973, and was used in the research described in this paper.

The study will examine three major categories of possible impact and attempt:

1. To evaluate the effectiveness of the ALEX system when used within the formal classroom situation as a substitute for the instructor's lecture, testing the effects of both light and heavy levels of treatment;
2. To evaluate the effectiveness of the ALEX system when used as auto-tutorial material outside formal classroom time; and
3. To explore some qualitative aspects of multi-media instruction in accounting.

Basic Hypotheses

Null Hypothesis 1: There will be no significant difference in learning (as measured by the difference between pre- and post-test scores) between three groups of beginning accounting students, one group receiving a light, five-module treatment of ALEX materials in class, another group receiving a heavy, ten-module treatment of ALEX materials in class, and a control group receiving no ALEX materials treatment in class.

Null Hypothesis 2: There will be no significant difference in learning (as measured by the difference between pre- and post-test scores) between three groups of second semester accounting students, one group receiving a light, four-module treatment of ALEX materials in class, another group receiving a heavy, eight-module treatment of ALEX materials in class, and a control group receiving no ALEX materials treatment in class.

Null Hypothesis 3: There will be no significant difference in learning (as measured by the difference between pre- and post-test scores) between three groups of beginning accounting students, one group assigned ALEX materials as additional out-of-class assignments, another group using equivalent (Knox College) materials as additional out-of-class assignments, and a control group with no additional out-of-class assignment.

Null Hypothesis 4: There will be no significant difference in learning (as measured by the difference between pre- and post-test scores) between three groups of second semester accounting students, one group assigned ALEX materials as additional out-of-class assignments, another group using equivalent (Knox

College) materials as additional out-of-class assignments, and a control group with no additional out-of-class assignment.

Null Hypothesis 5: There will be no significant difference in learning (as measured by the difference between pre- and post-test scores) between the main effects and interactions of the following variable characteristics of the students: sex, age, and attendance at class.

Basic Assumptions

1. The effects of programmed multi-media instruction are measurable.

2. Students in groups receiving treatment do not initially differ significantly in any relevant way from students not receiving treatment.

3. Differences between pre- and post-test scores are due to the effects of in-class materials treatments or the effects of out-of-class materials treatments, and do not result from the effects of extraneous factors.

Delimitations

This study is limited to the 303 freshman and sophomore students enrolled in Principles of Accounting 101 (ACC 101) and Principles of Accounting 102 (ACC 102), the two consecutive one-semester courses which comprise the Principles of Accounting sequence regularly offered at Lincoln Land Community College, Springfield, Illinois. Only daytime sections were selected for the study, since evening and Saturday sections were composed of primarily older, employed, and more business-experienced students. The twelve sections selected for the study met three times weekly for fifty-minute periods during the sixteen-week semester.

Pre- and post-tests, although given to all sections tested on the same date, could not be given to all sections in a single group at the same hour because of restrictions in scheduling and space. The nature of the testing instrument used (forty-five multiple choice questions) and staff monitoring during the examination process helped to limit, if not prevent, carryover of examination data from one section to another.

Organization of the Study

Five chapters comprise this study. The first is an introduction to the problem with stated null hypotheses, assumptions, and delimitations. The second chapter contains a survey of the literature appropriate to the study, including one section on programmed learning, another on applications of programmed learning in the field of accounting. Methodology and procedure are discussed in chapter three, including those appropriate definitions used in the study. Discussion of the study results appear in the fourth chapter, with the fifth and last chapter presenting summary discussion and recommendations for further study.

REVIEW OF LITERATURE

The survey of literature is divided into two parts. The first traces the development of programmed machines and their applications to the educational process. The second covers the application of programmed instruction to the area of accounting.

History and Development

One must initially distinguish between the use of programmed instruction, which has longer historical roots, and programming machine development, which is primarily a twentieth century activity. Lysaught and Williams (14, p. 3) propose that one of the earliest programmers was Socrates, who developed a program which today is known as the "Socratic approach" to teaching. It involves a conversational progression from facts, through insights, into understanding, all the while stimulated by questions to the student to insure that comprehension accompanies progression.

Examples of forms of programmed instruction are present in medieval history. One was the mechanism for training knights in the use of lancers, which mechanism delivered a blow to the trainee knight for missing the targeted shield. Success was rewarded by the absence of such a blow.

Universities in England, such as Oxford, and later in the United States, such as Harvard, used the tutorial method. The interplay of questions and answers, and the development and mastery of new materials based on prior learning, can be seen as a forerunner of programmed instruction.

Mechanical aids to assist teaching are nothing new. The U. S. Patent Office records over 600 teaching devices between 1809 and 1936 (1, p. 7). However, the first sustained attempt to develop and build a teaching machine was by S. L. Pressey, an Ohio State University psychologist. In 1926, Pressey published his pioneer studies on the first recognized teaching machine (16, p. 13). Originally intended as a testing machine, it presented a series of questions to a student and immediately informed him whether his reply was right or wrong.

Like many discoverers, Pressey found something he was not looking for: in an age of testing, he discovered something about teaching. Beginning with a machine that tested automatically, he observed that in giving and scoring the test in this standardized manner, his students were learning efficiently. Experiments such as that of Little (13, p. 49) support Pressey's claim of learning effeciency. It was of particular interest that Little reported that the greatest benefit accrues to students who usually score in the lower half of the distribution (13, p. 58).

Pressey's efforts towards programming instruction, sustained as they were (17, p. 672), generated no substantial movement among educators in the 1920's and 1930's. Two possible explanations have been offered for the lost impetus. First, no provision was made for systematic programming of materials to be used in these machines. Second, the onset of the depression and its impact on social conditions and education offered an unfavorable environment for an "industrial revolution" (14, p. 6) in the nation's schools.

Although the early 1940's were dominated by military needs in testing, teaching, and learning, no sophisticated development in programmed instruction ensued from the half-decade of war. Use was made of simulators in flight training during World War II, and involved some concepts of programming (26, p. 14).

Professor B. F. Skinner of Harvard University, along with fellow Harvard psychologist James G. Holland, devised auto-instructional methods in the early 1950's in response to the social pressures of that time. These pressures included the massive expansion of scientific knowledge, especially in the analysis of human behavior, and the demand for education on an unprecedented scale. The efforts of Skinner and Holland in this fresher climate for educational research produced the base for programmed learning which is still serving today.

Skinner identifies the acknowledgment of reward given an organism to reward satisfactory performance "reinforcement". "Once we have arranged the particular type of consequence called a reinforcement," wrote Skinner in 1954, "our techniques permit us to shape the behavior of an organism almost at will" (23, p. 87). A typical example of the procedure known as operant conditioning, and encompassing "reinforcement", follows:

> A pigeon is placed in a one-foot-square box which has smooth, unbroken sides, except that at one end there are two small circles of light. The pigeon is to be taught to peck the brighter of the two lights. Very soon it will peck one of the discs and it will immediately receive a small maple pellet as a reward. This is all automatically controlled so that the peck actuates a food-delivery mechanism. Now according to the particular procedure which is being followed, the pigeon is quickly trained to peck the brighter of the two discs, for which it receives a food reward, and to avoid the dimmer light for which it receives nothing. The procedure is so precise that when the intensity of the two lights is varied it is used to measure a discrimination threshold for the animal, that is, the exact point beyond which the bird cannot distinguish the difference in the two intensities (1, p. 10).

Skinner proposed that his extensive work on the experimental analysis of behavior had direct implications for the teaching process, and that its application could be effectively implemented by appropriate instrumentation (23, p. 94). He designed a mechanical device to present a carefully sequenced set of materials and reinforce a student's response at each step of a program by which he could progress toward the desired behavorial capabilities. "If our current knowledge of the acquisition and maintenance of verbal behavior is to be applied to education," Skinner wrote, "some sort of teaching machine is needed" (23, p. 97). Contingencies of reinforcement which change the behavior of lower organisms often could not be arranged by hand; rather elaborate apparatus was needed. The human organism required even more subtle instrumentation.

Skinner defined several important features such a machine must have. First, the student must compose his response rather than select it from a set of alternatives, as in a multiple-choice self-rater. Skinner's reasoning here was to induce student recall rather than recognition. Further, multiple-choice material must contain plausible wrong responses, which are in the delicate process of shaping behavior because they strengthen unwanted forms. A second feature speaks to the nature of acquiring complex behavior, in which the student must pass through a carefully designed sequence of steps, often of considerable length. Each step must be small so that it can always be taken, yet in taking it, the student moves somewhat closer to full competent behavior. The machine must make sure those steps are taken in carefully prescribed order (22, p. 970).

The move from concept to practice in machine teaching generated expected criticism and support. Gagné and Bolles suggested that a gap between what is known about learning in the laboratory and learning in training-job situations presented an initial hurdle (6, p. 14).

Obviously, one needs to examine in detail the extent of the effect of individual factors involved in learning efficiency. Gagné and Bolles further suggest that it is even more important to undertake research which will determine how far each of these variables, or a combination of them, can be pushed in making learning efficient (6, p. 46). In defense of automated teaching, Holland (9, p. 219) defines six principles essential to effective use of machines in teaching: Reinforcement, emitted behavior, gradual progression, fading (gradual withdrawal of machine support), control of student attention, and discrimination (identifying common property which characterizes a concept).

Stolurow (24, p. 116), in reviewing research on teaching machines used in teaching adult learners, sees a fairly consistent pattern. The devices are generally associated with rapid learning, can produce significant results justifying their cost, but are only one of several teaching avenues open, with the optimum one(s) not yet identified. A survey of thirty research studies on programmed learning by Quackenbush (20, p. 150) found evidence that the generalizations about the effectiveness of the method have been proven in classroom applications. Students taking programmed instruction scored higher on standardized achievement tests than did students taught by conventional methods. Variations in individual rates of learning through programmed units were confirmed. Moreover, students were making more progress than might have been expected, or they were mastering material that might have been beyond their level of comprehension.

Taber, Glaser, and Schaeffer (27, p. 3) concluded that while progress in the science of learning had been made in the experimental laboratory by precise specification of behavior, there appeared to be general reluctance among educators to submit student behavior to analysis in precise terms. To them, programmed instruction was an explicit process; it is what an effective teacher does intuitively.

The decade that followed Skinner's major publications of the mid-1950's witnessed a revolution in educational technology. Many of the roots of this revolution were in the psychological laboratories of other universities and research centers outside of Skinner's Harvard. However, this revolution had relatively little effect on the specific area of accounting instruction until the early 1970's.

Programmed Instruction in Accounting

By the early 1960's, programmed materials for accounting instruction had begun to be used in some colleges and universities. A survey by McCormick in 1965 (15, p. 177) showed several educational institutions using programmed books as assigned texts, and others offering non-programmed materials to students under supervision to enhance learning. In 1962, Larson (11, p. 223) determined that variations of media presentations had value to the student's learning achievement, as opposed to the traditional approaches to teaching accounting principles.

Tyra (28, p. 35) writes that the more spectacular of the innovations developed are occasionally reported in educational journals. However, a large number of these innovations are not published because they were subtle in nature and were part of an ongoing process of improving instruction. Furthermore, many experiments in teaching innovation did not meet the methodological requirements of research. In general, accounting educators, especially at the community college level, rarely think in terms of scientific experimentation. Rather, they mainly wish to draw personal conclusions to improve their teaching.

A study by Gibbs in 1969 (7, p. 22) noted the impact of auto-tutorial media in individualizing bookkeeping instruction. In the shift to an individualized approach, not only did the effectiveness of instruction increase, but the process actually provided a spring-board for more satisfying and creative teaching.

A joint study by Prickett and Butts (18, p. 1) during the 1968-69 academic year at Southern Oregon College, Ashland, Oregon, and South Georgia Junior College, Douglas, Georgia, resulted in several notable conclusions. Students in elementary accounting who experienced programmed laboratory study or audio-tutorial laboratory sessions achieved at least as well as students who experienced a traditional accounting instruction. However, it was determined that the audio-tutorial and programmed materials should be available to the student without any time limitations. Since the primary purpose of the study was to measure the relative effectiveness of audio-tutorial and programmed learning as a supplement to conventional classroom instruction, the research here pointed beyond the mere substitution of media for human instruction.

In a study of the effects of substitution of teaching machines for instructor lectures, Strueling and Holstrum (25, p. 806) prepared a program consisting of an unbroken sequence of frames utilizing audio tapes and visual slides. Their conclusions pointed to the greater potential of programmed, audio-tutorial, and auto-tutorial materials as learning devices to be most effectively used by the student outside the classroom. Their study was based on a previous study by Buckley in 1967 (2, p. 575) which laid the theoretical foundation for use of programmed materials to enhance learning of complex accounting subject matter. Three basic reasons were given to support the hypothesis of high utility in the use of programmed materials in teaching complex accounting subjects:

1. As a result of programming the instructional material, the subject matter is analytically divided into small, manageable segments and presented to the student in a logical sequence.

2. Programmed material requires continued, active response on the part of each student in the class; whereas under the conventional teaching methods, the instructor is often limited to a response from one student at a time.

3. After actively responding to a programmed question, the student receives immediate feedback as to the accuracy of his response (25, p. 807).

Although the earlier experimentation in programmed instruction in accounting involved relatively simple combinations of machines and material, the passage of time and experience led to more complex experimental arrangements. One example cited by Davis (4, p. 27) was the design of Reavis Hall, Northern Illinois University, DeKalb, Illinois, used for varied instruction including accounting principles. The mechanical arrangement provided three-screen front projection capability, which could be controlled by the instructor from a specially-designed podium. Images picked up by the overhead television camera are projected to fourteen monitors to serve up to 470 students. Each tablet-arm seat has a set of response buttons leading to a response-summarizing computer. A complex control console behind the screens enables a technician to coordinate the variety of aural and visual signals as a programmer punches a tape for automated control of presentations.

Another aspect of the development of programmed learning in accounting is the use of programmed textbooks. The most prominent of the texts is that authored by Edwards, Hermanson, and Salmonson, a two-volume set covering the basic accounting principles course (5). The Accounting Process (29) is a self-teaching text not intended for classroom use. Several publishers of programmed learning series have included accounting principles in their series. Schaum's Outline Series (3) and Irwin's Programmed Learning Aid (PLAID) series (19) are good examples of popular self-instructional aids in beginning accounting. A market survey by Huffman (10, p. 20) of college programmed accounting materials reveals that most accounting instructors were interested in short, supplemental units for review or remedial use. Because of difficulty in use, many believed that existing programmed texts did not fulfill their needs.

The current status of programmed materials and machine use in accounting instruction is difficult to ascertain. Little is mentioned in the literature on new developments in programmed materials and machines in accounting instruction since 1970, an exception being the study in 1976 by Laughlin, Gentry, and May (12, pp. 347-51), which essentially validates a number of findings previously reported.

The dearth of literature mentioned above could well be reflective of growing disenchantment of educators over the past decade with the utility of much of the media produced for sale. The documented advantages of media in the learning process have led the unwary to select media without adequately understanding what to look for or how to determine quality level of media. Much media was produced to sell, without adequate preparation or testing for effectiveness. One can hope for a more realistic attitude towards media and its use by professional educators in the coming years.

DESIGN OF THE EXPERIMENT

The basic thrust of this study was to determine the impact on learning produced through the use of programmed materials in the beginning accounting courses. An attempt was also made to determine the relative effectiveness of two different uses of programmed media in accounting principles courses, one in class, the other, out-of-class. This chapter describes the methods and procedures that were used to prepare for and conduct the necessary research, and to analyze the data gathered from the study. The chapter is divided into four parts:

1. Selection of the population for the study
2. Description of research materials used
3. Testing
4. Treatment of the data

Selection of the Population

Principles of accounting is a two-semester course of study at Lincoln Land Community College. The course is divided into two separate, sequential courses, each carrying three semester hours credit, and entitled Principles of Accounting 101 (ACC 101) and Principles of Accounting 102 (ACC 102). Both Principles of Accounting 101 and Principles of Accounting 102 are offered each semester. Each of the two principles courses covers approximately one-half of the chapters of the textbook used in both courses, namely, <u>Accounting: An Introduction</u>, authored by Kenneth W. Perry, published by McGraw-Hill Book Company, copyright 1971.

The enrollment process assigning students to sections of Principles of Accounting 101 and Principles of Accounting 102 was not random. However, the registration procedure did attempt to direct students into varying class hours to gradually fill sections on an approximately even basis. Multiple section offerings of alternative courses were arranged to help prevent conflicts in registering students evenly in the two basic accounting courses.

To test for randomness in student ability, American College Testing (ACT) scores were secured from official school records for all students in the twelve sections of Principles of Accounting 101 and 102 included in the study. The ACT scores for students within each of the four categories of research were ranked according to size. The Kruskal-Wallis one-way analysis of variance by ranks was used to test whether k independent samples could have been randomly drawn from the same continuous population. The Kruskal-Wallis formula is:

$$H = \frac{12}{N(N+1)} \sum_{j=1}^{k} \frac{R_j^2}{n_j} - \frac{3(N+1)}{1 - \frac{\sum T_j}{N^3 - N}}$$

where k = the number of samples in the jth sample;

N = n_j, the number of cases in all samples combined;

R = the sum of ranks in the jth sample;

$1 - \frac{\sum T_j}{N^3 - N}$ = the correction factor for ties, and

H = the measure of sample randomness.

The null hypotheses for the four categories of research, testing for student ability randomness, are as follow:

H_{o_1} : The three sections of Principles of Accounting 101 students used for the ALEX in-class study are not randomly drawn, as measured by student ACT scores.

H_{o_2} : The three sections of Principles of Accounting 102 students used for the ALEX in-class study are not randomly drawn, as measured by student ACT scores.

H_{o_3} : The three sections of Principles of Accounting 101 students used for the out-of-class study are not randomly drawn, as measured by student ACT scores.

H_{o_4} : The three sections of Principles of Accounting 102 students used for the out-of-class study are not randomly drawn, as measured by student ACT scores.

Table 1 below shows the results of the Kruskal-Wallis analysis. Since in each case the calculated probability is smaller than our previously set level of confidence (P = 0.05), the decision was to reject H_o in all four cases.

The Kruskal-Wallis test appears to be the most effecient of the non-parametric tests for k independent samples. It has a power-effeciency of $3/\pi = 95.5$ percent, when compared with the F test, the most powerful parametric test (21, p. 194). Use of the Kruskal-Wallis test avoids having to make the assumptions concerning normality and homogeneity of variance associated with the parametric F test, and allows one to increase the generality of the findings

Table 1. Kruskal-Wallis one-way analysis of variance to test for randomness in student ability

	ALEX in-class study		Out-of-class study	
	ACC 101	ACC 102	ACC 101	ACC 102
Calculated H	7.894	8.991	9.081	6.020
Table value, 2 df, P = .05	5.991	5.991	5.991	5.991
Probability of calculated H	0.020*	0.025*	0.011*	0.048*

* Level of significance = 0.05.

resulting therefrom (21, p. 189).

Description of Research Materials Used

ALEX materials are comprised of fifty modules, each module consisting of matched cassette tape and color filmstrip. Previous identification of the ALEX system has been made on page 1 of the first chapter. Knox materials are comprised of thirty-nine modules, each module consisting of matched cassette tape and workbook. Although not commercially available for distribution until January, 1976, thirty-six modules of the Knox materials were made available for use of this researcher through the permission of the author, Wilbur F. Pillsbury, including permission for limited reproduction of the materials. The Knox materials are presently being marketed by the Southwestern Publishing Company, Cincinnati, Ohio, under the title, Principles of Accounting: Audio-Cassette Study Guides.

ALEX and Knox materials assigned to students in out-of-class experimental sections were not available to any other students. The distribution and collection of materials assigned to the out-of-class experimental sections were controlled by fulltime staff members of the Lincoln Land Community College Learning Resource Center. Storage and use of the materials were confined to the audio-visual area of the Learning Resource Center, where staff members assisted students in their use of assigned materials and also limited their usage to approved students for maximum time periods.

ALEX and Knox materials assigned to students in experimental sections of Principles of Accounting 101 and Principles of Accounting 102 during the Spring semester of 1975 are described in Table 2. ALEX materials used in place of selected instructor lectures in experimental sections of Principles of Accounting 101 and Principles of Accounting 102 during the Fall semester of 1975 are described in Table 3.

Testing

The American Institute of Certified Public Accountants (AICPA) Achievement Test, Level I, copyright 1975 by the Psychological Corporation, New York, N. Y., was the testing instrument used for both pre- and post-testing. The six sections of Principles of Accounting 101 and six sections of Principles of Accounting 102 were all pre-tested during the second regularly scheduled

Table 2. Materials assigned for out-of-class study in Principles of Accounting 101 and Principles of Accounting 102

Text Chapter	ALEX filmstrip-cassette	Knox workbook-cassette
2	Accounting Framework	Accounting for Assets, Liabilities and Capital
3	Accounting Procedures	Debit and Credit Transactions with the Journal, Ledger, and Trial Balance
5	Receivables	Uncollectible Accounts Receivable
9	Adjustments to Accounting Records	Adjusting Entries for Deferrals and Accruals
10	Inventory Flow Concepts	Inventory Costing Procedures: FIFO, LIFO, and Weighted Average
11	Cost Expiration (Depreciation Methods)	Depreciating Plant Assets
12	Partnership Equity	Partnership: Division of Profits and Losses
16	Shareholders' Equity	Corporate Stock: Subscriptions and Treasury Stock
20	Funds Flow	Statement of Changes in Financial Position: Working Capital Concept of Funds
21	Preparing and Interpreting Statements	Financial Statement Analysis: Four Key Ratios

Table 3. ALEX modules used for in-class study in Principles of Accounting 101 and Principles of Accounting 102

Text Chapter	Light Treatment	Heavy Treatment
2	Accounting Framework	Accounting Framework
3	Accounting Procedure	Accounting Procedure
4		Accounting Cycle: Review
6		Notes and Interest
7		Bank Reconciliation
9	Adjustments to Accounting Records	Adjustments to Accounting Records
10	Inventory Flow Concepts	Inventory Flow Concepts
11	Cost Expiration (Depreciation Methods)	Cost Expiration (Depreciation Methods)
12		Payroll Accounting
13		Present Value Concepts
14	Partnership Equity	Partnership Equity
16	Shareholders' Equity	Shareholders' Equity
18		Income Taxes
20	Funds Flow	Funds Flow
21	Preparing and Interpreting Financial Statements	Preparing and Interpreting Financial Statements
22		Cost Behavior
23		Manufacturing Operations
25		Budgeting

fifty-minute class meeting of the semester. Directions for test administration were carefully followed, with scoring performed by the Psychological Corporation. Both pre- and post-test scores were not available to the two instructors involved in the study until completion of both semesters. The post-test was administered during the second from last regularly scheduled fifty-minute class meeting of the semester.

Differences in conditions of pre-testing and post-testing may have influenced the size of difference scores (difference between the pre- and post-test scores). Whatever the direction of the influence, if any, it was constant for both experimental and control groups. Both instructors recommended to students that they not attempt to guess at any answers they were unsure of. This advice probably accounted for some students showing a minimum gain of zero between pre- and post-tests, all other students having positive gain.

Treatment of Data

Table 4 below shows the arrangement of sections used in examining the two basic research questions. Brackets () indicate the number of students in each section who completed the course. The research design can be described as a multifactor analysis of variance. The University of Pittsburg Statistical Package for the Social Sciences (SSPS, Version 6.01.1, dated 25 Sept 1975) was the computer program utilized for the analysis of variance.

Table 4. Instructor and section arrangement of students in study of in-class materials and out-of-class materials

Principles of Accounting 101 Instructor A		Principles of Accounting 102 Instructor B	
In-class study	Out-of-class study	In-class study	Out-of-class study
Control (28)[a]	Control (26)	Control (26)	Control (19)
Experimental:	Experimental:	Experimental:	Experimental:
Light (26)	ALEX (29)	Light (23)	ALEX (23)
Heavy (28)	Knox (28)	Heavy (21)	Knox (26)

[a]Brackets () indicate number of students in each section.

ANALYSIS OF RESULTS

The problems posed by this study were expressed by the five hypotheses in the first chapter. Beyond this, further analysis of the effects of the interaction of age, sex, and attendance were made.

Experimental Findings: The Analysis of Variance

Table 5 presents the mean difference score (difference between

Table 5. Means and standard deviations of difference scores (difference between pre- and post-test scores) of experimental and control groups in study

Group	Experimental Treatment	N	Mean	Standard Deviation
1	Control: ACC 101	28	6.8571	4.4532
2	ALEX, Light: ACC 101	26	7.4615	4.2165
3	ALEX, Heavy: ACC 101	28	5.3929	3.2585
4	Control: ACC 102	26	4.6923	2.8110
5	ALEX, Light: ACC 102	23	5.1724	3.4956
6	ALEX, Heavy: ACC 102	21	4.4643	3.1796
7	Control: ACC 101	26	7.1154	3.2165
8	ALEX: ACC 101	29	5.5217	2.6777
9	Knox: ACC 101	28	5.9524	3.8010
10	Control: ACC 102	19	7.6316	3.1129
11	ALEX: ACC 102	23	6.1739	2.6569
12	Knox: ACC 102	26	6.1923	1.5497

Table 6. Summary of analysis of variance of difference scores (difference between pre- and post-test scores) of experimental and control groups in study

Groups	Source of Variation	Sums of Squares	DF	Mean Squares	F Ratio	Sig. of F
1, 2, and 3: ACC 101	Between groups	61.7362	2	30.8681	1.925	0.151
	Within groups	1266.5867	79	16.0325		
	Total	1328.3049	81			
4, 5, and 6: ACC 102	Between groups	33.5261	2	16.7630	1.592	0.209
	Within groups	704.3453	67	10.5275		
	Total	738.8714	69			
7, 8, and 9: ACC 101	Between groups	7.4557	2	3.7279	0.367	0.668
	Within groups	812.6407	80	10.1580		
	Total	820.0964	82			
10, 11, and 12: ACC 102	Between groups	28.7067	2	14.3534	2.394	0.097
	Within groups	389.7639	65	5.9964		
	Total	418.4706	67			

pre- and post-test scores) and the dispersion of these scores for each of the twelve sections involved in the study.

The core data for the analysis of variance are detailed in Table 6 above, which shows the results of two independent variables on one dependent variable. The dependent variable was the difference between before and after measures of achievement in subject matter. The independent variables were:

1. A contrast between two types of auto-tutorial learning experiences with a null condition; and
2. A contrast between two levels of programmed classroom instruction with a null condition.

An analysis of the first four hypotheses in the first chapter shows none of the group variances to be significant. A statement of the four hypotheses and the analysis required of them follow.

Null Hypothesis 1: There will be no significant difference in learning (as measured by the difference between pre- and post-test scores) between three groups of beginning accounting students, one group receiving a light, five-module treatment of ALEX materials in class, another group receiving a heavy, ten-module treatment of ALEX materials in class, and a control group receiving no ALEX materials treatment in class.

Rejection of Null Hypothesis 1 is not possible, with F probability of 0.151, which, though relatively low, is still above the 0.05 level of significance.

Null Hypothesis 2: There will be no significant difference in learning (as measured by the difference between pre- and post-test scores) between three groups of second semester accounting students, one group receiving a light, four-module treatment of ALEX materials in class, another group receiving a heavy, eight-module treatment of ALEX materials in class, and a control group receiving no <u>ALEX</u> materials treatment in class.

Null Hypothesis 2 cannot be rejected, with F probability of 0.209.

Null Hypothesis 3: There will be no significant difference in learning (as measured by the difference between pre- and post-test scores) between three groups of beginning accounting students, one group assigned <u>ALEX</u> materials as additional out-of-class assignments, another group using equivalent (Knox College) materials as additional out-of-class assignments, and a control group with no additional out-of-class assignment.

A probability for F of 0.668 does not allow rejection of Null Hypothesis 3.

Null Hypothesis 4: There will be no significant difference in learning (as measured by the difference between pre- and post-test scores) between three groups of second semester accounting students, one group assigned <u>ALEX</u> materials as additional out-of-class assignments, another group using equivalent (Knox College) materials as additional out-of-class assignments, and a control group with no additional out-of-class assignment.

The data do not allow rejection of Null Hypothesis 4, though the F probability of 0.097 is the smallest of any of the four groups, approaching the 0.05 level of significance.

Experimental Findings: Interaction Analysis

Although the initial four hypotheses were not statistically significant at the 0.05 level of significance, results of significance were obtained when interactions of age, sex, and attendance were measured.

Most students enrolled in the day sections at Lincoln Land Community College were fulltime freshman and sophomore level individuals who had entered college directly from high school. It seemed desirable to measure the impact on performance of students twenty years of age and younger as contrasted with those over twenty years of age.

Distinction between performance by male and female students was measured by separating students into male and female categories. The influence of attendance on performance was measured by dividing students into two categories. The first category included all students missing less than five (or ten percent) of the forty-eight scheduled class meetings; the second category included those missing ten percent or more of the forty-eight scheduled class meetings. Lincoln Land Community College had no formal class attendance policy.

Groups 1, 2, and 3

The data in Table 7 below indicate no significant interactions of age, sex, and attendance. The main effect of sex as a source of variation does approach significance with F = 0.093.

Table 7. Age, sex, and attendance as sources of variation and interaction in groups 1, 2, and 3 (ACC 101: ALEX in-class control and treatments)

Source of Variation	Sums of Squares	DF	Mean Square	F	Level of Sig.
Main Effects:	48.205	3	16.068	0.957	0.999
Age	1.956	1	1.956	0.116	0.999
Sex	47.430	1	47.430	2.824	0.093
Attendance	3.006	1	3.006	0.179	0.099
Two-way Interaction:	20.489	3	6.830	0.407	0.999
Age and Sex	17.361	1	17.361	1.034	0.313
Age and Attendance	8.385	1	8.385	0.499	0.999
Sex and Attendance	0.063	1	0.063	0.004	0.999
Residual	1259.610	75	16.795		
Total	1328.305	81	16.399		

Groups 4, 5, and 6

Table 8 indicates a significant main effect of attendance, with F = 0.011. No significant interactions are present.

Table 8. Age, sex, and attendance as sources of variation and interaction in groups 4, 5, and 6 (ACC 102: ALEX in-class control and treatments)

Source of Variation	Sums of Squares	DF	Mean Square	F	Level of Sig.
Main Effects:	86.468	3	28.823	3.038	0.033*
Age	9.413	1	9.413	0.992	0.999
Sex	2.769	1	2.769	0.292	0.999
Attendance	63.068	1	63.068	6.648	0.011*
Two-way Interaction:	12.619	3	4.206	0.443	0.999
Age and Sex	0.196	1	0.196	0.021	0.999
Age and Attendance	3.016	1	3.016	0.318	0.999
Sex and Attendance	5.498	1	5.498	0.580	0.999
Residual	721.009	76	9.487		
Total	820.096	82	10.001		

* Level of significance = 0.05.

Groups 7, 8, and 9

Highly significant main effects of age (F = 0.002) and attendance (F = 0.001) are shown in Table 9. No significant interaction effects are present.

Table 9. Age, sex, and attendance as sources of variation and interaction in groups 7, 8, and 9 (ACC 101: ALEX and Knox out-of-class control and treatment)

Source of Variation	Sums of Squares	DF	Mean Square	F	Level of Sig.
Main Effects:	256.254	3	85.418	11.461	0.001**
Age	79.669	1	79.669	10.690	0.002**
Sex	13.755	1	13.755	1.846	0.176
Attendance	132.388	1	132.388	17.763	0.001**
Two-way Interaction:	5.632	3	2.816	0.378	0.999
Age and Sex	4.648	1	4.648	0.624	0.999
Sex and Attendance	1.714	1	1.714	0.230	0.999
Residual	476.986	64	7.453		
Total	738.871	69	10.708		

** Level of significance = 0.01

Groups 10, 11, and 12

A significant main effect of age (F = 0.034) and a highly significant main effect of attendance (F = 0.007) are shown in Table 10. No significant interaction effects are shown.

Table 10. Age, sex, and attendance as sources of variation and interaction in groups 10, 11, and 12 (ACC 102: ALEX and Knox out-of-class control and treatment)

Sources of Variation	Sums of Squares	DF	Mean Square	F	Level of Sig.
Main Effects:	71.030	3	23.677	4.267	0.009**
Age	25.542	1	25.542	4.603	0.034*
Sex	7.376	1	7.376	1.329	0.252
Attendance	43.142	1	43.142	7.775	0.007**
Two-way Interaction:	8.975	3	2.992	0.539	0.999
Age and Sex	0.235	1	0.235	0.042	0.999
Age and Attendance	5.275	1	5.275	0.951	0.999
Sex and Attendance	2.397	1	2.397	0.432	0.999
Residual	338.466	61	5.549		
Total	418.471	67	6.246		

* Level of significance = 0.05.

** Level of significance = 0.01.

Null Hypothesis 5: There will be no significant difference in learning (as measured by the difference between pre- and post-test scores) between the main effects and interactions of the following variable characteristics of the students: age, sex, and attendance at class.

Since significant differences were found in some of the groups analyzed relative to sex, age, and attendance, Null Hypothesis 5 must be rejected. Rejection of the hypothesis does not imply that in every case there existed significant differences between groups of students in each and every one of the four statistical analyses.

The analysis of Principles of Accounting 101 (Groups 1, 2, and 3) showed no significant results regarding sex, age, and attendance. However, Principles of Accounting 102 (Groups 4, 5, and 6) did show significant main effects of attendance. In neither case, Principles of Accounting 101 nor Principles of Accounting 102, was there any significant interaction of the three factors.

The analysis of Principles of Accounting 101 (Groups 7, 8, and 9) showed highly significant results of the main effects of age and attendance. Principles of Accounting 102 (Groups 10, 11, and 12) showed significant results regarding the main effect of age, and highly significant results regarding the main effect of attendance. There was no significant interaction of the three factors in Principles of Accounting 101 and Principles of Accounting 102.

An examination of the possible correlation of age and attendance resulted in a Pearson product moment r coeffecient of determination value of -0.0328. This translates into a statistical significance of 0.285, well above the previously determined level of significance of 0.05, suggesting relatively low, negative correlation. The University of Pittsburg Statistical Package for the Social Sciences (SSPS) was the computer program utilized for the correlation analysis.

The above correlation analysis of age and attendance showed no statistical significance. This is consistent with the previously reported absence of two-way interaction at the significance level of 0.05 in all four experimental arrangements. With the exception of age and sex in the Accounting I, ALEX in-class experiment, all two-way interaction F values showed significance levels of 0.999.

One must be hesitant to extrapolate the results obtained in either the analysis of variance or the interaction analysis. Great care was taken by both instructors involved in the experimentation to avoid injecting personal bias or avoidable variation in those subjective aspects of teaching technique. The data analyses suggest that factors other than the experimental materials used were responsible for that portion of the change between pre- and post-test scores which could be statistically explained.

Experimental Findings: Some Qualitative Aspects

Several attempts were made during this study to secure some qualitative expressions from the student subjects. Short personal interviews by the researcher with each student withdrawing from the twelve sections included in the study elicited no negative comments about being part of an experimental learning experience. No withdrawing student interviewed indicated his/her reasons for withdrawal were related to being involved in an experimental group. The author was especially concerned about the possible negative effect on students considering withdrawal who were enrolled in the four sections assigned additional out-of-class material. Table 11 shows the number of withdrawals in both control and experimental groups.

An opinion instrument designed to anonymously survey the subjective reactions of students involved in the eight experimental groups was administered during the class session just preceding the post-test, but after informing students of their course grade. Results of the survey are given in Table 12 and Table 13.

Students in Principles of Accounting 102 experimental groups seemed to consider ALEX materials used in class more highly valued than did Principles of Accounting 101 experimental group students. There also appears to be a somewhat higher value placed on heavy versus light ALEX in-class use in both Principles of Accounting 101 and Principles of Accounting 102.

Table 11. Initial enrollment, withdrawals, and final enrollment of students for each of the twelve sections of Principles of Accounting 101 and Principles of Accounting 102 comprising the study

Group	Enrollments Initial	Enrollments Final	Withdrawals
ACC 101: In-class, control	35	28	7
ACC 101: In-class, ALEX, Light	34	26	8
ACC 101: In-class, ALEX, Heavy	36	28	8
ACC 102: In-class, control	32	26	6
ACC 102: In-class, ALEX, Light	30	23	7
ACC 102: In-class, ALEX, Heavy	30	21	9
ACC 101: Out-of-class, control	33	26	7
ACC 101: Out-of-class, ALEX	34	29	5
ACC 101: Out-of-class, Knox	35	28	7
ACC 102: Out-of-class, control	27	19	8
ACC 102: Out-of-class, ALEX	29	23	6
ACC 102: Out-of-class, Knox	31	26	5

It would appear that Knox materials were slightly more valued as contrasted with ALEX materials. This is especially evident in the number of students who indicated the response "Of little or no value." Ten students selected that response when evaluating ALEX materials used in class as contrasted with only one student who

Table 12. Student evaluation of the usefulness of ALEX materials used in regular class sessions in place of instructor lectures

Group	Experimental Treatment	Frequency of Response: Highly useful	Somewhat useful	Of little or no use	Total count
2	ACC 101: ALEX, Light	7	16	3	26
3	ACC 101: ALEX, Heavy	9	16	2	27
5	ACC 102: ALEX, Light	8	9	4	21
6	ACC 102: ALEX, Heavy	14	6	1	21

selected the same response when evaluating the use of out-of-class materials. General reaction by this researcher is that the data represented by Tables 12 and 13 were gathered in a nonthreatening manner, and as such, represent the beliefs of the students responding to the survey.

Table 13. Student evaluation of the usefulness of assigned additional out-of-class materials

Group	Experimental Treatment	Frequency of Response: Highly useful	Somewhat useful	Of little or no use	Total count
8	ACC 101: ALEX materials	12	14	1	27
9	ACC 101: Knox materials	16	10	0	26
11	ACC 102: ALEX materials	11	12	0	23
12	ACC 102: Knox materials	14	12	0	26

A Chi-square analysis of students' responses to experimental treatment materials was performed, again using the SSPS computer program. Four hypotheses were formulated:

H_{01}: Student evaluations of the usefulness of materials used in the Accounting I, ALEX Light and Accounting I, ALEX Heavy treatment groups do not differ significantly between the two groups.

H_{02}: Student evaluations of the usefulness of materials used in the Accounting II, ALEX Light and Accounting II, ALEX Heavy treatment groups do not differ significantly between the two groups.

H_{03}: Student evaluations of the usefulness of materials used in the Accounting I out-of-class treatment groups (ALEX and Knox) do not differ significantly between the two groups.

H_{04}: Student evaluations of the usefulness of materials used in the Accounting II out-of-class treatment groups (ALEX and Knox) do not differ significantly between the two groups.

Results of the Chi-square analysis are shown in Table 14 on the following page. Since in each case the significance of the Chi-square value is greater than previously set level of significance (0.05), the null hypothesis cannot be rejected in any of the four cases.

Table 14. Chi-square analysis of the significance of student evaluations of the usefulness of materials used for experimental groups

Groups	Experimental Treatment	Chi-square value	DF	Sig. of Chi-square
2 and 3	In-class, Accounting I: ALEX Light, ALEX Heavy	0.43129	2	0.816
5 and 6	In-class, Accounting II: ALEX Light, ALEX Heavy	0.43637	2	0.134
8 and 9	Out-of-class, Accounting I: ALEX, Knox	2.20021	2	0.339
11 and 12	Out-of-class, Accounting II: ALEX, Knox	0.01807	2	0.999

SUMMARY

The stated purpose of this study was to examine three major categories of possible impact made by the ALEX system of auto-tutorial instruction. The following will summarize the progress and results of this investigation.

The first objective was "To evaluate the effectiveness of the ALEX system when used within the formal classroom situation as a substitute for the instructor's lectures, testing the effects of both light and heavy levels of treatment." Hypotheses 1 and 2 were directed towards examining any significant differences between mean scores on before- and after-measures of three sections each of Principles of Accounting 101 and Principles of Accounting 102.

Principles of Accounting 101 (Groups 1, 2, and 3) sections included a section which received a light, five-module treatment of ALEX materials, another section which received a heavy, ten-module treatment of ALEX materials, and a control section which received no treatment of ALEX materials. Principles of Accounting 102 (Groups 4, 5, and 6) sections included a section which received a light, four-module treatment of ALEX materials, another section which received a heavy, eight-module treatment of ALEX materials, and a control section which received no treatment of ALEX materials. All treatments in Groups 2, 3, 5, and 6 were within the class, both in terms of physical arrangements and time constraints.

Principles of Accounting 101 (Groups 1, 2, and 3) showed no

significant variances between mean scores; nor were there any statistically significant main effects. Principles of Accounting 102 (Groups 4, 5, and 6) mean score differences were not significant, and only the factor of attendance generated a significant main effect, with an F significance of 0.011. Although one might reasonably expect attendance at class to positively influence test performance, further research is recommended on this question.

The second objective stated the attempt "To evaluate the effectiveness of the ALEX system when used as auto-tutorial material outside formal classroom time." The statistical analysis of the data did not show any significant differences between mean scores on before- and after-measures of three sections of Principles of Accounting 101 (Groups 7, 8, and 9), one section assigned ALEX materials as additional out-of-class assignments, another section assigned Knox materials as additional out-of-class assignments, and a third section as control with no additional out-of-class assignments.

The data analysis likewise did not show any significant differences between mean scores on before- and after-measures of three sections of Principles of Accounting 102 (Groups 10, 11, and 12)), one section assigned ALEX materials as additional out-of-class assignments, another section assigned Knox materials as additional out-of-class assignments, and a third section as control with no additional out-of-class assignments.

A further analysis of the effects of age, sex, and attendance in the three Principles of Accounting 101 se tions (Groups 7, 8, and 9) showed highly significant F values for age and attendance, with significance of 0.002 and 0.001 respectively. Principles of Accounting 102 sections (Groups 10, 11, and 12) showed a significant main effect of age (F significance of 0.034), and a highly significant main effect of attendance (F significance of 0.007). There were no significant F values for two-way interactions in Principles of Accounting 102.

All students assigned additional out-of-class materials, namely, Groups 8, 9, 11, and 12, were required to check out the materials under time and place supervision. With this constraint, a reasonable conclusion would ascribe value to age in the learning process which involves assigned materials as additional out-of-class work. Since there was an initial screening which determined that none of the students involved in the study had any significant experience in the practice of bookkeeping or accounting, the older students' significantly better performance could be explained in a number of possible ways.

The students in the "over twenty" category beginning their study of accounting could be more highly motivated to succeed in the learning process, and therefore viewed the additional out-of-class assignments in a more positive way. Also, the "over-twenty" student could have more clearly defined career and course objectives, or be more conscious of the relationship between learning and practice. Either condition would seem to help explain the improved performance of the older student who uses the additional out-of-class materials.

The highly significant effect of attendance at class is more difficult to explain. Students who attend class regularly could have stronger learning motivations which carry over to out-of-class assignments. Their regular attendance at class might also be indicative of better study habits and/or better attitudes towards learning. Another assumption would identify a correlation between learning which occurs because of physical presence in the classroom and reinforcement of that learning through use of additional out-of-class materials. Further research is recommended to examine the relationship between attendance at class and motivation to use additional out-of-class materials for learning reinforcement. Additionally, research examining the relationship between age and learning resulting from additional out-of-class assigned materials seems desirable.

The third category, "To explore some qualitative aspects of multi-media instruction in accounting," was examined by surveying students in experimental sections of the study on their subjective reactions to the degree of usefulness of the materials tested. The Knox materials used as out-of-class assignments seemed to be the most highly valued by students, and the light, four-module use of ALEX materials in class in place of instructor lectures seemed the least highly valued. Personal comments made to the instructors during the length of the study generally paralleled the results of the written survey of student opinion. Brief interviews with the students withdrawing from experimental sections showed no discernible negative reaction to either substitution materials or additional assigned materials as factors in withdrawal from class.

Some concluding remarks are in order. This study attempted to explore some limited aspects of the utility of multi-media learning systems. The results presented and conclusions drawn cannot be extrapolated beyond the population selected for this study. This author invites repetition of the study, or portions thereof, to further examine and hopefully validate the results presented herein. In addition, the author hopes this study stimulates additional research on the effectiveness of auto-tutorial learning systems.

This study involved the use of copyrighted materials. The American Institute of Certified Public Accountants (AICPA) exam used for pre- and post-testing could not be included as appendix material for obvious security reasons. The ALEX and Knox materials were excluded because of their physical nature. All copyrighted materials mentioned above are available for purchase or use through commercial sources or from the publishers.

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