AV Autotutorial Instruction: A Review of Evaluative Research[1]

KATHLEEN M. FISHER

BRIAN MACWHINNEY

INTRODUCTION

Autotutorial (A-T) instruction using audio recordings was first proposed and developed in 1961 by Samuel N. Postlethwait at Purdue University, primarily to meet the challenge of teaching biology to large numbers of students (Postlethwait, Novak, & Murray, 1972). Since that time, the method has been adapted to many different subject areas, class sizes, and institutions.

Two brief reviews of the research aimed at measuring the effectiveness of A-T instruction have appeared. One is an unpublished report by Hinton (1970) containing largely impressionistic evaluations of autotutorial teaching in the California Community Colleges. The other is a recent paper by Mintzes (1975) reviewing 20 studies.

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Kathleen M. Fisher is associate professor of biological sciences education and director of the Teaching Resources Center, University of California—Davis, Davis, CA 95616. Brian MacWhinney is assistant professor in the Department of Psychology, University of Denver, Denver, CO 80210.

In this paper, we review a broad spectrum of the research that has been undertaken to evaluate A-T instruction. There are wide variations in both the evaluative research designs and in the A-T course structures reported on here. No articles were omitted because of design variations or deficiencies, but an effort is made to highlight strengths and weaknesses of the various studies and to give some insight into the experimental procedures employed.

Articles were incorporated into the review if the experimental course being studied utilized modular independent study materials with a recorded audio component on either audiotape or videotape. Visuals and printed materials were often but not always coordinated with the audio presentations. Laboratory experiences were sometimes included. In most courses, student-teacher communication occurred primarily in individual or small group discussions. Lectures were either not given or were used for motivational rather than informational purposes.

Several parameters of instructional design were inadequately reported in the majority of the studies reviewed, precluding any analysis of their individual effects. Among these were the criteria for assigning grades, the frequency and nature of testing, and the extent of student control of pacing.

The 89 studies cited in this review were obtained from educational journals, science journals, abstracts, conference reports, and dissertations during the period 1962-1975. The research focuses largely on college teaching, with some studies in elementary, secondary, business, and special skills classes. Forty-four of the studies evaluate comparative student achievement and 27 report on student attitudes. Others examine predictors of achievement in A-T classes, effects of individual components of A-T instruction, and various other aspects of A-T teaching/learning.

FORTY-FOUR COMPARATIVE STUDIES OF STUDENT ACHIEVEMENT

Forty-four comparative studies are summarized in Table 1. Each one compares the achievements of two groups of students who are enrolled in the same or similar courses and who are exposed to two different instructional methods, A-T and traditional. All but three (Russell, 1968; McVey, 1971; Fisher, Sorensen, Guenther, Stewart, & MacWhinney, 1975) compare treatment groups within a single campus. Com-

parisons are usually made between concurrent courses, sometimes between successive courses. The comparisons attempt to maintain similar or identical subject matter coverage between the two groups.

The 25 studies marked with asterisks in Table 1 include the following parameters in their experimental designs: 1) matched experimental and control groups; 2) use of either a pretest or random assignment or both; 3) identical posttest measures; 4) comparability of subject matter presented to the two groups; 5) statistical analysis of the data; and 6) a minimum of confounding variables. These studies, in the estimation of the authors, were acceptably well designed, executed, and reported to warrant trust in the findings.

The 12 studies in Table 1 having no symbols by the authors' names also made comparisons between treatment groups on the basis of similar or identical posttests. They do not include all of the design parameters listed above, however, and some take quite different approaches in experimental design.

The seven studies in Table 1 marked with stars compared student achievement with A-T and traditional instruction on the basis of final grades earned by the two groups, usually in successive rather than concurrent courses. Comparability of neither the subject matter nor the grading criteria were clearly established. The courses being compared were generally taught by the same person(s), however, and the authors tend to believe that the comparisons are justified.

Studies Favoring Lecture Method

The traditional group surpassed the A-T group in one study (Russell, 1968). He compared the use of multimedia A-T biology instruction at El Centro College with conventional biology instruction in Tarrant County Junior College. The American College Test (ACT) Natural Science score was used as a covariant. Some students were excluded from the study because they lacked a score on the ACT or because they had had previous college courses in science; these selection criteria may limit the generality of the results. Russell found a significant difference ($p < .05$) in final exam performance between the two groups.

Studies Favoring A-T

Thirty studies found the A-T method to be superior to the conventional method in producing student achievement as measured by final examinations. The differences were significant at $p < .05$ in 18 of these.

TABLE 1
Comparative Studies of Student Achievement[a]

Study[b]	*Subject*[c]	*Exp.*[d] *N*	*Control N*	*Assign. Random*[e]	*Pre-test*[f]	*Weeks Rx*[g]	Favors[h]	*Signif-icance*[i] p <
Elementary								
*Gardiner (1971)	Word Pattern Identification	~ 30	~ 30	---	yes	8	A-T	.05
*White (1972)	Spelling	24	24	yes	yes	~10	A-T	.05
Junior High								
*Johnston (1969)	Mathematics	71	68	?	yes	15	neither	---
High School								
Knoop (1969)	Physics	40	40	---	yes	~30	neither	---
*McVey (1970)	Vocational Agriculture	366	232	yes	yes	2	neither	---
*Nordland & Kahle (1973)	Biology	59	59	yes	---	3	A-T	.06
*Volker (1970)	Biology	-311-		yes	yes	?	A-T	.05
College Level, Science								
⋆Allen (1973)	General Chemistry	610	?	---	---	15	A-T	---
Arnwine & Juby (1969)	General Biology	18	0	---	yes	~15	A-T	.001
Becker & Shumway (1972)	General Genetics	18	194	yes	---	~15	A-T	---
⋆Blizzard, Clark, & Humphreys (1973)	Chemistry	25	326	---	---	6	A-T	---
Brewer (1970)	Plant Anatomy	250	?	---	---	?	A-T	.001
⋆Diederich & Macklin (1973)	Physics	115	188	---	---	~15	neither	---
Erhart (1969)	Physical Geography	320	?	---	---	~15	A-T	---
*Fisher, Sorensen, Guenther, Stewart, & MacWhinney (1976) Genetics		386	237	---	yes	10	A-T	.001
Flocker (1972)	Plant Science	210	755	---	---	~15	A-T	---

TABLE 1 *(Continued)*

*Gould, Langford & Mott (1972)	Earth Science	190	305	yes	yes	~15	A-T	.001
*Grobe (1970)	Biology	38	41	yes	yes	~15	neither	---
*Hahn (1971)	Biology	1183	1626	---	---	~15	A-T	---
*Meleca (1968)	General Biology	48	43	yes	yes	~30	A-T	.05
*McClurg (1971)	Geology	98	14	---	yes	~15	neither	---
*Quick (1971)	Biology	?	?	yes?	yes	?	A-T	.05
⋆Richason (1970)	Geography	?	?	---	---	~30	A-T	---
*Rowsey (1973)	Animal Biology	134	190	yes?	---	~10	A-T	.05
Russell (1968)	Biology	233	187	---	yes	~30	lecture	.05
*Short (1970)	Food Science	29	29	yes	yes	~15	neither	---
*Siemankowski (1969)	Physical Science	19	147	yes	yes	1	A-T	.05
⋆Sparks & Unbehaun (1971)	General Biology	190	180	---	yes	?	A-T	.05
Weaver (1969)	Biology	268	53	---	yes	~15-30	neither	---
Welker (1969)	Biology	38	38	---	yes	10	neither	---
*Welser, Lewis, & Stockton (1970)	Canine Anatomy	42	30	yes	---	?	neither	---
⋆Yarger & Cranson (1969)	Earth Science	~900	?	---	---	~15	A-T	---
College Level, Nonscience								
Anderson (1969)	Western Civilization	135	?	---	---	15	A-T	---
*Cunningham (1973)	Algebra	?	?	yes	yes	~15	neither	---
Dworkin & Holden (1959)	Atomic Bonding	39	39	yes	no	~10	neither	---
*Edwards (1969)	Business Machines	~ 30	~30	yes	yes	~10	A-T	.025
*Fields (1973)	Shorthand	15	21	---	yes	~15	A-T	.05
*Hinds (1971)	Machines for Teaching	48	29	---	yes	6	A-T	.01
*Junkmann (1971)	USAF Academic Instruction	48	46	---	yes	5	A-T	.05
*Onah (1971)	Accounting	-62-		yes	yes	~15	neither	---
Phillips (1972)	Industrial Engineering	-30-		---	---	1	A-T	---
*Sherman (1969)	American History	46	22	---	---	~15	A-T	---
*Stuck & Manatt (1970)	Law	108	111	yes	yes	1	A-T	.01
*Tipling (1973)	Use of A-V Materials	40	20	---	yes	~15	A-T	.001

See footnotes, p. 234.

Elementary. In two of the courses under examination, audiotapes were employed without visuals. Gardiner (1971) found that second graders who received instruction in reading with audiotapes and printed materials registered significantly higher gains on a test of word pattern identification and a reading attitude survey than did students who received teacher-presented reading instruction. Using the Iowa Test of Basic Skills spelling test as pretest and covariant, White (1972) observed that students who received instruction in spelling with audiotapes performed significantly better than the control group on the final examination.

High School. Nordland and Kahle (1973) assigned subjects in a high school biology class randomly to A-T and traditional sections. There were no significant differences between groups on any of 11 ability measures prior to treatment. After three weeks, the A-T group scored higher on a posttest at a nearly significant ($p < .06$) level. Volker (1970), using the pretest as a covariant, found that six sections of a high school biology class that received multimedia A-T instruction performed significantly better on the posttest than did six sections receiving conventional instruction.

College Science. Several studies compared multimedia approaches or Postlethwait-style A-T instruction to conventional lecture-demonstration-laboratory methods. Meleca (1968) found that the A-T group scored significantly higher

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TABLE 1 (*Continued*)

[a]Table 1 summarizes 44 studies which compare student achievement with A-T and lecture instruction.

[b]The 25 studies marked with asterisks (*) appear to incorporate consistent parameters of evaluative research design as described in the text. The seven studies marked with stars (⋆) made comparisons on the basis of final grades achieved. The 12 studies having no notation by the authors' names made comparisons on the basis of similar or identical final exam items. The studies are listed by author and grouped by level and field.

[c]Indicates the subject taught in the course under study.

[d]*Exp. N and Control N* give numbers of subjects in the experimental and control groups. In some cases only the total number is given. Where specific numbers were not provided but the study involved one class, the class size was assumed to be ~30.

[e]Indicates whether or not subjects were randomly assigned to instructional treatment.

[f]Indicates whether or not a pretest was given.

[g]Indicates approximate length of treatment. Where precise lengths were not provided, a quarter was assumed to be about 10 weeks, a semester about 15 weeks, and a year 30 weeks.

[h]Indicates whether the comparative study favored lecture, A-T, or found no difference (neither).

[i]Indicates the level of significance of the achievement differences between the A-T and lecture groups.

on final achievement tests, although there were no significant differences between treatment groups on a Scholastic Aptitude Test (SAT) in math, College Entrance Examination Board (CEEB) Biology Tests, or the Achievement Test in Genetics that were used as pretests. Using the Test on Understanding Science as a pretest and posttest for both groups, Quick (1971) found the A-T group in college biology to score significantly higher on the posttest. Sparks and Unbehaun (1971) found that two treatment groups in biology did not differ significantly on the American College Test (ACT) of Natural Science Skills used as a pretest, but the A-T group scored significantly higher on 274 test items given throughout the course. Rowsey (1973) assigned 324 students to A-T and conventional treatments in Animal Biology, presumably on a random basis; the A-T group scored significantly higher on the Achievement in Biology Test used as a posttest.

Arnwine and Juby (1969) derived a set of regression equations (one for males, one for females) based on high school grades, ACT composite scores, and grades earned during the first semester of a college biology course. Eighteen students were then selected from 169 second semester enrollees and placed in an experimental A-T group. A predictive regression score was calculated for each of the 18 students in the experimental class. A chi-square analysis showed that the A-T students achieved significantly better than predicted. A control group consisting of 18 students received conventional instruction, but comparisons of predictive regression scores and performance were not reported for this group.

Fisher, Sorensen, Guenther, Stewart, and MacWhinney (1975) made pretest-posttest comparisions for students enrolled in introductory genetics courses having similar purposes and contents on three different campuses of a single university. Students enrolled in the video-autotutorial course performed significantly better than students enrolled in two different lecture courses.

Two studies compared performances on an examination where there were obvious differences in motivational levels between the two groups. Becker and Shumway (1972) gave a final examination to 18 students receiving A-T instruction and 194 students receiving conventional instruction; the final was important in determining grades for the conventional

group while having no effect on the grades of the A-T group. The authors note that the A-T groups " . . . did not study as hard for it (the exam) as they would have if it had been determining their grade" (p. 126), yet the mean grade point average for the A-T group was slightly higher (148.1 ± 5.6) than that for the conventional group (145.6 ± 2). Flocker (1972) gave 210 A-T students an unannounced midterm which had been taken by 755 conventionally taught plant science students during previous terms on an announced basis; there was no significant difference in performance between the two groups despite the difference in preparedness.

Siemankowski (1969) gave A-T instruction to 19 randomly selected volunteers from a total sample of 166 students in a course in physical science for elementary school teachers. The A-T group scored significantly better than the conventional lecture group.

Gould, Langford, and Mott (1972; see also Gould and Langford, 1970) assigned students randomly to A-T or conventional classes in earth science. In two successive trials, only 18.6 percent and 12 percent of the grades earned by A-T students were lower than "C," while in the conventional groups 29 percent and 30 percent of students respectively scored less than "C" on identical examinations.

Erhart (1969) compared an A-T course in physical geography with a conventional course that used the same visuals and outline. Erhart reports that the mean scores on four hourly exams were very similar for the two treatments, but that the proportion of students receiving "A" was 20 percent higher in the A-T class, while the proportion receiving the grade of "D" was greater in the conventional class. Actual numbers are not reported.

Brewer (1970) found the distribution of scores of 246 students enrolled in A-T plant anatomy in 1969 and 1970 to be higher than those of 92 students enrolled in a lecture course in plant anatomy in 1968. Application of a chi-square test to the data yields a value of $\chi^2 = 74.90$ (df = 2), which is significant at the $p < .001$ level. However, no pretest was administered in this study; the problem is especially severe here since it appears that changes in admissions procedures may have resulted in higher ability levels in the A-T group.

Five studies report higher grades for students enrolled in

A-T science courses as compared to students enrolled in similar lecture classes which were generally taught previously (Allen, 1973; Blizzard, Clark, & Humphreys, 1973; Hahn, 1971; Richason, 1970; Yarger & Cranson, 1969). Hahn (1971) compares performance on identical unit questions and final examinations, but he doesn't show the data. In the other studies, grades were based in part on identical examinations. Allen's comparison (1973) involved mastery grading in the A-T course with nonmastery tests in the lecture course. Richason (1970) covered about 40 percent more material in the A-T course than in the conventional one.

College Level Nonscience. Junkmann (1971) studied the effectiveness of a single lesson delivered to students in an Air Force academic instructor course. The A-T lesson utilized compressed speech with related visual stimuli. With a pretest as covariant, Junkmann found that the group which listened to a single lesson tape with speech compressed to 250 words per minute did significantly better than the group which heard a lecture.

Four studies looked at courses teaching special skills. Edwards (1969) found that students receiving audiovisual instruction in the operation of business machines scored significantly higher on the final exam than did students receiving conventional instruction. Hinds (1971) examined the effects of A-T and conventional methods in a course designed to introduce simple machines to elementary school teachers and, using an analysis of pretest-posttest gains by a two-tailed t-test method, found a significiant difference in favor of A-T instruction. Using a pretest as a covariant, Fields (1973) found that film-tape instruction produced significantly faster dictation speeds in classes in shorthand. Tipling (1973) used a 160-item pretest-posttest in a course on the use of audiovisual materials in teaching; with the pretest score as a covariant, the A-T group was found to perform significantly higher on the posttest.

Phillips (1972) examined the effectiveness of three different methods of presentation (taped lecture, taped lecture plus visuals, and handout) with three different topics (foundry-working, machining, welding). His experimental population consisted of three classes with ten students in each class. Pretests were not given and random assignment was not

achieved. However, Phillips reports that the students had similar backgrounds and that each group was exposed to each two-way comparison for a different topic. Phillips concluded that there were significant differences between the presentation methods in favor of taped lecture plus visuals for all three subject areas.

A-T methods are not widely used in the humanities, and two studies deserve mention more for their course content than for the strength of their evaluation design. Anderson (1969) reports that A-T students earned about 100 points more than lecture students on a final examination in history, but it is not clear whether 100 points represents a significant difference. Sherman (1969) reports that the mean overall score for an A-T group in American History was 85 percent, while a previous control group earned 63 percent.

No Difference

Thirteen authors found no differences in achievement between treatment groups. Several of these studies were rather complex. McVey (1970) studied the instruction of vocational agriculture in 12 high school classes located throughout Iowa. Six schools were randomly selected to receive A-T instruction and six others were randomly chosen to serve as conventional comparison groups from a total population of 48 high schools. The A-T groups received audiotape and slide programs as supplemental teaching aids. Welser, Lewis, and Stockton (1970) examined 72 students in canine radiographic anatomy. Assignment to treatment was random for all but 12 students. Of the remainder, 30 studied conventionally for three weeks and then studied with A-T for three weeks, while the other 30 reversed this pattern.

Some of the studies finding no differences in achievement between treatment groups suffered high attrition rates. Welker (1969) used the matched pair technique to compare achievement of 76 students out of a total of 199 who completed A-T and conventional classes in biology at Olney Community College. Selection of 19 males and 19 females was made from the experimental group using a random numbers table, and matching students were selected from the control group on the basis of sex, pretest scores, and ACT composite scores. Students chose the instructional method they preferred on the basis of scheduling convenience. Attrition in this study was about 20 percent. Weaver (1969) used

the Nelson Biology Test as a pretest and posttest for conventional and A-T groups in general biology. Although students selected the instructional method they preferred, there was 40 percent attrition in the conventional group and 10 percent attrition in the A-T group.

The following studies also report no differences between treatment groups. Knoop (1969) compared performance in a Postlethwait-style course in high school physics to that in a previous lecture course, selecting 40 students from each group for whom a Primary Mental Abilities score, geometry grade, and fourth semester cumulative index were available; these measures served as covariants. Performance was measured by six identical unit tests, six weekly grades, and a final grade; the bases for the latter two were not specified. Grobe (1970) compared biology classes using the CEEB Advanced Placement Exam in Biology as a pretest and an alternate form as a posttest. Diederich and Macklin (1973; see also Diederich, 1973) compared final grades in A-T and conventional sections of a physics course. Three-fourths of the final grade was based upon performance on identical examinations, while the remainder was determined by scores on laboratory reports. Dworkin and Holden (1959) used the matched pairs critical ratio technique to compare the use of sound filmstrips and lectures on four topics in a communications development program that was otherwise taught by conventional lectures.

Cunningham (1973) used the California Test Bureau Basic Skills Mathematics Test as both a pretest and posttest for the junior college algebra classes that he compared. Students were allowed to register for any section, and then assignments of treatment to section were made randomly. The A-T classes were fully self-paced, used audiotapes with no graphics, and included some programed instruction. There were no significant differences in pretest-posttest gains between treatment groups even though many of the self-paced students had not finished the course at the time the posttest was given while all of the traditional students had completed the course.

Johnston (1969) found no differences in achievement with treatment in seventh grade math using a multifactor analysis of covariance design in which intelligence quotient (IQ),

grade point average (GPA), and a pretest score were employed as covariants. McClurg (1971) found no difference in achievement with conventional lecture-laboratory or tape/slide instruction in geology.

Several of the studies reporting no significant differences used the pretest-posttest repeated measures design (Grobe, 1970; McVey, 1970; Short, 1970; Onah, 1971; and Cunningham, 1973). Some authors suggested that the large error term required by this design may account for the lack of significance in their findings. On the other hand, five of the studies finding significant differences used a similar design (Siemankowski, 1969; Stuck & Manatt, 1970; Gardiner, 1971; Hinds, 1971; and Quick, 1971). Findings attained in the comparative studies of achievement are summarized in Table 2.

OTHER EFFECTS OF A-T INSTRUCTION

The most well documented attribute of A-T instruction is its favorable valuation by students. In essentially all cases, students are reported to like A-T instruction at least as well as lecture instruction, and in many studies they are reported to favor the innovative method.

Some authors report the proportion of students who like the A-T course. Among the comparative achievement studies, Siemankowski (1969) found that 100 percent of the students liked his A-T course in teacher education. Eighty percent of the students liked Hahn's (1971) A-T course. Tipl-

TABLE 2
Summary of Findings of 44 Comparative Studies of Student Achievement

	Conclusion			
	Favors A-T			
Type of Study	*$p < .05$*	*No. sig.*	*Favors Lecture $p < .05$*	*No Difference*
*	16	1	0	8
⋆	0	6	0	1
-	2	5	1	4
Total	18	12	1	13

*Studies that appear to incorporate consistent parameters of research design as reported in the text.

⋆Studies that made comparisons on the basis of final grades achieved.

-Studies that made comparisons on the basis of similar or identical final exam items.

TABLE 3
Proportion of Students Who Prefer A-T to Lecture Instruction[a]

Study	*Students Preferring A-T (%)*	*Achievement Comparison Favored*
Gould, Langford, & Mott (1972)	97	A-T
Postlethwait (1964)	96	---
Brewer (1970)	95	A-T
Meleca (1968)	91	A-T
Knoop (1969)	90	neither
Hinton (1970)	98-90	---
Sather (1969)	87	---
Sherman (1969)	87	A-T
Smith, Skold, & Swingle (1969)	85	---
Erhart (1969)	85	A-T
Allen (1973)	83	A-T
Richason (1970)	80	A-T
Welser, Lewis, & Stockton (1970)	79	neither
Becker & Shumway (1972)	77	A-T
Rowsey (1973)	76	A-T
Yarger & Cranson (1969)	70	A-T

[a]Summary of studies reporting the proportion of students who prefer audio-autotutorial (A-T) instruction to lecture instruction. Many of these studies also made achievement comparisons, as shown.

ing (1973) reports only a 39 percent favorable assessment, but then he also reports 45 percent with neutral attitudes. Anderson (1969) says that from 21 percent to 65 percent of her students liked audiotutorial history; she considered these results favorable as compared to those obtained with conventional instruction. In all of these studies, the A-T students performed better than the traditional group.

In other studies, Himes (1971) reports that student opinion was almost universally favorable. Williams & Rich (1968) note a 98 percent favorable response. Maccini (1969) reports that 81 percent of the students liked his A-T course in geology.

Other investigators have asked students whether they prefer A-T or conventional instruction (Table 3). Overall, about 85 percent of the students prefer the A-T method.

In addition to these global assessments of A-T instruction, there are a few reports of student attitudes toward specific attributes of the method. For example, Edwards (1969) found that the majority of students enjoyed the freedom provided by the individualized approach. Becker & Shumway (1972)

reported that students felt they learned more with A-T instruction. Sather (1969) found 92 percent of the students felt that A-T instruction was more stimulating than conventional instruction and 87 percent noted a greater ease of learning. Zimmerman (1969) reported 84 percent of the students felt that A-T instruction was more motivating than conventional instruction.

In spite of the fact that A-T teaching was rated as better than conventional instruction, Erhart (1969) found that 80 percent of the students responded that they would not like more than one A-T class per year. Hinton (1970) reports that students would not like audio-tutorial materials shelved in libraries and separated from instructors. And, in general, the positive attitudes associated with A-T instruction are limited to the instructional method itself. Short (1970) and Hoffman and Druger (1971) found no significant differences in attitudes toward the subject matter between students in A-T and conventional classes, even though students demonstrated clearly positive attitudes toward the A-T method of instruction.

Effects of A-T instruction on faculty are reported less frequently. Smith, Skold, and Swingle (1969) found that A-T teaching did lead to improved course organization and increased faculty interest and enthusiasm. Three studies report that it was possible to increase coverage in the A-T course over the coverage of its conventional predecessor, presumably desirable from the faculty point of view (Dworkin & Holden, 1959; Postlethwait, 1964; Richason, 1970). Faculty at Mt. San Jacinto replaced some routine lectures with autotutorial programs in order to free faculty for more interaction with students, also presumably a desirable effect (Banister, 1968). On the other hand, Himes (1971) alludes to the limitations of the A-T method, particularly the necessity for motivation and willingness on the part of the teacher to make the program work profitably for the student. Dengler and Friend (1973) report that numerous problems were encountered in advising students in a large A-T biology course which was developed by a team of 12 staff members and in which students could choose their own content from an array of modules.

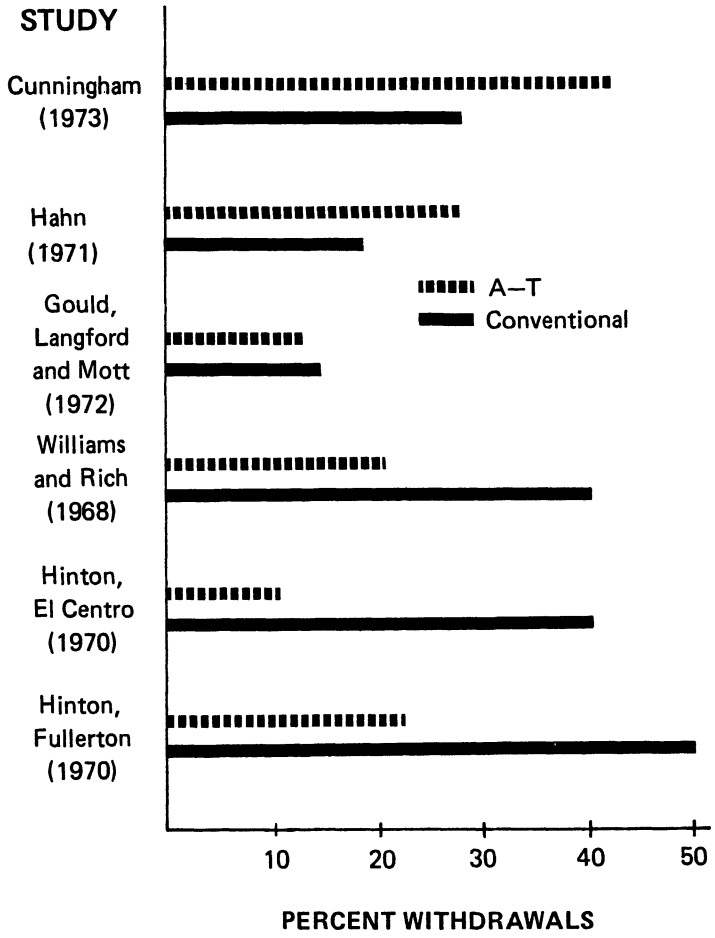
Cost studies generally attribute economic advantages to the A-T method, but the authors point out that the initial expen-

ditures required for A-T instruction are relatively high and that several years may be necessary for the realization of these advantages (Tirrell, 1966; Banister, 1968; Davis, 1968; Meleca, 1968; Williams & Rich, 1968; Hahn, 1971; Nance, 1971; Gould, Langford, & Mott, 1972; Pullen & Klaus, 1973). In most cases the advantages are projected on the basis of equipment costs and student enrollments, and little or no consideration is given to the cost of revision of A-T materials. Postlethwait (1963) reports an actual savings of $11,900 attributable to increased efficiencies resulting from flexible scheduling and multiple use of equipment. Cunningham (1973) reports a savings of $1.07 per student credit hour with A-T instruction ($35.24 for A-T compared to $36.31 for traditional) and suggests that these savings could be increased with higher student enrollments.

If A-T instruction does provide greater motivation and makes learning easier, one would predict dropout rates to be reduced in A-T classes. On the other hand, the increased student responsibilities that are required by A-T instruction may have the opposite effect. In fact, both kinds of results have been reported (Figure 1). Two out of six comparative studies of audiovisual autotutorial instruction report higher dropout rates for students in A-T classes as compared to those in comparable conventional classes.

In comparisons of A-T and traditional approaches, there is no clear-cut evidence to suggest that one is intrinsically more efficient than the other. Six studies report more time is spent in A-T learning (Allen, 1973; Becker & Shumway, 1972; Nord & Sparks, 1969; Rowsey, 1973; Welser, Lewis & Stockton, 1970; Zimmerman, 1969), and an equal number report that more time is required for learning with the conventional method (Brewer, 1970; Gelinas, 1969; Postlethwait, Novak, & Murray, 1972, p. 65; Smith, Skold, & Swingle, 1969; Stuck & Mannatt, 1970; Tope, 1969). Most of these conclusions are based on student opinions. Welser, Lewis & Stockton (1970) found that students spent an average of 81 minutes per week in the A-T class, while only 57 minutes per week were spent in the conventional class. Rowsey (1973) found the average time spent by a student in A-T sections were 67 hours per quarter, while only 51 hours were spent by students in conventional sections.

FIGURE 1
Dropout Rates in Comparative Studies of A-T and Conventional Instruction



Few studies have focused on retention. Buffington (1971) found that learning with self-pacing within an A-T class in Russian was superior to instructor pacing in a similar A-T class when such learning was measured at the end of the term of instruction. However, the significant difference between learning under these two conditions disappeared after three months.

Hinton (1970), reporting on his survey of 34 California Community Colleges, noted that half the colleges believed that retention was better in A-T instruction than in conventional instruction, 46 percent felt that retention was about the same with both instructional methods, and one college (4 percent) felt retention was less by the A-T method.

EFFECTS OF INDIVIDUAL COMPONENTS OF A-T INSTRUCTION

Audio-autotutorial methods employ a variety of subcomponents. Several papers examined the effects of various components on student achievement or student attitudes.

In the courses where unit-mastery grading has been instituted it has received favorable evaluation. Allen (1973) reports that 90 percent of the students in his class approved of unit-mastery grading, and Becker and Shumway (1972) found that unit-mastery grading received the fourth highest evaluation of nine A-T components. Nord and Sparks (1969) and Sather (1969) indicate that students react favorably to frequent oral quizzes.

Looking at the pacing variations permitted by providing students with a means to stop and replay A-T tapes, Burford (1971) found increases in positive mood factors and a decrease in negative mood factors associated with providing playback controls. Similarly, Brewer (1970) felt that the success of A-T instruction in her classes could be attributed to self-pacing and independent study. In addition to the students' positive attitudes toward self-pacing, Buffington (1971) and Smellie (1967) found that self-pacing did enhance student achievement in some experiments at statistically significant levels.

General assembly sessions (GAS) providing motivational lectures have not received high student evaluation. Nord and Sparks (1969) report that 74 percent of their students felt that the GASs were not necessary. Similarly, in an A-T class using GAS, Meleca (1968) found that only 4 percent of the students thought lectures necessary. In the first semester of A-T instruction observed by Hahn (1971) the students criticized the GAS sessions for being a total waste of time. Hahn suggests that this evaluation improved in later terms, but fails to say to what extent. Husband (1970; see also Husband & Postlethwait, 1969) found that GAS received the lowest rating of all the A-T components examined. On the other hand, in an A-T class which was operating without a GAS, Gelinas (1969) found that 52 percent of the students would have liked to have a lecture provided.

Group discussion sessions received the highest rating of the nine components evaluated by the students of Becker and Shumway (1972). Jenkins (1972) assigned students randomly either to listen independently to the A-T tapes or to listen and

discuss them in groups of six. A barely significant difference ($p < .10$) in favor of the small group sessions was observed in both immediate learning and after a period of one month. Jordan (1972) found that the addition of group discussion sessions to an A-T college-level course in audiovisual methods failed to result in significant achievement gains.

Independent study sessions also receive favorable ratings (Nord & Sparks, 1969). Gelinas (1969) indicates that 85 percent of the students enjoy the opportunity to study alone without distraction from other students. Husband (1970) found that students gave the highest rating to independent study.

Becker and Shumway (1972) observed that the typed contents of the audiotape were rated as the fifth most useful of nine A-T components, while the tapes themselves were rated as the eighth most useful. Apparently, the students preferred to study the lessons by reading the transcripts rather than by listening to the tapes. However, Buffington (1971) found that use of a tape with a transcript was no more effective than use of a tape by itself.

Hoffman and Druger (1971) designed two parallel A-T courses which differed in that one was based upon indirect instruction with self-quizzes, problem-solving activities, and a large amount of student-teacher interactions, while the other consisted of direct instruction from teacher to student. Differences between the actual materials used in the two approaches were verified psychometrically by a tape analysis instrument. Students were randomly assigned to treatment and one test was used as pretest, posttest, and retention test. No differences between treatments were observed in regard to learning or retention of factual information or concepts. However, a significant difference in the development of problem-solving ability was observed in favor of the indirect method even though the experimental period lasted only six weeks.

Elliott (1972) and Hill (1973) have evaluated the use of A-T instruction as enrichment within the context of a conventional course. Hill found that the use of A-T materials for teaching creativity in chemistry not only significantly increased creativity, but also increased knowledge of laboratory techniques. Elliott (1972), on the other hand, found that a

group which did library research for enrichment achieved as well as a group which used A-T instruction.

PREDICTORS OF ACHIEVEMENT IN A-T CLASSES

This section is concerned with the way in which certain student traits predict success in audio-autotutorial and in lecture instruction.

Intelligence

Measures of intelligence comprise the most intensively studied predictors of success. In general, performance on intelligence tests correlates highly with achievement. Nine out of 13 studies report no significant interaction between ability and treatment (Edwards, 1969; Welker, 1969; Grobe, 1970; Junkmann, 1971; Sherrill & Druger, 1971; Szabo & Feldhusen, 1971; Postlethwait, Novak & Murray, 1972; Fields, 1973; Fisher, Sorensen, Guenther, Stewart & MacWhinney, 1975).

Significant interactions with treatment were observed in three studies. Using the Johnson-Neyman technique, Diederich and Macklin (1973) found that students with high SAT math scores and high pretest scores did significantly better with conventional instruction, while students with low SAT math scores and low pretest scores did significantly better with A-T instruction. Students with mid-range scores did as well with both treatments. Thus, a significant trait-treatment interaction is present in Diederich and Macklin's data. They hypothesize that the greater individualization provided by A-T instruction benefits low-ability students, while the increased hours of recitation sections in the conventional treatment (2 hours per week) benefit high-ability students.

Knoop (1969) and Nordland and Kahle (1973) also report disordinal interaction of ability with treatment. In the latter study the interaction is so extreme that the slope of the regression line for the A-T treatment is negative. Thus, lower ability students (those scoring below the 40th percentile on a given cognitive measure) perform better in A-T study than higher ability students. This negative regression slope is found for seven of the nine cognitive measures. Within the conventional treatment the usual positive correlation between ability and achievement is found. In contrast, Meleca (1968) observed that SAT math and CEEB biology scores were effective predictors *only* for the A-T condition.

Personality

Five studies have examined the role of personality factors in predicting success in the A-T condition. Sherrill and Druger

(1971) measured attitude with a special questionnaire and personality by factors on Stern's Activities Index and concluded that neither were related to performance in the course. Haakonsen (1969) likewise found that the addition of personality factor scores to cognitive predictors did not significantly increase the resultant multiple correlation coefficient. McDuffie (1973) reported that personality measures from the Guilford-Zimmerman Temperament Survey accounted for only slight amounts of the total variance in achievement.

Szabo and Feldhusen (1971) observed that scores on the restraint scale of the Guilford-Zimmerman Temperament survey did correlate with achievement, in that high restraint (the tendency to be serious-minded and responsible) was found with high achievement. They also observed that among high achievers, prior achievement in mathematical reasoning skills and social studies correlated with success in the conventional course while prior achievement in mathematics computational skills and science achievement were related to success in the A-T course. This suggests that high achievers with low verbal aptitude and low restraint should learn more under A-T instruction.

Finally, Welker (1969) found that of the four classes of scales of the California Psychological Inventory, only the Class IV scales (psychological-mindedness, flexibility, and femininity) have a significant effect ($p < .01$) on achievement in that students with high Class IV scores did better on the posttest. However, this effect did not interact with the specific instructional treatment.

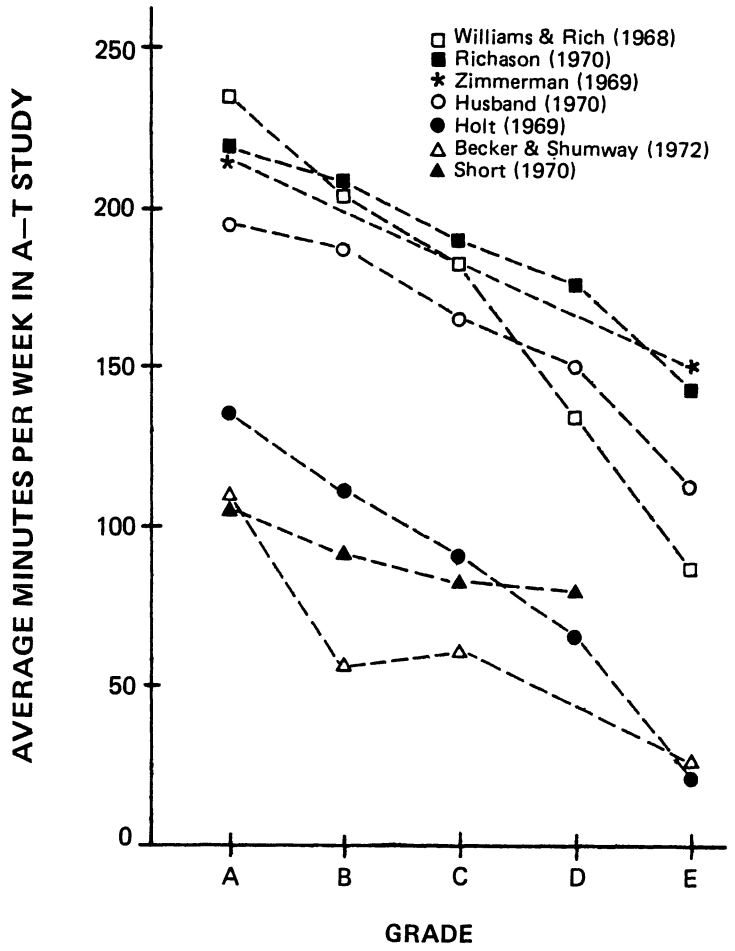
Preference for Instructional Components

Diederich (1973) investigated the possible effect of preferences for instructional components or instructional treatments upon achievement. Although the tendency to find lectures "helpful" was not a significant predictor of performance, the tendency to find recitation sections "helpful" interacted significantly with instructional treatment. Students who found recitation sections helpful did better in the conventional treatment. It should be noted that Diederich's conventional treatment included two hours of recitation per week, while the A-T treatment included one hour per week. Maccini (1969) found that attitude towards A-T instruction was not important in predicting achievement.

Study Time

Seven studies show a correlation between the mean time

FIGURE 2
Correlation Between Study Time and Achievement with A-T Instruction



spent in A-T study and the achievement of letter grades (Figure 2). Armstrong (1970) similarly found that time spent in A-T study correlates substantially with pretest-posttest gains (r = .65). Hinton (1970) quotes a report from East Los Angeles College where it was found that the students who spent more time in an A-T skills center scored one-half grade-point higher than those students who spent less time in the center. Three studies find no correlation between time spent in the A-T lab and achievement (Maccini, 1969; Welker, 1969; Steffen, 1971).

Steffen's (1971) detailed and unobtrusive observations of time spent in A-T study may be of value in interpreting these results and in designing future studies. Steffen found that

observer-reported laboratory attendance time correlated with student-reported attendance time at $r = .77$. Furthermore, observer-reported attendance time correlated with actual working time at $r = .94$. Steffen concludes that, "It would appear that if the desired information is only the overall amount of time a student spends in the laboratory, student-reported time is the most economical method, even with its potential for inaccuracy" (p. 78).

Other Predictors

Comparing A-T and conventional instruction, both Cunningham (1973) and Johnston (1969) found that sex failed to produce a significant main effect and failed to interact with treatment. Armstrong (1970) found that females showed significantly greater learning gains in an A-T botany course than did males, while Welker (1969) found that males scored significantly higher than females in both A-T and conventional treatments in biology. In Welker's study, females in the A-T group scored significantly higher than females in the conventional group.

A final ability measure is that of the grade point average received from earlier college courses. Maccini (1969) found that accumulated GPA was a good predictor of achievement in the laboratory. However, Tipling (1973) reports that the correlation between GPA and achievement gain from the pretest to the posttest was only .08 for the A-T group and .07 for the conventional group.

The predictor variable of class in college was examined by both Armstrong (1970) and by Cunningham (1973). Welker (1969) looked at the effect of listening ability; and both Grobe (1970) and Welker (1969) studied size of high school attended as a predictor variable for success in either treatment. None of these variables were found to have significant main effects or interactions with instructional treatments. Similar negative results were found by Russell (1968), Edwards (1969), and Grobe (1970) in regard to the effect of previous courses in science upon performance in the class observed.

DISCUSSION

The single most striking observation emerging from this review is the cumulative evidence to suggest that A-T instruction may often be more effective that the lecture method in producing student achievement as measured by performance on written examinations. These findings differ markedly from those of previous investigations comparing teaching

methods. Dubin and Taveggia (1968), for example, reviewed over 100 studies in which lecture, discussion, lecture/discussion, and independent study methods were compared. Summarizing the various two-way comparisons, the authors concluded that, in all cases, studies detecting significant differences were approximately equally distributed between those favoring method A and those favoring method B. Costin (1972) drew similar conclusions. In contrast, only one of 44 comparisons reviewed here favor the lecture method of instruction, while more than two-thirds attribute superiority to the audio-autotutorial approach, with 18 of these finding the differences to be significant at $p = .05$ or less. If one discounts all but the 24 studies which, in the opinions of the reviewing authors, embrace consistent parameters of evaluative design as described in the text, the conclusion remains the same. Student achievement on written examinations with audio-autotutorial (A-T) instruction nearly always equals, and usually exceeds, that obtained with the conventional method of instruction.

The favorable affective response toward A-T instruction seems equally profound when examined in a historical light. Students have not typically embraced innovative teaching methods. In a comprehensive review of research examining the effectiveness of televised lectures, for example, Dubin and Hedley (1969) found a "typical" response pattern consisting of an initial negative reaction followed by gradual acceptance of the method. Even when televised lectures are accepted and perceived to be approximately equal to face-to-face lectures in effectiveness, however, students continue to indicate a marked preference for the traditional approach. With A-T instruction, on the other hand, more than three-fourths of the students favor the new method upon their first exposure.

Proponents of autotutorial instruction suggest that this method of teaching offers numerous advantages to students (Creager & Murray, 1971a). They are purported to benefit in part because they become actively involved in the learning process, develop a sense of responsibility for their own learning, can study at their own rates, and need not spend time on material they already know (Creager & Murray, 1971b). Freedom in and individualization of learning are maximized

(Postlethwait & Russell, 1971). To some extent, the research tends to support these contentions. The components of A-T instruction most valued by students are self-pacing, independent study, group study, and mastery grading. There is some evidence to suggest that self-pacing may enhance achievement as well as attitude, and that indirect approaches may enhance problem-solving ability . The component of A-T instruction least valued by students is the general assembly session.

Novak (1970) states that studies contrasting A-T and traditional lecture/discussion approaches to instruction are most certainly comparing apples and eggs. He argues that students will invest whatever time they deem necessary in any given learning environment to attain a level of achievement acceptable to them, and that the crucial variable is therefore study time rather than achievement. Yet, significant differences in achievement are observed, while the available evidence suggests that A-T and conventional instruction may be about equally efficient with respect to study time. There is a definite correlation between study time and grade achieved within the A-T method, however.

Dropout rates with A-T instruction appear to be approximately equal to and perhaps slightly lower than those obtained with conventional instruction. Although the data are sparse, these findings offer an interesting contrast to those obtained with the nonaudiovisual Personalized System of Instruction (Keller, 1968) as reviewed by Kulik, Kulik, and Carmichael (1974). The audiovisual components of the A-T method may be significant in providing motivation. Studies directly comparing A-T and nonaudiovisual Keller methods could shed light on the specific effects of the audiovisual elements.

Berliner and Cahen (1973) have reviewed much of the literature describing the interaction between a given student trait and an instructional treatment. In general, intelligence tests correlate about as highly with achievement tests as different intelligence tests correlate with one another (Anastasi, 1968, p. 393). Diederich and Macklin (1973) have suggested that A-T instruction may differentially benefit low ability students, and they offer some interesting evidence to substantiate this notion. Such trait/treatment interactions were observed in only three out of 13 studies, however. It would be

interesting to assess the impact of the two-hour recitation period that was included in the lecture method but not in the A-T method in the Diederich and Macklin study. There is considerable data to suggest that A-T methods can be improved by increased use of recitation sections and decreased use of general assembly sessions.

The effect of sex upon academic performance has been examined frequently and discussed by McKeachie (1968), Peltier (1968), and others. No consistent effects of sex were observed in the A-T studies.

Of the personality factors that have been examined, only restraint (the tendency to be serious-minded and responsible) appears to give significant trait/treatment interaction, such that high achievers with low verbal aptitude and low restraint may learn more with A-T instruction.

Economic advantages are frequently attributed to the A-T method, but have not been rigorously demonstrated. Initial investments are moderately high and savings are purportedly realized over a period of years.

The Carnegie Commission, in *The Fourth Revolution* (1972), suggests that the new teaching methodologies can enhance the teaching experience from the faculty point of view. Unfortunately, very little documentation is available concerning the effects of A-T instruction of faculty. Yet, their attitudes may be more critical than those of students in determining whether or not A-T methods will be utilized. If A-T teaching requires more work and is generally less satisfying than lecturing, for example, then A-T methods probably will not become prevalent even if they are shown to enhance learning effectiveness. Learning theorists might profitably apply themselves to devising means for increasing the faculty rewards of A-T teaching. Other, equally important rewards related to tenure and promotion criteria can be initiated by administrators.

Several tentative conclusions emerge concerning future applications of the A-T method. First utilization of the A-T design seems particularly desirable for courses having high fact/principle contents and for instruction of special skills, especially where student populations are not homogeneously composed of high achievers. Second, inclusion of a discussion or recitation section may be important for challenging the high achievers and for enhancing their learning; recitation

provides a valuable alternative to the less satisfactory general assembly sessions. Third, when problem solving skills are a valued outcome, indirect instruction should be incorporated into the teaching strategy. And fourth, exploitation of the technology through the use of compressed speech seems a promising avenue for further exploration.

Is the conclusion that A-T instruction is superior warranted on the basis of the present evidence? Certainly a healthy skepticism is justified. One can find numerous faults in the research and it is easy to rationalize the findings in terms of investigator biases. However, the burden of proof at this point would appear to lie with the disclaimers of A-T effectiveness. The hypothesis must at least be seriously entertained that the A-T method is superior to the lecture method for producing achievement gains and positive affective responses with many students in many subject areas.

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