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ABSTRACT

Members of the Physics Department and the Science Education Department have combined their efforts to implement an audio-tutorial (A-T) mode of instruction in an introductory physics course for non-physical science majors. In the A-T approach, a tape-guided discussion is integrated with various student activities such as laboratory work, viewing film-loops, observing and conducting demonstrations, and solving problems. Self-pacing, integration of activities, concentration of effort, lessons which are tested presentations, variety of approaches, and immediate feedback are aspects of A-T which are stated as being very attractive. An outline of the development of A-T materials is given as starting with a trial effort in 1969-1970 and a larger trial in 1970-1971 including changes in response to feedback. A description of the course and facilities are provided. The methods of evaluation are bi-weekly quizzes and oral presentations and discussion of laboratory reports. (Author/TS)

An Instructional Exploration in College Physics

The Use of Audio-Tutorial Methods in Introductory Physics at Cornell University[1]

Martin N. Thorsland and Joseph C. Wesney

Introduction

Resistance to change is a universal characteristic of large bodies, and such "inertia" is especially common to educational institutions. This "inertia" may prove to be beneficial in some instances and detrimental in others. When it comes to instructional innovation in a physics department of a large university, to overcome tradition is a task indeed. In such situations the primary sources of difficulty are the size of the course to be transformed, and the lack of time for existing faculty and staff within the department to take on this large task in addition to their other teaching and research responsibilities. At Cornell University, members of the Physics Department and the Science Education Department have combined their efforts to overcome these difficulties and to bring about such a change in introductory physics instruction with very favorable results. This paper will deal with that change, the implementation of an audio-tutorial (A-T) mode of instruction in an introductory physics course for non-physical science majors.[2]

Rationale for Change

The desirability for change from the traditional lecture-recitation-laboratory (L-R-L) approach to physics instruction was recognized by Dr. Kenneth Greisen, senior professor for the course, and reflects similar recognitions by physicists at other institutions, as indicated by the various attempts to use alternative modes of instruction (e.g., Ben Green at M.I.T.[3], Clifford Swartz at Stony Brook[4], Gunther Schwarz at Florida State[5,6], Lowell Knoop at Jefferson High School[7], to name just a few). Some of the more common complaints frequently heard from students who have experienced the L-R-L approach were rather nicely summarized by Dr. J.A.G. McClelland[8]. They are:

1. The lecture may suffer from a lack of efficiency, efficacy, and general humaneness for some students.

2. The lecture is, by necessity, a one-shot affair in which students could miss part, or for that matter all, of the information in his frantic attempt at note-taking.

3. Demonstrations often are hard to observe, and, generally, offer little opportunity for personal involvement on the student's part.

4. Laboratory sessions are often not in synchronization with the material presented in the rest of the course, and sometimes the relatedness to the rest of the course is not at all clear.

5. The recitation meeting too often becomes a mini-lecture for some, a passive, dogmatic "do-it-this-way" problem session for others and a coherent, meaningfully spent hour for far to few.

In recognition of some of these shortcomings of the traditional L-R-L approach it was decided by Greisen and McClelland that an attempt would be made to use a method of instruction which would integrate most of the tasks now being handled separately by the lecture and laboratory, and at the same time provide some means of permitting the student to more efficiently control his own work in the course. To fulfill these desires they decided to explore the use of an A-T method of guidance and instruction similar to that used by Dr. S.N. Postlethwait. Dr. Joseph Novak, the head of the Science Education Department at Cornell, worked with Professor Postlethwait when they originated the audio-tutorial approach for use in the introductory botany course at Purdue University in 1961.[9] With his background and experience in applying A-T methods to various levels and subjects of instruction, Novak was able to provide valuable orientation and guidance in the exploration.

The Nature of A-T

In the A-T approach, a tape-guided discussion is integrated with various student activities, such as laboratory work, viewing film-loops, observing and conducting demonstrations, solving problems, and so forth. All materials are available in a central location with an instructor on duty for individual help at all times. There are several aspects of the A-T approach that make it very attractive as an instructional format. Among them are the following:

1. Self-Pacing - The student is free to choose the amount of time he needs to spend on physics. He may do his week's work at one or several different times, depending on his interest and constraints in his schedule imposed by other commitments. In addition he has control of the taped narration by being able to stop to ponder and, if necessary, replay difficult sections.

2. Integration of Activities - The laboratory work, demonstrations, film-loops, etc, can be presented when they seem most appropriate, not as determined by a rigid class schedule. The student then has the prerogative to change the sequence and/or order of presentation if he so desires.

3. Concentration of Effort - The student is self-motivated to do the work when he sees fit, and while working individually in a carrel he is isolated from disturbing influences. (All work is not necessarily done individually, though it can be. Many activities may be planned and carried out in small groups.)

4. Lessons are a Tested Presentation - Material presented to students is reviewed for correctness with a faculty member and is tested before final form is achieved. Revision is relatively quick, easy and effective, even during the period of the lesson's presentation. All students are receiving uniform recheckable input, which from the standpoint of debugging and control offers definite advantages.

5. Variety of Approach - A multi-media input brings experiments, problems, demonstrations, visual aids, etc. to the student. A variety of levels may be offered to conform to the student's background and needs. For example, calculus and non-calculus tracks could be implemented as well as tracks for remedial work or extension.

6. Immediate Feedback - Through the use of self-quizzes and frequent checks with the instructor, the student can monitor his own progress. With the availability of an instructor in the center at all times, the student is able to obtain assistance at the exact time that a difficulty is encountered.

The production of a coherent unit of material, consisting of the study guides and scripts for the taped narrations of the main lessons and associated activities, is by no means a trivial task. Although it is difficult, and possibly misleading, to guess at a "reasonable figure" to associate with the time required for one or more persons to plan and develop at A-T presentation, a "ball park" estimate of 20 to 30 manhours per hour of taped presentation and its associated written materials might not be too far out of line. Obviously, the time for preparation is a function of a large number of factors and varies widely from unit to unit. Certainly the time and effort associated with the production of an A-T unit could be reduced by adopting shortcut procedures, but this would most likely have to be done at the expense of the effectiveness of the lessons.

The steps taken in the development of A-T materials quite closely parallels those taken in other instructional development projects. Ideally, the steps involved would be:

1. Specification of instructional objectives, as agreed upon by all personnel associated with the course. These objectives should not only serve as guides for the planning and development of the lessons, but they should also be spelled out, in some manner, in these lessons, so that the students can be aware of them.

2. A search for appropriate laboratory activities, demonstrations, film-loops, visual materials, etc. to be incorporated in the lessons, or presented as supplements to them. Those activities and materials ultimately selected for use should provide as much direct experience and active involvement of the students in the lessons as possible.

3. Preparation of an outline of the conceptual development on the basis of psychological considerations as well as the inherent logical structure of the material.

4. Writing of the preliminary scripts and associated study material. In this initial writing the following factors must be considered.
   a) The taped presentation is <u>not</u> to be a recorded lecture.

b) The activities and materials should be programmed into the presentation at appropriate points so as to provide a smooth, coherent unit.

c) Creative use of humor, music, voice combinations and sound effects on the tape can provide a novelty effect and thus enhance attentiveness.

5. Review of the preliminary version of the script and study guides by other members of the staff and faculty to uncover mistakes and potential weaknesses, and then make necessary corrections and prepare a trial version.

6. Use of the trial version with a few volunteer students to obtain feedback (on such matters as cueing, pacing, clarity of directions, uncorrected mistakes, ambiguities, etc.) and then presentation of a second version of the material which could be separated into smaller (e.g., single-concept, daily, weekly, biweekly) lessons.

7. Duplication and set-up of the revised version of the lesson for use by the students.

8. Evaluation of student accomplishments and analysis of weaknesses of the unit in terms of student response and performance in quizzes and laboratory work.

9. Revision of the unit and preparation for future presentation, on the basis of strengths and weaknesses revealed in the use of the second version.

The Use of A-T in Physics 101-102

In the design used for the Physics 101-102 A-T exploration a typical week's activities for a student would primarily take place in the A-T Center, which was liberally scheduled to be open each weekday and several evenings. The number of hours scheduled was determined on the basis of an anticipated required time plus about 30 percent "buffer" time. Study times were not assigned, thus students were free to arrange their work at their convenience. A majority of students, therefore, found that they could study physics when they "felt like it" and used this as one of the main determining factors in deciding when to go to

the Center. Students were strongly encouraged to finish a week's work in that week. To accomplish this, most students used more than one sitting to finish, but others expressed their appreciation for being able to work in one concentrated session.

The A-T Center was furnished with student work space, instructor conference area and a coffee facility, in addition to the carrel units, film-loop viewing area and laboratory and demonstration areas. (See Figure ONE)

In a typical visit to the Center a student would check-in by recording the date, time, and intended activity on his record card. He would then pick up a study guide and any other handout materials, and go to an empty carrel. Shortage of carrel space was a minor problem late in certain weeks and, as expected, before examinations. In the carrel, the student would put on the headphones and start the tape. The instructor's taped narration would then take over and guide the student through the development of conceptual material, and suggest at appropriate points in the development that the student conduct related demonstrations and laboratory work, view film-loops and work with associated study material. If some point in the taped presentation was not clear to the student, he could rewind the tape and go over the point of difficulty. (It is interesting to note that a comparable option is usually not available to the student in a large lecture situation.) If and when a question or ambiguity arose which the student was unable to resolve, he could stop the activity, whether it be taped discussion or demonstration, and get assistance from the instructor on duty. At any one time it would be common to see students working in carrels, watching film-loops, performing laboratory work, doing demonstrations, interacting with other students, talking with the instructor, and so forth.

It was found that one instructor could easily handle the queries of students using ten carrel setups and in some instances more than this number without feeling overburdened. Certain common difficulties or errors which arise in connection with the A-T materials, and the tapes or study guides can be rather easily revised to alleviate such problems.

The basic core of material for the week, typically consisting of one hour of tape discussion plus time for associated activities, film-loops, demonstrations, laboratory work, and option material available for the student to use as he wishes. Most of the students found the optional demonstrations very helpful, and they liked the demonstrations' "look see" nature, with no long detailed writeups required.

On the average, the students spent about three hours per week in the A-T Center, though the times varied over a wide range for students, (from extreme instances of individual times in one particular week ranging from zero to twenty hours). Though there is no way of precisely knowing, students felt they spent no more time in the A-T portion of the course than would have been necessary for studying the same material by the traditional format.

The Exploration of 1969-70

The Physics 101-102 course taught by Dr. Greisen at Cornell University is a four semester hour, non-calculus, introductory physics course taken primarily by students majoring in the biological or agricultural sciences. Of the approximately 400 students enrolled in the course, about 70 percent are enrolled in the College of Agriculture, and 25 percent in the College of Arts and Sciences; 20 percent are taking a premedical curriculum, and 27 percent are taking a preveterinary curriculum. The course is taught throughout the year with Physics 101 offered in the Autumn Semester and Physics 102 presented in the Spring Semester. The standard format for the course is to have students attend two one-hour lectures and two one-hour recitation meetings each week, and a two-hour laboratory period on alternate weeks. This mode of instruction is referred to as the L-R-L format.

The first material selected for presentation via A-T was a 2 1/2 week unit on Heat and Thermodynamics scheduled for use in November, 1969. Greisen and McClelland selected this unit because it was rather short and self-contained, and it offered ample opportunity for including active involvement of the student in the lessons. Material was produced by

McClelland and Martin Thorsland and "debugged" by having several students who had completed the course the previous year work through the preliminary versions. During a 2 1/2 week period in November, three, of the 19, recitation sections in the course were selected for participation in the A-T program, and these students were excused from regular lectures and laboratory sessions. They still attended their two regular recitation meetings per week where problems were discussed as usual.

After the unit ended, all students in the course took the same exam, and the A-T students demonstrated as much understanding of the Heat and Thermodynamics material as the L-R-L students. However, the affective response of the A-T students was so favorable (students overwhelmingly preferred the A-T method over the regular approach, and cited reasons similar to those outlined above) that Greisen and those of us interested in continuing the exploration made plans for presentation of another A-T unit in the Spring Semester. Owing to other demands in his schedule McClelland had to retire to an advisory capacity and the authors shared the responsibility for continuing the effort.

During the spring, a unit on Special Relativity was presented. Greisen selected the topic of Special Relativity becuase it is probably the least amenable unit for presentation via the A-T method of any unit in the course. The rationale behind this attempt was simply that if this particular unit could successfully be adapted to A-T presentation, anything else treated in the course could as well.

We set out early in 1970 to produce the materials for the unit. In the course of the development of the unit we worked more closely than before with Greisen and Delvaille who were jointly in charge of the course at the time, and this interaction served to produce a certain unity of purpose toward the improvement of instruction.

In March 1970, this second unit was presented to about fifty students. Everything proceeded quite smoothly, and it was obvious that student interest had increased to the point where about twenty students, not selected for participation in the trial, took it upon themselves to come

to the A-T Center for extra help. This interest did not go unnoticed. Many people finally became aware that this method was workable and that the purposes established within the new approach were viable and realizable.

Plans For 1970-71

On the basis of the rather successful outcome of the use of the two A-T units during the 1969-70 academic year, sufficient interest had been generated that those of us involved in the earlier work decided to seek permission from Dr. Holcomb, the head of the Physics Department, to continue on an expanded scale, during the 1970-71 academic year. Staff and faculty members felt that it was necessary to try the use of A-T over a longer period of time with a somewhat larger group of students. With the rather late completion and evaluation of the results of the second unit, there was little opportunity to seek funding and staff to carry-out a large-scale writing and development program to prepare materials for the entire course during the summer of 1970. Holcomb and Greisen decided, however, that Federal or private foundation funding would be looked into as a possible solution to the cost of future expansion by the Physics Department.

Our initial plans for the Autumn Semester (Physics 101) were to develop and present material from the beginning of the semester, through the topics of kinematics and about half of dynamics, through momentum conservation. Greisen was particularly interested in seeing whether the laboratory work, (involving the use of an oscilloscope, air track, photo cell gate, and other complex devices), associated with this material could be incorporated in a more meaningful and less tedious fashion than he had previously been able to achieve. Treatment of these topics would represent a period of about one month of presentation time, and would terminate with the first preliminary examination serving as a rather convenient point for the students to return to the regular L-R-L course format. In addition, the existing unit on Heat and Thermodynamics, scheduled 3 1/2 weeks later, would be revised and the students would at that time return to the A-T presentation of this material. Though it would have been desirable to have a continuous A-T presenta-

tion from the start of the semester through the revised Heat material, it was deemed too large a task for us to undertake on a "part-time" basis. Fortunately, Dr. Ezra Heitowit, a post-doctoral fellow from the Center for Research in Education and Vivian Talisayen, another graduate student in Science Education with a strong physics background, agreed to assist with the development of the intervening material on angular momentum, gravitation, planetary motion, and energy, as well as assisting with the staffing of the A-T Center. With this welcome assistance it was possible to provide a continuous presentation of the material in Physics 101 for the first ten weeks of the course, leaving only the concepts of waves and optics to be treated by the L-R-L method.

The Autumn Semester's Exploration

The primary differences in the physical and administrative arrangements between the trial effort of 1969-70 and that conducted during the Autumn Semester of 1970-71 were as follows:

1. The students were exposed to a much longer continuous presentation (approximately three-quarters of a semester) from the beginning of the course.
2. The number of students involved had increased from about 50 to 70.
3. Staff participating in the A-T work had increased, and the graduate student teaching assistants, normally scheduled to serve as recitation instructors of the students participating in the A-T work, were more actively involved in staffing and preparation.
4. The physical facilities had improved through the use of a very pleasant, well-lighted, newly-remodeled room which had been furnished with eight carrel units and laboratory-demonstration tables. This represented a welcome change from the temporary arrangement used for the previous year's trial units.

The primary features in the 1970-71 method not used in the 1969-70 trial are as follows:

1. Entire student effort was spent at work in the A-T Center without the use of recitation meetings.
2. Problem solutions were duplicated (and on a few occasions taped solutions were prepared), and distributed to the students to enable them to check their own work when they completed it.
3. In lieu of problem solutions submitted for grading, the students were given weekly quizzes treating the previous week's material.

This expanded attempt at the use of the A-T approach produced positive results similar to those obtained previously. In addition to the positive results obtained, however, there were a few areas of difficulty. Students, as well as staff, noted the need to return to at least one recitation section per week with an associated greater emphasis placed on problem solutions, since the A-T students were taking the same examinations as the students in the L-R-L format. Also, a more efficient means of handling the orientation to, the evaluation of, a student's laboratory work seemed desirable. The third major need expressed was one of improved communication of announcements between staff and students. We sought to correct some of these difficulties with the units to be developed and presented for the Spring Semester, 1971.

The Spring Semester's Exploration

During the Spring Semester with the help of Gay Zaumeyer, a teaching assistant in the course, and Carl Naegele and Al Hilgendorf[10], graduate students in science education, several new units were developed and presented via A-T. The units dealt with the topics of Electricity and Magnetism, presented during the first 6 weeks of the semester, and the subsequent 3 1/2 week revised unit on Special Relativity. This material carried the students through the first two preliminary examinations. Due to lack of staff time, the remaining material in the course (the quantum nature of matter and energy, atomic and nuclear physics) was not presented via A-T methods. Thus the A-T students returned to the L-R-L format following the second prelim.

In light of some of the shortcomings noted during the Autumn Semes-

ter, the following features were added to the Spring Semester presentation.

1. Instead of weekly quizzes, biweekly quizzes were initiated.
2. Students were scheduled to attend one recitation meeting each week during which topics of common interest, quiz results, announcements and solutions to complex or especially troublesome problems are dealt with.
3. Students were assigned problems associated with each lesson, and were required to turn in their solutions to a few of the assigned problems. Duplicated solutions for all assigned problems were available to the students after they had submitted solutions to the selected problems. The graded solutions were then returned to the students during that week's recitation meeting.
4. Finally, student laboratory work was evaluated on a somewhat different basis than that normally used. Instead of evaluating a student's laboratory work on the basis of reports written and submitted for batch grading along with reports of other students, the students individually brought their completed reports to one of the instructors, and the evaluation was made on the basis of the student's oral description and explanation of the work to the instructor. It was felt that this placed a more appropriate emphasis on being able to understand the communicate laboratory results, gave the student immediate feedback concerning successes as well as difficulties, and provide the instructor, in roughly the same or less time, with a better estimate of the understanding and skills gained by the student.

A Look Into the Future

It is envisioned that ultimately the entire course, accommodating 400 to 500 students, will be redesigned to include the A-T format. Though it may not have been apparent thus far, the authors do not feel that the A-T mode of instruction should be used to the exclusion of all other methods available. On the contrary, it is our feeling that there are aspects of instruction which are handled better in other formats. The

first arrangement we would like to attempt in a full-scale utilization of A-T would incorporate what we feel are the best features of all methods available for working with students. The major concept development, illustrated through student-conducted, small-scale demonstrations, film-loops, textbook, etc., can be nicely integrated via the audio tape with the laboratory experience of the student. (We have not considered presentation via video tape because of the prohibitively greater expense and the technical difficulties associated with its large-scale use by individual students.) Discussion of problems, common difficulties, etc., providing for group interaction and group contact with a teaching assistant could be handled with several regularly scheduled recitation meetings per week open to students on an optional basis. The opprotunity for students to see large-scale demonstrations, hear motivational, general interest lectures dealing with topics (historical, philosophical, etc.) which excite or have excited physicists, as presented by the faculty, guest lectureres, and graduate students can best be handled in the standard large group lecture format. The viewing of larger 16-mm films and administration of tests can also be more conveniently accomplished in such common assemblies. Evaluation would, in part, be conducted through the use of more frequent, short examinations (rather than the current two, two-hour exams given each semester), together with the administration of the standard final examination. These marks along with periodic evaluation of the student's laboratory work, perhaps would be used, with other information related to the student's work, to arrive at his final grade in the course.

The pace and magnitude of future developments in connection with the Physics 101-102 A-T program will primarily depend on the availability of financial support for hardware for a large-scale operation and the availability of staff, faculty and graduate students sufficiently interested in the project to expend the effort to develop and revise the software. It is hoped that a major development project can be conducted during the summer of 1971.

An exploration of this type, whether it be into the use of A-T, "self-paced instruction", computer-based instruction or whatever, provides an opportunity for trying a number of different things which might not otherwise be attempted, and to learn, through "self-examination",

how best to incorporate available forms of instruction, the old as well as the new, into a course format to provide a more efficient, and more enjoyable course for students to take. After all, isn't this what it's all about?

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Notes and References

1. This is a draft of the paper from which a contributed paper was presented on February 3, 1971, at the 40th Annual Meeting of the American Association of Physics Teachers.

2. We wish to acknowledge that the work in this exploration was in part supported by the Shell Companies Foundation, Inc.

3. B. A. Green, Jr., "A Self-Paced Course in Freshman Physics", Occasional Paper Number 2 of the Education Research Center of M.I.T., Cambridge, Massachusetts, 1969.

4. C. E. Swartz, "An Individualized Introductory Physics Course", American Journal of Physics, 36, 1495.

5. G. Schwarz, "Elementary Physics Through C.A.I.", American Journal of Physics, 36, 82.

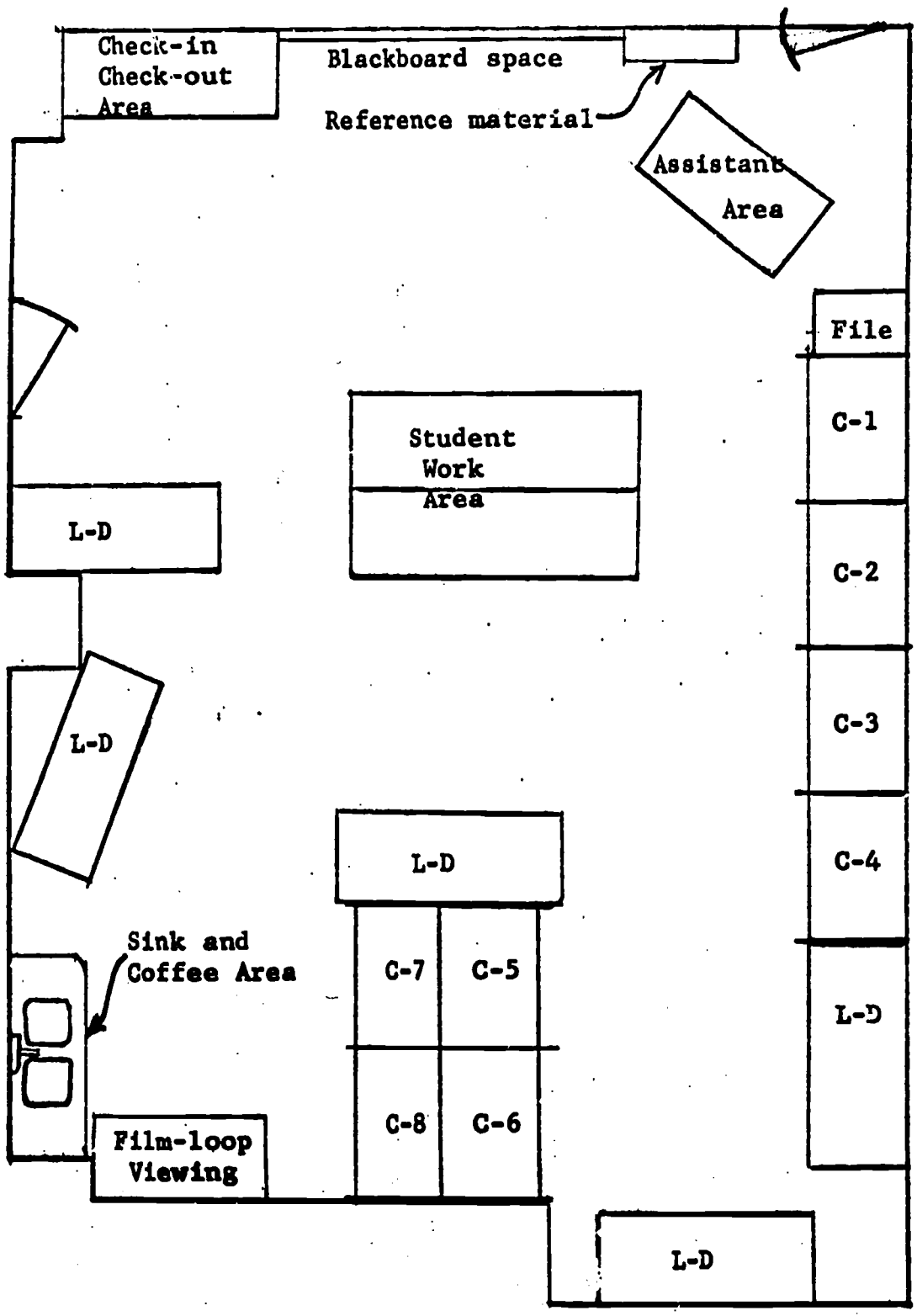
6. O. M. Krombout, S. Edwards, and G. Schwarz, "A Computer-Guided, General-Education Physics Course", American Journal of Physics, 37, 995.

7. L. Knoop, "High School Physics by Audio-Tutorial Mode", The Physics Teacher, 6, 68.

8. The authors wish to acknowledge the inspirations, ideas and insights provided by Dr. McClelland. While at Cornell University during 1968 through 1970, McClelland's efforts were primarily responsible for conceiving and initiating the exploration of the application of the A-T approach to instruction in Physics 101-102. McClelland has returned to his position as a member of the faculty of the Physics Department at the University of Ghana.

9. S. N. Postlethwait, J. Novak and H. T. Murry, Jr., The Audio-Tutorial Approach to Learning, Second Edition, Burgess, Minneapolis, Minn., 1969.

10. Carl and Al are interested in adapting the computer to instructional programs, and during the first two week unit of the semester they used a computer terminal in the A-T Center with a few of the students for the purpose of giving quizzes and guiding students to various alternative sources of instruction after each segment of the unit.



C-1 through C-8 are Carrel Spaces

L-D refers to Laboratory and/or Demonstration Areas

FIGURE ONE- ARRANGEMENT OF AUDIO-TUTORIAL (A-T) CENTER

An Exploration of the Use of Audio-Tutorial Instruction
in an Introductory Physics Course
at Cornell University

Martin N. Thorsland and Joseph C. Wesney, Cornell University

At Cornell University, members of the Physics Department and the Science Education Department have combined their efforts to bring about a change in introductory physics instruction with very favorable results. This paper will deal with that change, the implementation of an audio-tutorial (A-T) mode of instruction in a four credit hour, non-calculus, introductory physics course for non-physical science majors.

In recognition of the shortcomings inherent in the traditional lecture-recitation-laboratory (L-R-L) approach it was decided that an attempt be made at a method of instruction which would integrate most of the tasks now being handled separately by the lecture and laboratory, and at the same time provide some means of permitting the student to more efficiently control his own work in the course. To fulfill these desires it was decided to explore the use of an A-T method of guidance and instruction similar to that used by Dr. S.N. Postlethwait. Professor Postlethwait originated the audio-tutorial approach for use in his introductory botany course at Purdue University in 1961.

In the A-T approach, a tape-guided discussion is integrated with various student activities such as laboratory work, viewing film-loops, observing and conducting demonstrations, solving problems, and so forth. All materials are available in a central location with an instructor on duty for individual help at all times. There are several aspects of the A-T approach that make it very attractive as an instructional format. Among these are student self-pacing, integration of activities and concentration of the student's effort. The lessons are a tested presentation which can be designed to offer the student a variety of approaches and the format offers the availability of immediate assistance and feedback.

The first material selected for presentation via A-T was a 2½ week unit on Heat and Thermodynamics scheduled for use in November, 1969. This unit was selected because it was rather short and self-contained, and it offered ample opportunity for including active involvement of the student in the lessons. Fifty of the 400 students enrolled in the course were selected for participation in the A-T program, and received material similar to that presented in the lecture and laboratory portions of the course. All students in the course took the same exam. The A-T students demonstrated as much understanding of the Heat and Thermodynamics material as the L-R-L students. However, the affective response of the A-T students was so very favorable that plans were made for another A-T unit in the Spring Semester.

In March 1970, a second unit on Special Relativity was presented to about fifty students. This topic was chosen because it is probably the least amenable unit for presentation via the A-T method of any unit in the course, and it was felt that if it could successfully be adapted to A-T presentation, anything else treated in the course could as well. The student response to this unit proved extremely favorable, even to the point where 20 or so students not in the A-T sections sought extensive extra help through the A-T materials.

On the basis of the rather successful outcome of the use of the two A-T units during the 1969-70 academic year, sufficient interest had been generated to seek a continuation, on an expanded scale, during the 1970-71 academic year. With assistance from other graduate students the first 10 weeks of the Autumn Semester were presented via A-T to about 70 students. This included all the topics of Newtonian Mechanics, and Heat and Thermodynamics offered in the course. For the remaining four weeks of the semester the students returned to the standard L-R-L course format. This expanded attempt at the use of the A-T approach produced positive results similar to those obtained previously.

During the Spring Semester the new units to be developed and presented via A-T will deal with topics in Electricity and Magnetism, and followed by the revision of the Special Relativity unit.

It is envisioned that ultimately the entire course, accommodating 400 to 500 students, will be redesigned to include the A-T format. Though it may not have been apparent thus far, the authors do not feel that the A-T mode of instruction should be used to the exclusion of all other methods available. On the contrary, it is our feeling that there are aspects of instruction which are handled better in other formats. The first arrangement we would like to attempt in a full-scale utilization of A-T would incorporate what we feel are the best features of all methods available for working with students. The major concept development, illustrated through student-conducted, small-scale demonstrations, film-loops, etc., can be nicely integrated with the laboratory experience of the student via the audio tape. Discussion of problems, common difficulties, etc., providing for group interaction and group contact with a teaching assistant could be handled with several regularly scheduled recitation meetings during the week, open to the student on an optional basis. The opportunity for students to see large-scale demonstrations, view 16mm films, and hear motivational, general interest lectures dealing with relevant topics of current, historical, and/or philosophical interest can best be handled in the large group lecture format. These large group sessions could be conducted by faculty, guest lecturers, and graduate students handling those aspects and topics which interest them most. Tests can also be more conveniently administered in such common assemblies. Evaluation would, in part, be conducted through the use of more frequent, short examinations (rather than the current two, two-hour exams given each semester), and administration of the standard final examination. These marks along with periodic evaluations of the student's laboratory work, perhaps based on personal interviews with instructors (depending on the results of this semester's trial use of this method of evaluation) would be used, with other information related to the student's work, to arrive at his final grade in the course.

The pace and magnitude of future developments in connection with the Physics 101-102 A-T program will primarily depend on the availability of financial support for hardware for a large-scale operation and the availability of staff, faculty and graduate students sufficiently interested in the project to expend the effort to develop and revise the software. It is hoped that a major development project can be conducted during this coming summer.

An exploration of this type provides an opportunity for trying a number of different things which might not otherwise be attempted, and to learn, through "self-examination", how best to incorporate available forms of instruction, the old as well as the new, into a course format to provide a more efficient, and more enjoyable course for students to take. After all, isn't this what it's all about?

(This paper is being presented as a contributed paper on February 3, 1971, at the 40th Annual Meeting of the American Association of Physics Teachers.)