magister scientiae

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ISSN: 0852-078X
Susunan dewan Redaksi Magister Scientiae : *(berdasarkan SK Dekan FKIP Unika Widya Mandala Surabaya Nomor: 420/WM04/N/1993)*

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GUIDELINES FOR DEVELOPING COMPUTER ASSISTED INSTRUCTION (CAI) COURSEWARE TO PROMOTE SELF-LEARNING

Y.G. Harto Pramono

INTRODUCTION

There are many instructional media which can be implemented to deliver instructional materials to the learners. These instructional media, among others, are printed media (such as textbooks and modules), audio-visual media (such as sound slides, videos, and televisions), computer (computer assisted instruction), and audio media (such as radio and audio cassette programs).

Among those media, computer assisted instruction (CAI) is not widely implemented due to some factors, namely: (1) the high initial cost, (2) lack of hardware or facilities and program development, (3) the poor quality of the programs themselves, (4) the absence of skilled personnels who create computer programs, and some other factors. As a matter of fact, nowadays some of those factors have been successfully overcome. Presently the introduction and rapid spread of inexpensive, powerful, reliable, and simple-to-use personal computers has dropped the cost. In addition, the number of personnels who master computer language has rapidly increased.

Regardless of those stumbling blocks along the paths toward adopting CAI, the potential of CAI in education has been demonstrated in hundred of programs created in the last decade. At the present time, however, there is still a critical shortage of courseware for CAI as well as a very few professional CAI authors or developers. Therefore, this article offers guidelines for developing CAI courseware. It discusses procedures for developing CAI courseware so as to make it good and effective to promote self-learning.

This article is intended to be of some help for those who would like to develop CAI courseware and for those who would like to teach themselves to develop CAI lessons.

CAI COURSEWARE CAN PROMOTE SELF-LEARNING

In learning there is a two-way communication or interaction between the learners and the learning resources. And the learning itself will be more

effective if the interaction between the learners and the learning resources occurs effectively. CAI courseware when developed appropriately can promote a two-way communication between the learners and the learning resources as it is provided with feedback. Feedback as defined by Wager and Wager (1989) is any message or display that the computer presents to the learner after response. Feedback serves two functions during the instruction: (1) it motivates the learner, and (2) it provides information as to the correctness of the learner's response so that she or he has the opportunity to correct her or his misconceptions. The motivational aspects of feedback are highly personal.

The computer can also provide reinforcement and encouragement by printing words such as good, excellent, you may continue, and try again immediately after each performance of each activity by the learner. This can also add to his or her enjoyment (Menis, 1980). The greater the enjoyment, the more effective is the learning. With CAI, motivation and enjoyment are increased and active involvement is demanded.

In addition, as stated by Dhaif (1989), CAI courseware provides a self-evaluation device by which the learners can measure their own performance. The device can give an immediate feedback and score so that the learners will know their own progress immediately.

Learning material is one of the most important components in the learning process. Accordingly, the learning material should be easy to learn, interesting and able to encourage the learners to learn actively. These criteria can be fulfilled by the CAI courseware provided that it is developed carefully. McGreal (1988) states that a major advantage of the computerized instruction lies in its ability to interact individually with learners. It is supported by Chapelle and Jamieson (1986) that CAI promotes individualization in which the computer enables learners to work alone and at their own pace. Through the use of individualized instruction, poor learners can attain additional practice, and good students are provided with advanced materials.

The computer, more than conventional methods of teaching, facilitates the concretization of abstract concepts and thereby makes learning easier for the learners who have not yet attained intellectual maturity.

Animation, graphics, cartoon characters, colours, and other creative devices serve to create variety and interest in the display which appears on the monitor. Used creatively, these capabilities of computer systems can contribute greatly to effective self-learning programs.

Based on the above discussion, it is apparent that CAI courseware can promote self-learning. Anyhow, not any CAI courseware can automatically do so unless it is developed as well as possible. The following sections will spell out the guidelines for developing CAI courseware which will be of some help for the CAI author to produce an effective CAI courseware.

THE THEORETICAL UNDERPINNING OF CAI

Not all CAI program can increase the quality of instruction due to the fact that there are many CAI programs on the market which are not effective. In response to this situation, CAI programs must be developed systematically based on instructional principles.

The CAI model which predominates today is as the new form of Programmed Instruction (PI) which is based on the law of effect. The law of effect is also the basis of behavioral psychology. The main assumption of the law is simple: Behavior which is followed by pleasure is more likely to be repeated than that which is not followed by pleasure. Based on the law of effect arouse S-R theory (consisting of stimulus, response, and reinforcement). In an instruction based on S-R theory, a learner is given a question as the stimulus, she or he then answers the question (or gives a response). Feedback is then provided. The theory is that the learner will be rewarded, and learning will be reinforced by the mere feedback that the answer is correct.

Based on this theory, the main characteristics of programmed instruction and CAI are the following: (1) small steps, (2) active responding, and (3) immediate feedback (Burke, 1982).

DEVELOPING THE CAI COURSEWARE

In order to develop an effective CAI courseware, there are several phases we, as a CAI courseware developer, should conduct: (1) preliminary planning, (2) preparing the content of CAI courseware, (3) designing the lesson, (4) creating the lesson, (5) writing documentation, and (6) validating the lesson. These phases will be spelt out as follows:

Preliminary Planning

Before we plan and develop any effective instructional program, CAI program is no exception, we must, first of all, start with a purpose, an idea, a learning need, or in some cases, our problems identified within an instructional design. As stated by Hord (1984) if we cannot explain why we are doing what we are doing, there is a good chance we are wasting our time. Whatever our purpose, it is the most important element when designing instruction because all elements depend on it.

The second step we have to do is develop the objectives. The objectives depend on our purpose and, if they are stated adequately, will reflect that purpose. As stated by Hord (1984) our goals and objectives should give us, our colleagues, and our pupils a clear idea of what we regard as a successful outcome of instruction.

The next thing to do is that we must consider the learners' characteristics. The characteristics of the learners who will be using and learning from our materials cannot be separated from our statement of objectives. Therefore, we must know some of the relevant characteristics of the learners and the condition under which it will be used. At a minimum we will need to know the grade level of the learners and

whether or not the program will be used in a classroom, along with other materials, or individually at the learner's home.

Then, consider the instructional strategies including the choice of media. Here we have to decide what type of media is the most appropriate for our instruction. Will the computerized instruction best suit our needs? After we have come to the decision that computerized instruction will best suit our needs, then we are ready to begin planning and preparing our CAI courseware.

We may be capable of planning and preparing our CAI courseware without the assistance of others. If we are, we have skills in three areas. First, we have a good knowledge of the subject. Second, we know how to plan instructional media. Third, we have the necessary technical skills in computer programming, and are familiar with computer language. But if we feel inadequate in any of these areas, Kemp and Dayton (1985) suggest that we should obtain assistance or use a team approach. Three individuals or three groups having each of the above skills might make up the production team. Their skills are complementary.

Preparing the Content of CAI Courseware

Now consider the content for our CAI courseware. There are hints which must be considered in preparing the content of CAI courseware. The description of each hint can be followed below.

Choose appropriate content for a CAI lesson

In choosing the appropriate content for a CAI lesson, we need to consider the following:

- The content should relate to the objectives. Consult with a subject specialist if necessary.
- The content must be suitable for a CAI lesson. It must be material which can be well represented within the symbol set of the microcomputer we have available.
- The content chosen should be that which many people need to learn.
- The content of CAI lesson should be material that does not change often because we want our lessons to have as long a useful life as possible.
- Since our material will be used along with existing materials, we must become familiar with the other materials. In that way, we can make our material more useful.

Determine the scope of the lesson

It is wise to select a lesson size which can be accomplished in a reasonable period of time. A lesson which is too long can be discouraging.

Designing the Lesson

After we do the preliminary planning, prepare the content of CAI lesson, then we are now ready to begin designing the CAI lesson.

Determining CAI lesson design

Here, we need to select an appropriate lesson design that will be used for developing our CAI lesson. Before

we do it, we need to do task analysis. It gives much information that enables us to select an appropriate lesson design. Actually there are three design decisions to be made as suggested by Burke (1982), namely: functional design, physical design, and logical design.

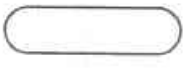
Functional design of the lesson (also termed as types of CAI lesson) concerns with the instructional function the lesson serves--for example, does it introduce new material? is it the primary means by which the material will be presented? or does it serve mainly to supplement or reinforce learning which has occurred by other means? In relation with the function of the lesson, there are five common functional designs which should be considered--that is, tutorial design, drill-and-practice design, problem-solving design, simulation design, game design (Burke, 1982; Kemp and Dayton, 1985). One or combination of those designs should be determined and then used to develop our CAI courseware. An example of functional designs can be observed in Appendix 1.

Physical design of the lesson concerns with the paths the learners follow through the lesson. As stated by Burke (1982) this dimension of CAI lesson design is perhaps the most interesting because it reflects the characteristics and the potential of computer technology. There are three popular physical designs which can be selected--linear design or sequence structure, branching design or choice structure, and repetition design (Hord, 1984; Kemp and Dayton, 1985). Either one or combination of them can be determined for our CAI lesson. Flowcharts of the physical design can be seen in Appendix 2.

Logical design of the lesson concerns with a strategy which structures our thinking as an author and gives the learners experience in thinking logically as it exercises them in the content they are to learn. The common logical design includes deduction, induction, analogy, EGRUL, RULEG, and so on. One of those designs should be selected for our CAI lesson.

Developing the flowcharting

Our next step should be to prepare a visual representation of the program's flow. The technique which can be done is termed as flowcharting. It is valuable in communicating our ideas to our programmer/partner. Flowcharting is used to represent the major parts of the CAI lesson and to arrange them in the sequence that the lesson will follow. Detailed flowchart is then made based on the major flowchart. Flowcharting is usually made up of just three types of symbols: the terminator symbol, the operations box, and the decision box.



Terminator symbol

Operations Box

Decision Box

The rules of flowcharts are simple. Flow is always shown by arrows pointing down or to the right. Arrows are not allowed to cross each other (Burke, 1982). An example of flowchart and detailed flowchart can be observed in Appendix 3.

Creating the Lesson

The next phase we should do is to create the lesson. We do this phase after we have completed the preliminary planning, decided the content, selected a lesson design, and made the flowchart of the lesson. To create the lesson there are several steps which should be done: (1) selecting a production strategy, (2) developing the screen mapping, (3) writing the criterion frames, (4) writing the teaching frames, (5) writing the program, and (6) developing a record-keeping strategy. Each of these steps will be spelt out below.

Selecting a production strategy

The next phase is that we need to select a strategy we will use in the actual development of the lesson. The selection will be determined by the following factors:

(1) The computer language, the author language, or the authoring system we will use. This will be determined by our skill level (or our assistance we have available, or computer programmer), and the time we can allow for creating the lesson.
(2) The amount of resources we have available, including time, money and representative test subjects for validation cycles.

Developing the screen mapping

After the detailed flowcharts are completed, begin to write out a script of our lessons on each frame in much the same way as we design a storyboard for a slide presentation. The technique which can be used is called screen mapping. It provides us with the opportunity to see the exact presentation of the material as it will appear on the screen. Like frames of a storyboard, screens in screen mapping depict what the user will see on the computer monitor, and denote the logical order in which the screens will appear in the program. Screen mapping is also valuable in communicating our ideas to our programmer/partner.

To prepare a screen map, simply write, type, or draw, the information that will appear on the computer monitor for each screen from the beginning to the end of the program.

There is another suggestion made by Burke (1982) and Kemp and Dayton (1985) about how to write scripts on each screen. They state that many people find it useful to use prepared screen coding forms. Such a form allows the CAI author to lay out the frames exactly as they will appear on the screen. Figure 1 presents an example of screen coding form.

Writing the criterion frames

Criterion frames are essentially questions which are designed to test the progress of a learner's understanding, whether or not she or he has met the learning "criterion". They are also to test the learner's readiness to move on

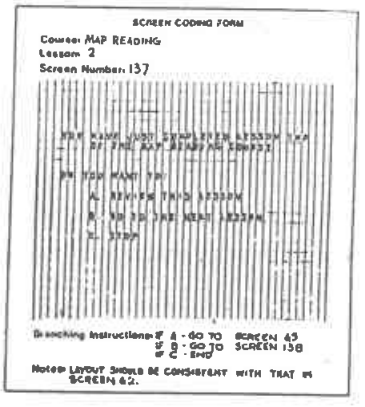


Figure 1
Screen Coding Form
as quoted from Kemp (1985:251)

within the lesson. In addition, criterion frames are also the main device by which the CAI author can determine the effectiveness of the sequence of the lesson to which the criterion frame refers. There is no teaching intended to take place on the criterion frames.

It is not unusual to begin the construction of a lesson by writing all of the criterion frames first. The author then writes only enough teaching frames, in front of each of the criterion frames, to enable the learner to answer each of the criterion frames correctly (Burke, 1982). Figure 2-1 is an example of a criterion frame.

The bag is red.

pencil	*interesting*
window	*green*
book	*white*
teacher	*open*
pen	*smart*
chalk	

Use the words to invent sentences like the model above.

Figure 2-1
criterion frame

Writing the teaching frames

A teaching frame is one which contains information for the learners to learn. It often contains enough information so that the learner could answer the frame without seeing any other frames in the lesson. It is nearly always written directly in support of the succeeding criterion frame. A teaching frame may or may not require a response. As suggested by Burke (1982), teaching frames may contain a question, or it may consist simply of simple narrative material. Figure 2-2 and 2-3 present an example of teaching frames.

THE SMALLER UNIT OF TIME USUALLY COMES BEFORE THE LARGER

Study the sentence below :
- *The meeting is at* three o'clock
(smaller)
on Monday, June 18th.
(larger) *(larger)*

Figure 2-2
a teaching frame which requires no response

Writing the program

Up to this point we have ignored the microcomputer. Now it's time to begin to put the material into the computer using our computer language, authoring language, or authoring system. A computer language is the complete set of commands which can be

THE SMALLER UNIT OF TIME USUALLY COMES BEFORE THE LARGER

Rearrange the sentence below :

- *I left last week, at five in the morning*

_____

_____

Figure 2-3
a teaching frame which requires response

used to write a program, as well as the rules which tell us how the commands must be used to write programs. Common, general-purpose languages are BASIC, Pascal, and FORTRAN. When writing a program, we must recognize that a computer requires very specific instructions.

An authoring language has been developed to increase the efficiency of the programming process. It is designed specifically for the production of CAI. PILOT is an example of an authoring language. Such an authoring language is easier to learn than most general purpose languages such as BASIC. However, they still require considerable knowledge on the part of the programmer. To overcome this, a number of authoring system have been developed which assume little or no prior programming experience. An authoring system does much more than an authoring language.

To put the material into the computer, we need to examine the flowcharting (the detailed flowchart) we have made, and assemble the screen mapping (the storyboards) in a correct sequence. Then enter the information into the program in sequence with the screen mapping.

Developing a record-keeping strategy

Many would-be authors of instructional material seem to forget entirely about keeping track of learner responses by record keeping. They follow the outlined procedures for writing CAI lesson and then suddenly quit. Record keeping should be included in all CAI lesson because it is needed for validation purposes (Beebe, 1983). To properly validate a lesson, the author must know exactly which frames were missed, and exactly what the incorrect answers were. It is also helpful to know how much time the learner is required to produce each answer -- both right and wrong answers. A quick wrong answer can mean that she or he is strongly confused. A slow correct answer can mean that the lesson segment preceding it needs some improvement (Burke, 1982). The record keeping will be needed for the validation process of the finished CAI courseware.

Writing Documentation

The final element in our finished CAI program should be the documentation. Documentation provides the descriptive material which accompanies the program and explains its purpose. It must tell the learners and the instructor how it is supposed to work. It is simply a set of instructions describ-

ing the whys, hows, whats, and whatever else users should know to set the program in motion. Kemp and Dayton (1985) suggest that at a minimum the documentation should include (1) a description of the computer system(s) upon which the software will run, (2) a list of the objectives, and (3) instructions as to how the program is started. In, addition clear and consistent descriptions should be provided for all parts of the program. These may be in the form of printed materials, or may be incorporated into the software itself.

Furthermore, good documentation as suggested by Burke (1982) is the one which:

- contains complete vital pieces of information. For example, informing about computer models, memory size, special hardware modification, disk, and so forth,
- easy to use even for the least knowledgeable users,
- is written in simple, clear, and complete language,
- informs the average amount of time learners are likely to require to complete the material,
- indicates the degree to which teacher assistance is required by the lesson,
- includes many of the process documents used in the development process -- for example, the rationale, the objectives, the task analysis, and the validation data.

Validating the Lesson

CAI lesson cannot be considered CAI lesson until it has been validated. To validate a program means to prove its validity empirically by conducting field-testing. It is field-tested with a sample of learners who are representative of the learners who will be using the program (Burke, 1982). Only after we have put our lesson through a number of validation cycles do we consider our lesson CAI lesson. The process of validation is done through the following procedures: (a) developing a frame identification strategy, (b) conducting pretest and posttest, and (c) conducting the field test.

CONCLUSION

To promote self-learning needs learning resources (especially instructional materials) which: (1) can activate a two way communication or interaction between the learners and the learning resources, (2) provide feedback which can motivate the learners' response so that they have the opportunity to correct their misconceptions, and (3) provide a self-evaluation device by which the learners can measure their own performance.

Good CAI courseware is one of the learning resources which can fulfill the above requirements. Producing good CAI courseware needs a careful planning and development. Otherwise, the CAI courseware we have developed will be ineffective and even useless and wasting our time, energy, and money. Following the procedures outlined in this article will improve the quality of CAI courseware and such a CAI courseware, therefore, will be able to promote self-learning.

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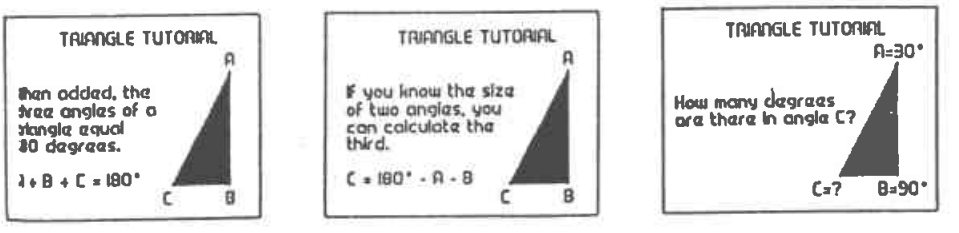
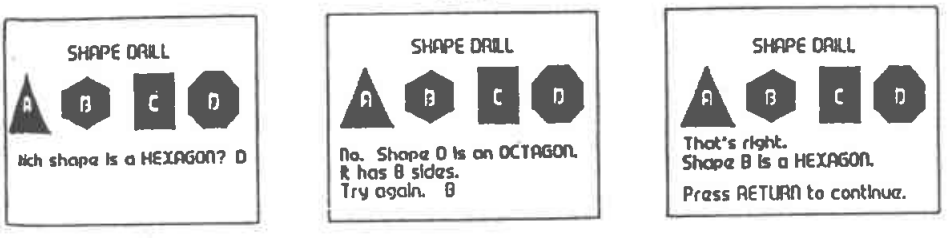
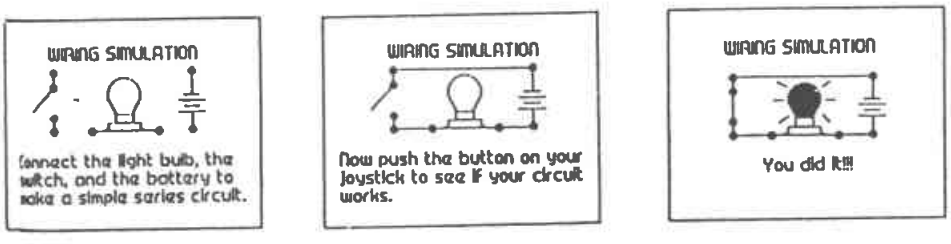
APPENDIX I
EXAMPLES OF FUNCTIONAL DESIGNS
Quoted from Kemp (1985:247)



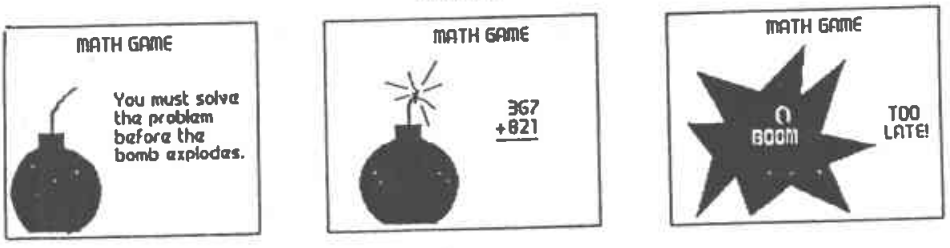
Tutorial



Drill and Practice

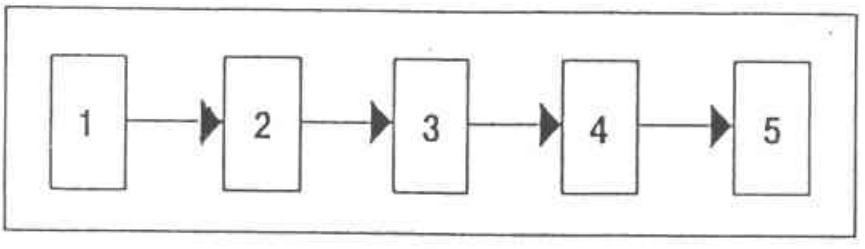


Simulation

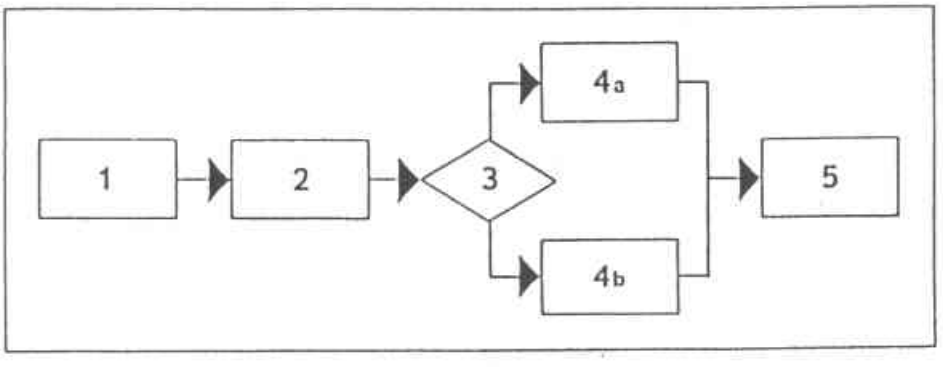


Game

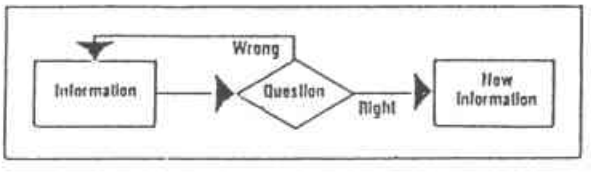
APPENDIX II
FLOWCHARTS OF PHYSICAL DESIGNS
Quoted from Kemp (1985:249-252)



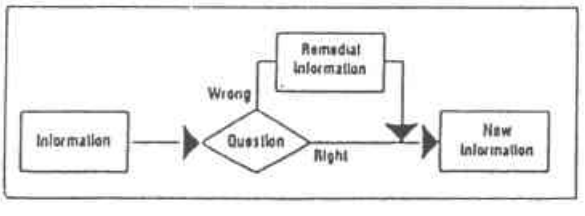
Linear Program



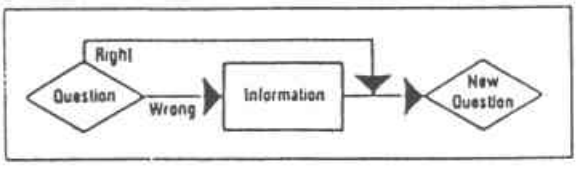
Branching Program



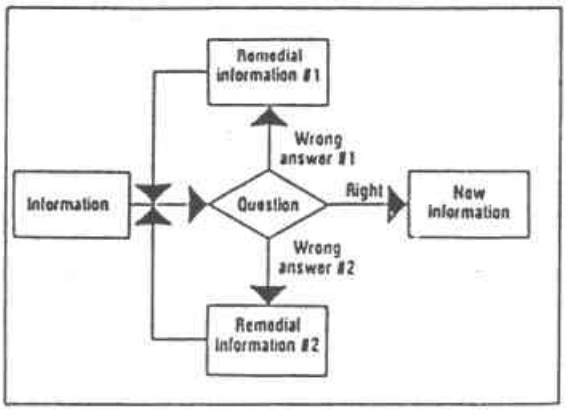
Linear format with repetition



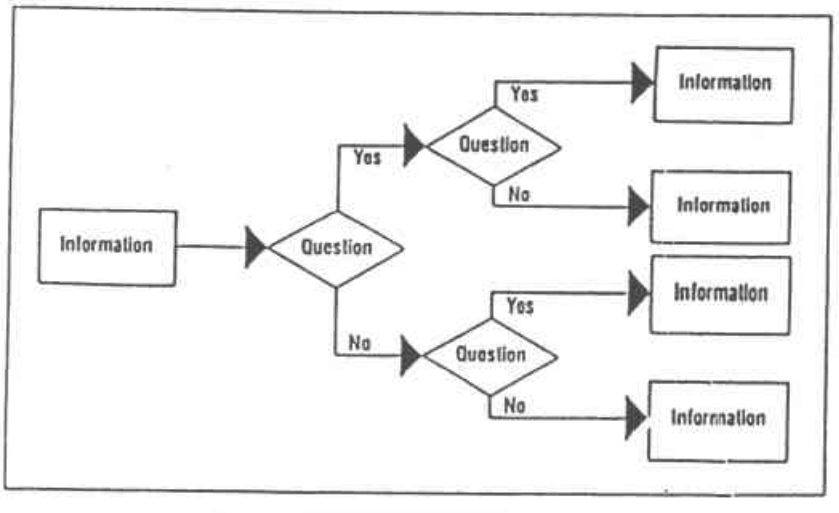
Single remedial branch



Pretest and skip format

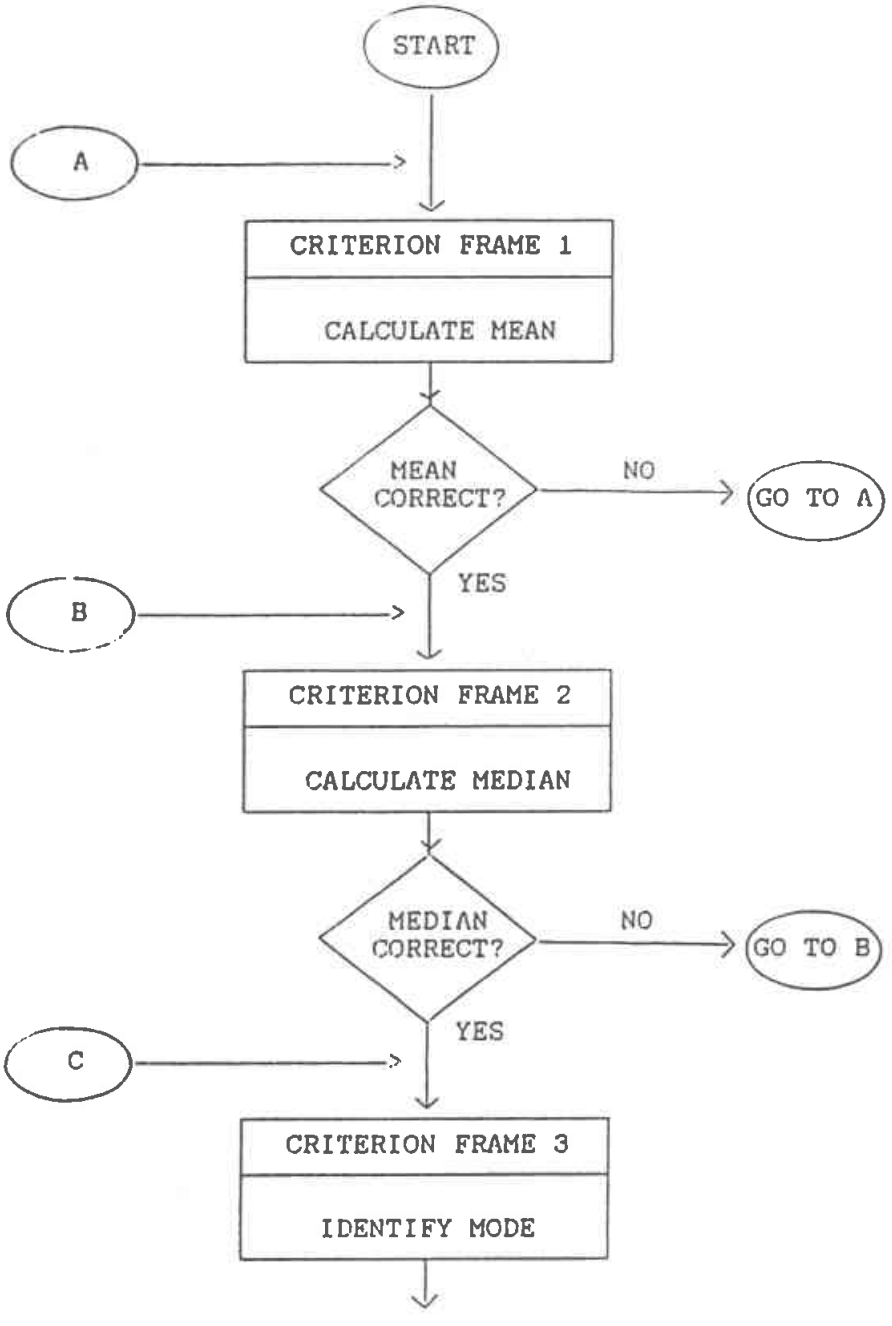


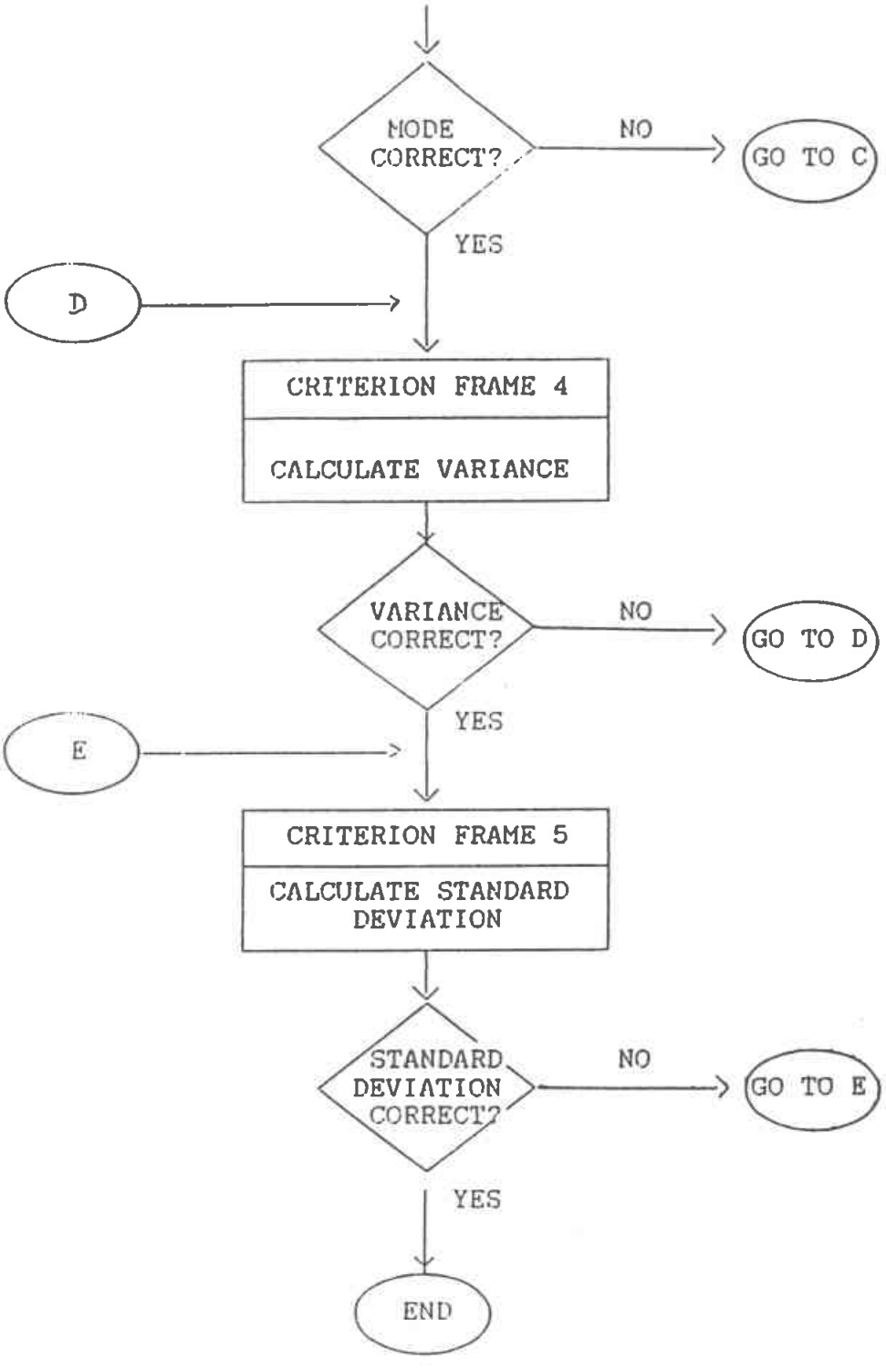
Multiple remedial branches

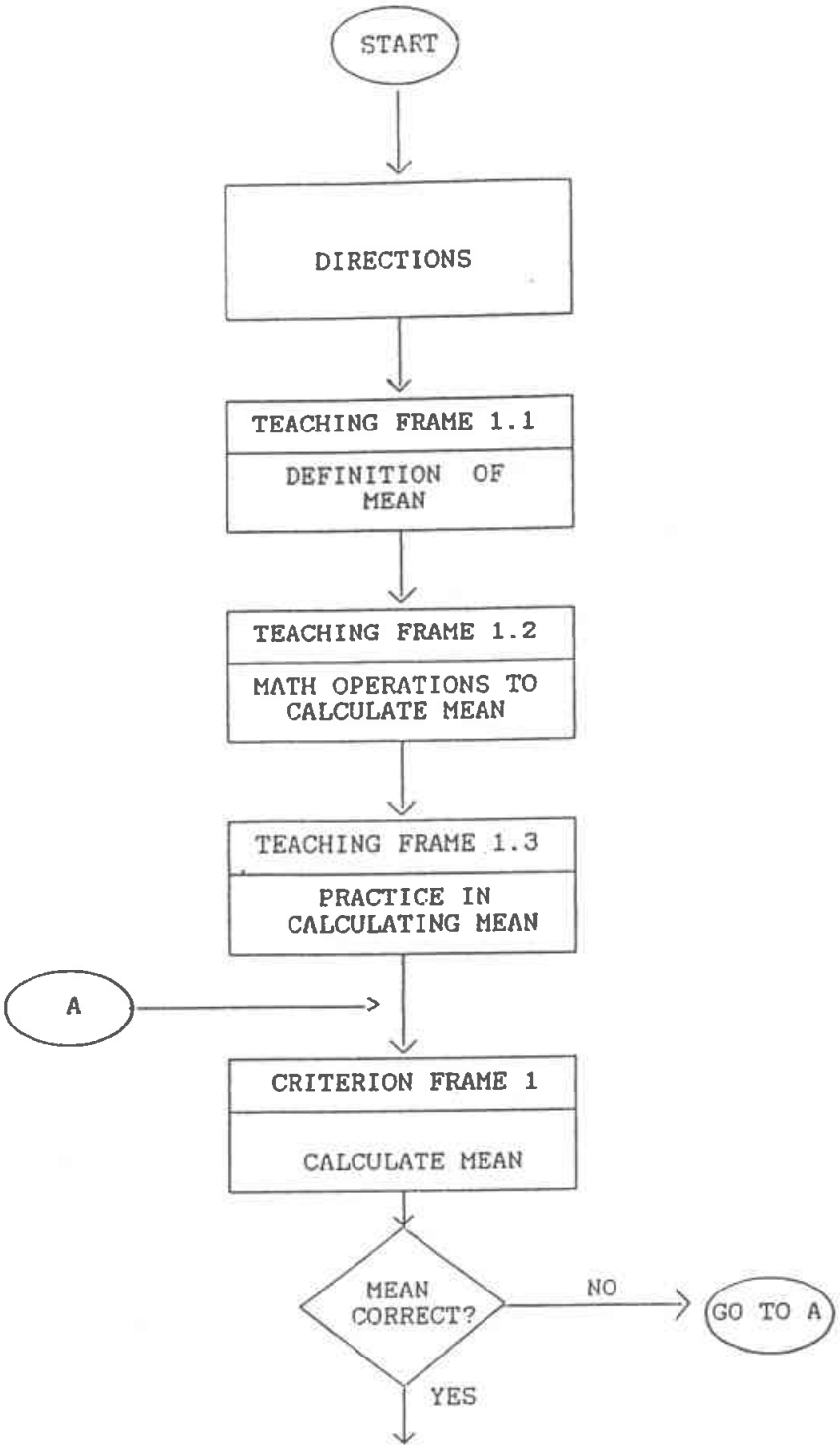


Compound Branches

APPENDIX III
EXAMPLES OF FLOWCHART AND DETAILED FLOWCHART
Quoted from Burke (1982: 136-138)




MODE CORRECT?
NO
GO TO C
YES
D
CRITERION FRAME 4
CALCULATE VARIANCE
VARIANCE CORRECT?
NO
GO TO D
YES
E
CRITERION FRAME 5
CALCULATE STANDARD DEVIATION
STANDARD DEVIATION CORRECT?
NO
GO TO E
YES
END


START
DIRECTIONS
TEACHING FRAME 1.1
DEFINITION OF MEAN
TEACHING FRAME 1.2
MATH OPERATIONS TO CALCULATE MEAN
TEACHING FRAME 1.3
PRACTICE IN CALCULATING MEAN
A
CRITERION FRAME 1
CALCULATE MEAN
MEAN CORRECT?
NO
GO TO A
YES