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ABSTRACT

In this second volume of a three-volume series on the construction of self-instructional systems, the system synthesis phase is described and directions are given for the construction of a preliminary system version. In order to aid the program constructor in establishing the correct sequence of instruction, various models of programing are outlined, including the prototypical models of Skinner and Crowder, linear models, micro- and macro-branching models, and completely student-adapted models. A flow model is suggested which starts from the subject matter content and includes considerations of terminal behavior characteristics and of the characteristics of the student population. The problem of determining the proper information component for each instructional unit is examined, with special emphasis on the questions of step size, prompting, and the use of fading technique. The advantages and disadvantages of such response factors as overt response, covert response, errors, constructed responses, multiple-choice responses, relevance, and position in the text are explored. The importance of providing the correct type and quantity of result indications is stressed. See also volume one (EM 009 072) and volume three (EM 009 074). (JY)

SYSTEM SYNTHESIS IN INSTRUCTIONAL PROGRAMMING: THE INTERMEDIATE PHASES OF THE PROGRAM CONSTRUCTION PROCESS

Åke Bjerstedt

The construction of a self-instructional system can be seen as a work process with three main phases: (1) System analysis: Preparatory work; (2) System synthesis: Construction of a preliminary system version; and (3) System modification and evaluation: Post-construction control and improvement. - While phase 1 in the program construction process was dealt with in an earlier report (Didakometry, No. 30), the present survey focuses upon phase 2, discussing various aspects of the writing of a preliminary version (such as choice of "flow model", working out the information component of instructional units, designing response requests and result indications).

CONTENTS

9. PREPARATORY ESTABLISHMENT OF SEQUENCES: CHOOSING "FLOW MODELS"

After analysis of prerequisites and subject-matter, but before preparing the individual instructional units for the student, the constructor of self-instructional material should provisionally establish the sequences; this will include choosing the "flow model" (e.g., deciding on possible branching in order to individualize the content).

9.1 TWO "OLD" PROTOTYPES: THE SKINNER MODEL AND THE CROWDER MODEL

The best-known types of "flow model" are the two which are called, after their inventors, the Skinner type and the Crowder type. The main characteristics of the former are (a) that all students go through the study material in the same way, i.e. work through all the tasks in the same order (linear model) and (b) that the students give self-constructed answers (either by means of a system of levers controlling a series of letters or numbers, as in certain types of teaching machine, or, more usually, by writing their answers on the work sheet). The characteristics of the Crowder type are (a) that branching occurs in the material for error treatment and sometimes to individualize the amount of work (branching model) and (b) that the students respond by choosing between ready-made alternative answers (either, when using a teaching machine, by pressing buttons representing different answers, or by turning to different pages in a book, depending on which alternative solution they choose).

A good deal of the early discussion about the preparation of material concerned the advantages and disadvantages of these two main types. Both gave rise to somewhat aggressive schools of thought in defence of the advantages of each of them. Some research projects have also studied the question, but mostly without coming to any definite conclusion clearly favoring one side or the other. It is obviously difficult, in any case, to generalize from the results of this type of research. Presumably different models suit different topics and varying groups of students. Furthermore, so many other factors affect the effectiveness of the material that, in the research which has been done, it has often been difficult to isolate the effect of the flow model used. It must be added, and indeed emphasized, that the two models most commonly used during the first years are by no means the only possibilities. Many other forms are certainly conceivable and probably just as effective. The usual combination of flow model and type of answer found in these two "old" prototypes is also by no means self-evident (cf. Figure 9.1).

9.2 SOME BASIC CONCEPTS

Even if different "schools" of programming have not agreed about the best type of flow model or answer, they do agree on many basic points. Thus most programmers have had no doubt that the material should be divided up into small units for presentation and that, in addition to new information, these units should also contain some form of request for an answer and be followed by some kind of report to the student about the correctness of the answer.

Unfortunately there is no generally accepted terminology for these basic characteristics which at the same time (a) is unconnected with some special form of presentation, (b) does not favor a particular theory, and (c) is sufficiently exact to be used unambiguously. Thus the term "frame" is often used for the basic unit, in spite of the fact that it is really only suitable for certain types of presentation (it does not seem suited, for example, to an auditive presentation). In addition, the term has not been used consistently, since certain writers use it about the whole complex: information + response demand + indication of result, while others use it only for information + response demand (regarding the indication of result as a separate phenomenon, which in fact it is in certain forms of presentation). In other words, the expression "frame" vacillates between its original meaning as a technical term referring to a specific presentation method and a later, broader interpretation.

/The word "frame" also tends, unfortunately, to lead to a restricted understandning of what is meant by an instructional step. Many people think that the "small steps" so often talked about in programming are more or less identical with what can be presented in the small rectangular opening of a simple teaching machine (perhaps 1 1/2 x 3 ins.). (For problems of the size of steps, see below.)/

Similar difficulties arise with other words which are used in this connection. The terms "stimulus" and "response" are so general that they are difficult to use in the sense of component parts of a single unit of presentation in teaching material of the above type. The word "reward" is misleading because of its everyday meaning. The term "reinforcement" is theoretically "loaded" and should in principle not be used a priori. In other words, it should be used only when it has been demonstrated that a certain report of the correctness of behavior does in fact "reinforce" that behavior, i. e. makes it easier to produce.

At one of the early international conferences on programmed learning (Berlin, 1963) there was a Terminology Committee whose task was to examine critically existing terminology in the field of programmed instruction. From the discussions in the committee, it became evident that the main problem was not to find adequate translations from one language to another (although that aspect of the problem could certainly be important), but to arrive at a sufficiently unambiguous and functional terminology in English, the initial language. Several people, and especially the specialist on learning theories, E. K. Hilgard, expressed the opinion that this terminology should be fairly neutral from a theoretical and interpretative point of view, so that educational psychologists with different theoretical points of departure could nevertheless agree on a basic descriptive vocabulary as a common point of reference.

As an illustration of this endeavour we can mention the attempt to find a series of simple starting terms in English, German and French for five key concepts or stages in programmed instruction: (a) what the student is offered in the way of information and tasks, (b) the processes thereby set in motion in the students, together with the preparatory behavior which can be registered, but which does not constitute the actual response reaction; (c) the response reaction itself, (d) the indication given by the teaching program of the correctness or incorrectness of the response reaction; and (e) the (partly hypothetical) processes which register the result for the student together with the necessary manipulations (if any) for proceeding to the next unit of study (manipulation of levers, turning the pages of a book etc.). The suggested terms and their mutual relationships are shown in Figure 9. 2.

The examples of terms given here can naturally form only a modest beginning for a descriptive terminology. In many cases there is a need for a fairly specific terminology, for which existing linguistic usage does not give a sufficient lead. In such cases, it is naturally often necessary to introduce completely new terms. In the following we present a few terminological suggestions which, at least within the framework of the present survey, should serve the purpose of referring unambiguously to some basic concepts.

In what follows we shall thus when needed use the term "didule" for the typical instructional unit in programmed study material, to include "information", "response demand" and "feed-back" to the student. The term is assumed to include both what is called "frame content" (stage 1) in Figure 9. 2 and also "result indication" (stage 4). (As already indicated, the term "frame" is not completely satisfactory as a description of stage 1, since certain programmers also use it for stage 4 and also because it has some undesirable side-associations.) It will be noticed that the representatives for both the other main languages avoided corresponding words in the terms they recommended).

Within each didule we can differentiate three more specific components, for which we shall use, for the present, the following technical terms: (a) stimule for that part of the teaching unit which presents focal stimuli (central teaching material) plus support stimulation; (b) respule for the response demand connected with it; and (c) corrule for the feed-back connected with the student's response, i. e. usually the indication to the student of the correctness of his answer ("result indication" in Figure 9. 2). [1] Thus a typical "didule" consists of "stimule" + "respule" + "corrule". When desirable to express these concepts by brief symbols, we shall use the letters D, S, R and K to refer to them.

We shall use these concepts in our discussion of the characteristic properties of the different flow models. To begin with we classify the different flow models into two groups: (1) linear models (with a sequence independent of the responses) and (2) different branching models (with a sequence dependent upon the responses). [2] Branching models may in turn be said to be of two main types: (2a) micro-branching models, in which differentiated treatment occurs only within a didule, while the didules themselves are arranged wholly linearly; and (2b) macro-branching models, in which branching also occurs with respect to the didule sequence and/or the number of didules.

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1) The term "result indication" can in some cases be far too general, as it can also be used for the final result as shown e. g. by the error counter of a teaching machine.

2) The linear model has been the most used. Among 749 British programs during 1960-66, 68 % were linear; and among 468 American programs, commercially available in England, during the same period, 84 % were linear. (Cf. Cavanagh & Jones, 1966.)

		TYPE OF ANSWERS	
		Self-constructed answers	Choice between alternative answers
FLOW MODEL	Linear model	A Linear model with self-constructed answers (Skinner type)	B Linear model with alternative answers
	Branching model	C Branching model with self-constructed answers	D Branching model with alternative answers (Crowder type)

Figure 9.1 Different possibilities of combining "flow model" and "type of answer"

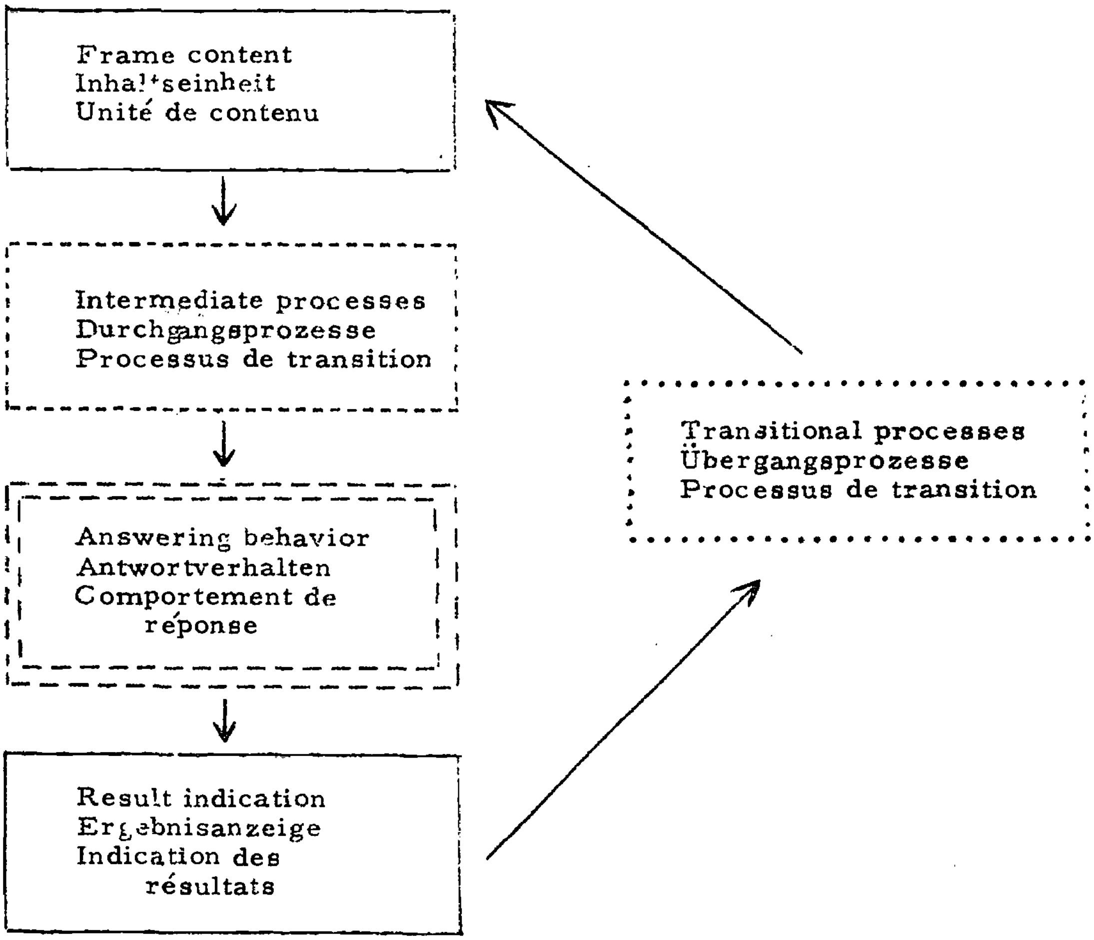


Figure 9.2 Terminological description of some basic stages in a self-instructional situation

Note: The student's direct response behavior is marked by a double line (====). Other student processes are shown by a dotted line (.....). Stages in the program are marked by a continuous line (——).

9. 3 SOME BASIC MODELS

9. 3. 1 The Simple Linear Model

The simple linear model is represented by the best-known form of the Skinner program. In this, all the students in the target population go through all the didules in a pre-ordained order. This can be done by means of presentation in book form one of the most well-known courses of this type is the psychology course which Skinner worked out in co-operation with Holland) or by presentation by a simple type of machine.

In principle, we get a build-up of the kind shown in Figure 9. 3 (and in Box 9. 1). The student responds to one task at a time and immediately gets information about the correct answer. If he has given the wrong answer, he is made aware of it, but nevertheless goes straight on to the next task. The response request functions as part of the learning process and does not constitute any "test" of what has been learned. Fairly often, rather short didules have been used in these programs, but this is of course not a necessary consequence of the flow model.

9. 3. 2 A Variation of the Linear Model: The Chaining Model

A variation of the linear model is the "chaining model", advocated by John Barlow (1960). In both models all students go through the same didules in the same order. A characteristic of the chaining model, however, is that the didules are "chained together" in such a way that the corrule-component in one task is incorporated as a part of the stimule-component in the next (cf. Figure 9. 4). The student is first given a task in the ordinary way and gives his answer. Instead of getting information about the correct answer separately (as is usual in the simple linear model), the right answer is incorporated in the next task unit as one or more words in different type (e. g. capitals). See Box 9. 2.

This special technique can have two advantages, (a) the student can experience greater continuity in the material, and (b) it prevents the constructor from making too large leaps in his thinking and can therefore act as an aid in reminding him of the "small steps" principle. The special form of writing is obviously of great importance, for there may sometimes be a risk of reduced "focusing" and lesser "readability". Few studies seem to have used the method in research (but cf. Trittipoe et al., 1963, and Greenberg, 1968).

9.3.3 The Micro-Branching Model: Branching for Error Treatment

The most usual kind of branching seems to have been that special type of error treatment most often used in the Crowder program which has already been summarily treated above. It consists mainly of a branching within the individual didule without alteration of the total didule sequence or number of didules.

This error treatment in general takes the following form (cf. Figure 9.5 and Box 9.3). In study unit 1 the student is given information and the accompanying task. He will answer by choosing one of a number of alternative possible answers. If he gives the correct answer, he immediately gets the next information and task. If, on the other hand, he gives the wrong answer, he gets instead an explanation of his mistake, which shows that he has made a mistake and explains why the answer was wrong. As a rule, the student is then directed back to the first study unit with instructions to choose another alternative ("stimule and respule repetition") before continuing.

This procedure can be expressed in another way thus: All the students get the same basic stimule and respule components, but as a result of the student's answer, the corrule can take various forms. When a wrong choice is made, the corrule consists of error treatment (different for different errors) and, when the correct choice is made, of an indication to this effect and direction to the next didule. This indication is sometimes only implicit: the student knows that he has given the right answer since the next task is presented. But frequently it takes the form of a "pat on the back", e.g.:

"Right you are."
"You are correct, of course."
"Excellent."
"You are doing fine."
"Grand."

Error indication in a typical Crowder program often begins with some form of chaffing:

"Now, wait a minute!"
"Now, you really know better than that."
"Oooops!"
"Oh, come on now."
"Sorry, bad guess."

The latter phrases, however, always lead to a more detailed explanation, and it is this explanation which is most characteristic of Crowder's micro-branching error treatment. Other constructors have worked with multi-choice alternatives without error treatment (e.g. Pressey). In these cases it would be more natural to speak of a linear program with alternative answers (cf. Figure 9.1, cell B) than of micro-branching.

9. 3. 4 The Macro-Branching Model (1-2): Sequence Differentiation of the Repetition Type

The ability of different students to profit from something new varies greatly, depending, among other things, on their background experience. The need of practising the application of certain rules is therefore also very varied. From the point of view of time and effectivity, it can be uneconomic to suit the construction of self-instructional material to the "lowest common denominator", i. e. to build into it as much repetition for all as for the student with the greatest need for repetition. An alternative possibility worth considering is therefore a sequence variation in the material with more repetition for the students with the greatest need of it.

A simple example of such macro-branching is shown in Figure 9. 6. Here a special "post-checking didule" has been introduced into the task sequence. If the student does this well, he simply goes on to further study material. If, on the other hand, he fails to complete it satisfactorily, he gets instead a larger or a smaller repetition task. In the simplest case, he is directed back to a certain earlier task number and instructed to repeat a series of didules which he has already gone through.

If one is dealing with subject-matter which is not sequential in character, e. g. the learning of individual associations (vocabulary in a foreign language etc.), the repetition can mean that the student goes back to the tasks in which he earlier made mistakes and works through them again. This post-check is often arranged so that the student has to go through the tasks to which he has given the wrong answer until he has answered each task correctly at least once. It should be noted that Skinner, in his earlier experiments with the so-called "disc programs" (discs inserted in a apparatus similar to the old memory psychologists' "mnemometer") worked with study material of this type. Skinner's name has in the discussion been almost exclusively connected with strict linear programming. It is therefore interesting to observe that he also worked with highly individualized repetition programs (cf. Figure 9. 7).

9. 3. 5 Macro-Branching Model (3): Sequence Differentiation of the Rapid-Track Type

As a counterpart to simple "direction back" at a wrong answer in a post-checking didule, we can obviously devise a simple "direction forward" for other circumstances. Let us assume that we cannot presuppose, among the majority of the target population, a certain type of mathematical knowledge which is necessary so that a certain new stage in the course can be performed. We must, then, before we can start on this new stage, arrange a preparatory sequence to teach the necessary knowledge. However, the target population in all likelihood contains a few students who have already, in some way or other, acquired this knowledge and thus do not need to work through the preparatory didules. If we believe that this i , we can arrange a "pre-checking didule" which tests the students' knowledge in this respect. If this check is successful, i. e. shows that individual students really have this knowledge, we direct them to skip the preparatory sequence and instead let them start straight away on the next stage of the course. (Figure 9. 8 and Box 9. 4.)

Both pre- and post-checking didules can be thought of as "filter didules", which give information about the best possible flow track for the individual student. To avoid guess-work and chance playing too great a part at such important check points, it is often a godd thing not to be content with just one checking task, but to use several of this type. If they all give the same result, we can naturally be more certain that our recommendation of a flow track is based on reliable information about the student's qualifications.

9. 3. 6 Macro-Branching Model (4): Parallel Track Type

Both the repetition type and fast track type of sequence differentiation imply in a way only manipulation of a basic model of a "linear" type, a fixed chain of study units which we "shorten" or "lengthen" according to the needs of the individual student. We either make the student go back and go over certain sections again, which we believe he needs to repeat, or let him skip certain sections, which we think are unnecessary for him. But there are also possibilities of macro-branching with tracks which run parallel. A general diagram of such a model is given in Figure 9. 9.

A parallel track arrangement can be used for very different purposes: (a) repetition or practice material of different kinds for groups of students who show varying retention of material previously worked through, (b) informative material of varying scope for groups of students with varied pre-knowledge, or (c) treatment of the same set of problems from different angles depending on the students' various attitudes and opinions.

The first of these uses has a purpose very similar to that of the above-mentioned branching-model with repetition. There is sometimes a risk, however, that a strict repetition of material which has already been worked through (not least in the form occasionally presented by machines which "reverse back") can be a disagreeable experience for the students. Since a positive learning climate is of essential importance when self-instructional material is being used (one tries to produce this, for example, through sequences with a low error rate), it would be well to try to arrange it in a pleasanter way. All the students can, for example, get "new" practice tasks, so that those who have shown that they have not mastered previous material get a longer parallel series of practice tasks than the others. It is then a question of further training in the form of new tasks instead of strict and manifest repetition of the same tasks.

The last-named method - treatment of the same set of problems from varying angles depending on different students' varying attitudes and opinions - is perhaps the one that has been least used. If self-instructional material is to be made really effective in areas where different opinions exist and should be clarified, for example, a parallel track arrangement of this kind should be an excellent method, following in several respects the important principle of the time-honoured Socratic discussion method.

9.3.7 Directed vs. Voluntary Choice of Track

It is worth mentioning here that there are many ways of choosing a track at the point of differentiation in a multi-track model. The most usual is perhaps that the choice is made on the basis of the student's response to a filter didule. He is directed to different study sequences according to the alternative answer he chooses. Another possibility is to choose a track as a result of some kind of reaction summation. If, for example, the student gives more than 90 % of the correct solutions in one section, he may continue directly with the next section. Otherwise he first has to work through a special review section.

Side by side with these two types of directed choice, there is also the possibility of a voluntary choice. The student chooses at a certain point (a) whether he wants to repeat a section or continue, (b) whether he wants to study a certain problem more deeply by going through our "extra course" sequence or skip this material, or (c) whether he would like to have a certain type of problem illustrated by examples from one special area of experience rather than from another (Box 9. 5, Example A).

A certain number of such opportunities for voluntary choice often give the students, especially if they are more adult, a valuable feeling of greater freedom in their work. Apart from the fact that such a choice of illustrations from a personally relevant area of interest can in itself directly promote effectivity at the particular point to be illuminated, is often increases motivation generally to be allowed to make such a choice. Hence, this technique may increase effectivity indirectly, too.

In certain cases such a voluntary choice inserted at an early stage helps a student to clear an "emotional block" caused by misunderstanding of the instructor's presentation of the facts and his intentions. This means that an unnecessary barrier to communication is broken down, thus making a further contribution to increased instructional effectivity (cf. Box 9. 5, Example B).

9. 3. 8 The Completely Student-Adapted Model

Even if branching models of the type now under discussion result in greater attention being paid to the individual differences than the linear model admits, they hardly mean that one proceeds in every single task as a really effective private teacher would have done. Sometimes a particular student is given unnecessarily many examples. Sometimes he is given too few. It is, however, quite possible in principle to build up considerably more student-adapted models in which each unit of presentation is chosen on a basis of the student's reaction to the one immediately preceding it.

Computer techniques can be used for this purpose. However, this demands comprehensive preparatory work to create instructionally suitable patterns of "machine behavior" (cf. Box 8. 1 above). Advanced computers within the school system are still expensive and not very frequent. This means that while such possibilities are certainly of great theoretical interest, they have as yet limited practical value for many teaching situations. (Readers interested in developments of this kind may refer to Stolurow & Davis, 1965, Bushnell & Allen, 1967, and Lehnert, 1970, among others.)

(a) With undivided units:

$$D_1 \longrightarrow D_2 \longrightarrow D_3 \longrightarrow \cdots \rightarrow D_n$$

(b) With components analysed:

$$\boxed{S_1\ R_1\ K_1} \rightarrow \boxed{S_2\ R_2\ K_2} \rightarrow \boxed{S_3\ R_3\ K_3} \cdots \rightarrow \boxed{S_n\ R_n\ K_n}$$

Figure 9.3 General diagram of the simple linear model

(a) With undivided units:

$$D_1\ D_2\ D_3 \longrightarrow \cdots \rightarrow D_{n-1}\ D_n$$

(b) With components analysed:

$$\boxed{S_1\ R_1} \rightarrow \boxed{(K_1+S_2)\ R_2} \rightarrow \boxed{(K_2+S_3)\ R_3} \cdots \rightarrow \boxed{(K_{n-1}+S_n)\ R_n K_n}$$

Figure 9.4 General diagram of the chaining model

Box 9. 1 The simple linear model: An example

37. DE- is a negative prefix that is put in front of verbs. DE- means "do the opposite of" the verb's meaning. HUMANIZE means "make human". The opposite of making something good for humans is making it bad: the opposite of HUMANIZE is ________________.

- -

DEHUMANIZE

38. An army is called together and trained for action: it is mobilized. When the time of service is over, the men are let go.
They have been _______________.

- -

demobilized

39. If the laws of a country are "made fit for humans" (or changed to what is favorable for man), we say that they have been humanized. If the changes are unfair to man, we would say that the laws have been dehumanized. HUMANIZE is the ___________ of DEHUMANIZE.

- -

opposite

40. DEHUMANIZE, DECENTRALIZE, DEMORALIZE, DEODERIZE - All these words have the n_________ prefix DE-.

- -

negative

41. A hundred years ago, young boys worked in factories and in mines. Boys as well as men worked twelve hours a day for very little money. Before long, such treatment of children was considered inhuman. There now are laws against it. The laws have __________ (dehumanized/humanized) the treatment of working children.

- -

humanized (Things are better now)

Sample units, slightly edited, from S. M. Markle: "Words. A programed course in vocabulary development."

Box 9. 2 The chaining model: An example

37. DE- is a negative prefix that is put in front of verbs. <u>Humanize</u> means "make human". The opposite of making something good for humans is making it bad: the opposite <u>humanize</u> is ________________.
38. DEHUMANIZE, decentralize, demoralize, deoderize - All these words have the n___________ prefix de-.
39. Using the NEGATIVE prefix de-, you can often express the opposite of a verb's meaning. An army is called together and trained for action: it is <u>mobilized.</u> When the time of service is over, the men are let go. They have been __________________.   etc.

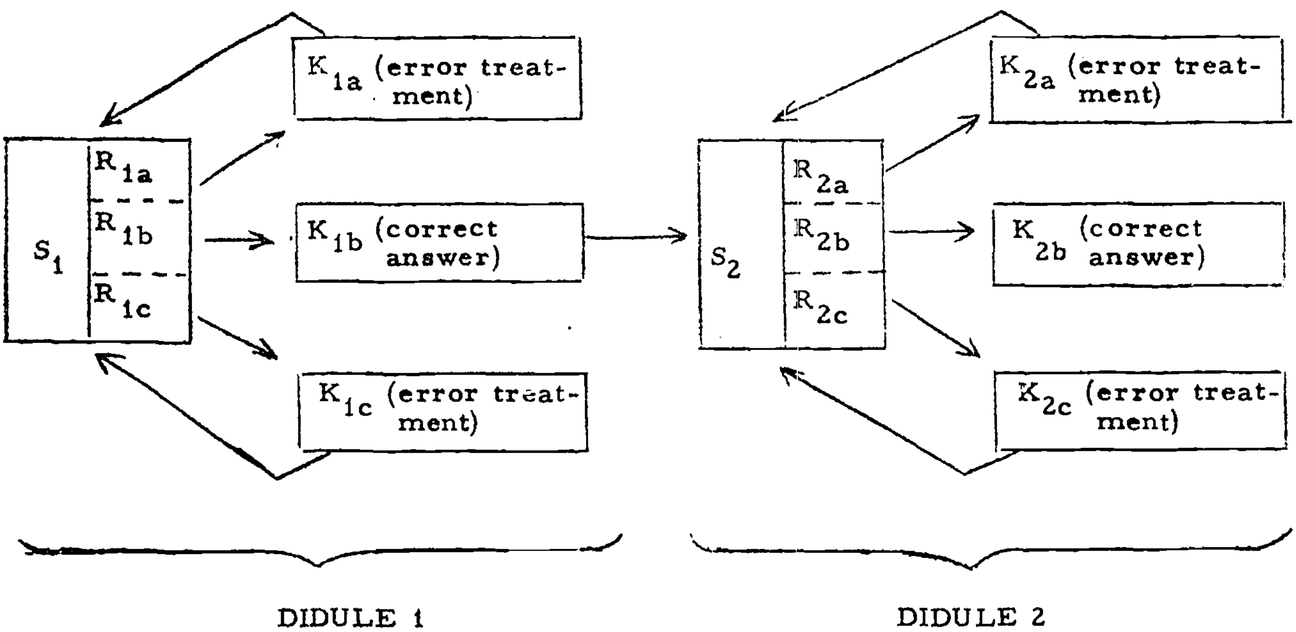


Figure 9.5 General diagram of the micro-branching model

Box 9. 3 Micro-branching: An example

Note to the reader:

This is not an ordinary book. Although the pages are numbered in the ordinary way, you must not try to read them consecutively. You must follow the directions at the bottom of each page. Now start with page 1.

PAGE 1

What Is a Poem? Few writers are in complete agreement, but many seem to agree in one area: a poem must at least be honest, consistent, and complete. - Almost everyone has read some poetry, and we can all recognize a poem when we see one. Or can we?

Which of the following statements is true?

I?
Why?
is not a poem. (See page 7)

abcdefg
hijklmnop
qrs and tuv
w and xyz
is not a poem. (See page 9)

Both of the above are poems. (See page 11)

Neither of the above is a poem. (See page 13)

PAGE 2

You have reached this page by mistake, for you could not have arrived here by following directions. You must not try to read the pages serially. On each page there are clear instructions directing you to the next page you are to read.

Now go back to the page you just came from, and follow directions.

PAGE 7 (from page 1)

YOUR ANSWER:

I?
Why?
is not a poem

Why not? Do you think that a poem must have a specific number of lines or look regular or contain a certain amount of material? If so, you are wrong. "I? Why?" has been called the shortest poem in the English language because its two words rhythmically express a complete thought. It asks a question that has plagued men since the beginning of time: "Why do I exist?"

During this century poetry has undergone a period of experimentation. Changes in style and subject matter have sometimes produced oddities. But language is flexible, and you must expect poets to utilize its versatility. However, the poem can still meet the three requirements mentioned earlier: honesty, consistency, and completeness.

Return to page 1 and select another answer.

Box 9. 3 (continued)

PAGE 9 (from page 1)

YOUR ANSWER:

abcdefg
hijklmnop
qrs and tuv
w and xyz
is not a poem.

Careful. It is a poem, for it well exemplifies the requirements of honesty, consistency, and completeness set forth earlier. The alphabet, although commonplace, is not an unfit subject for poetry, even though its poetic possibilities are limited. In fact, the alphabet, in its normal order, was actually used in the 1920's as a poem entitled "Suicide".

Poets often experiment, and you should be willing to accept variances from what you might consider traditional forms. In experimentation, however, the poet need not violate the requirements of honesty, consistency, and completeness.

Return to page 1 and select another answer.

PAGE 11 (from page 1)

YOUR ANSWER: Both are poems.

Yes, you are right. "I? Why?" could perhaps be entitled "A Metaphysical Introspection of Myself in Terms of the Universal". The alphabet, so presented, has a rythmical completeness that a reader may find attractive.

But you would have a difficult time justifying your view that the two examples are poetry unless you defined your terms. Most disagreements about poetry stem from a failure to do just this.

Therefore, it is desirable to clarify further the meaning of the three key terms mentioned above: honesty, consistency, and completeness. If we have a poem. . . . .

(Note: Here the program gives a new task with different response alternatives, leading on to different pages.)

PAGE 13 (from page 1)

YOUR ANSWER: Neither is a poem.

Are you willing to back up this belief with evidence? Can you define for yourself what a poem is? Try it. In 25 words or less, complete the following statement: "A poem is . . . . "

Could you do it? If so, did your definition contain references to rhyme and rhythm? Both texts contain rhyme and rhythm, don't they? If the two arrangements are not poems, what else are they? Just because a group of words does not appear to have a clear mening at first glance does not preclude its being called a poem, if the three requirements of honesty, consistency, and completeness are not violated.

For the moment, I suggest that you accept both of these examples as poems. If you had selected the answer "Both are poems", you had been directed to page 11. Go to that page now, and we will clarify the definitions further as we go along.

Sample units, abbreviated and slightly edited, from J. C. Pratt: "The meaning of modern poetry".

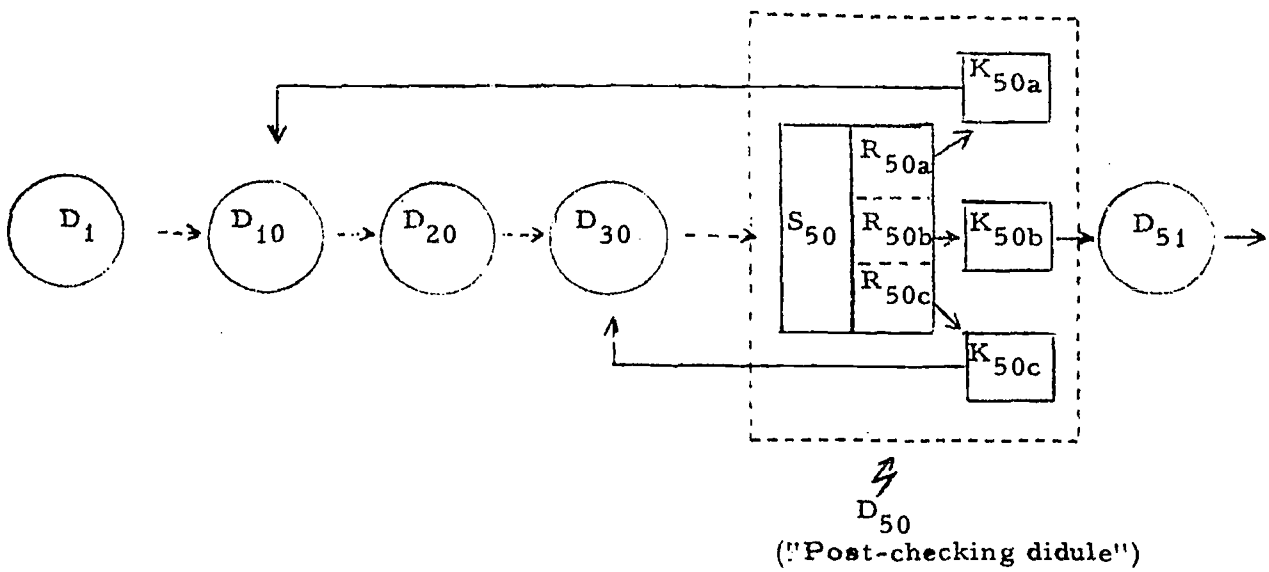


Figure 9.6 The macro-branching model 1: Sequence differentiation of repetition type - simple direction back after wrong answer in a post-checking didule

Note: The student has got as far as didule no. 50, which is a checking didule for the immediately preceding study section. If he answers correctly (alternative b), he gets the next task (D_{51}). If, however, he answers with alternative a, we perhaps consider this a serious mistake, which shows that the student has missed important information. The student is therefore directed back so that he repeats a long section, e.g. from D_{10} to D_{50}. If he answers with alternative c, which is considered a less serious mistake, he need repeat only a shorter section, e.g. from D_{30} to D_{50}.

Figure 9.7 Macro-branching model 2: Sequence differentiation of repetition type - direction back to individualized repetition, including previous wrongly-answered didules

Work criterion: Each task answered correctly once.

Initial sequence for all students:

$D_1 \to D_2 \to D_3 \to D_4 \to D_5 \to D_6 \to D_7 \to D_8 \to$

$\to D_9 \to D_{10} \to D_{11} \to D_{12} \to D_{13} \to D_{14} \to D_{15} \to$

Student A's work (completed in 18 stages)

Result of student A's work in first working:

$r_1, r_2, r_3, r_4, r_5, w_6, r_7, w_8, r_9, r_{10}, w_{11}, r_{12}, r_{13}, r_{14}, r_{15}$

(r = right, w = wrong)

Student A's individual work sequence, second working:

$D_6 \to D_8 \to D_{11}$

Pupil A's result in second working.

r_6, r_8, r_{11}

Student B's work (completed in 26 stages)

Result of student B's work in first working:

$r_1, r_2, w_3, w_4, w_5, r_6, w_7, w_8, r_9, r_{10}, w_{11}, w_{12}, r_{13}, r_{14}, w_{15}$

Student B's work sequence, second working:

$D_3 \to D_4 \to D_5 \to D_7 \to D_8 \to D_{11} \to D_{12} \to D_{15}$

Result of student B's work, second working:

$r_3, w_4, w_5, r_7, r_8, w_{11}, r_{12}, r_{15}$

Student B's work sequence, third working:

$D_4 \to D_5 \to D_{11}$

Student B's result in third working:

r_4, r_5, r_{11}

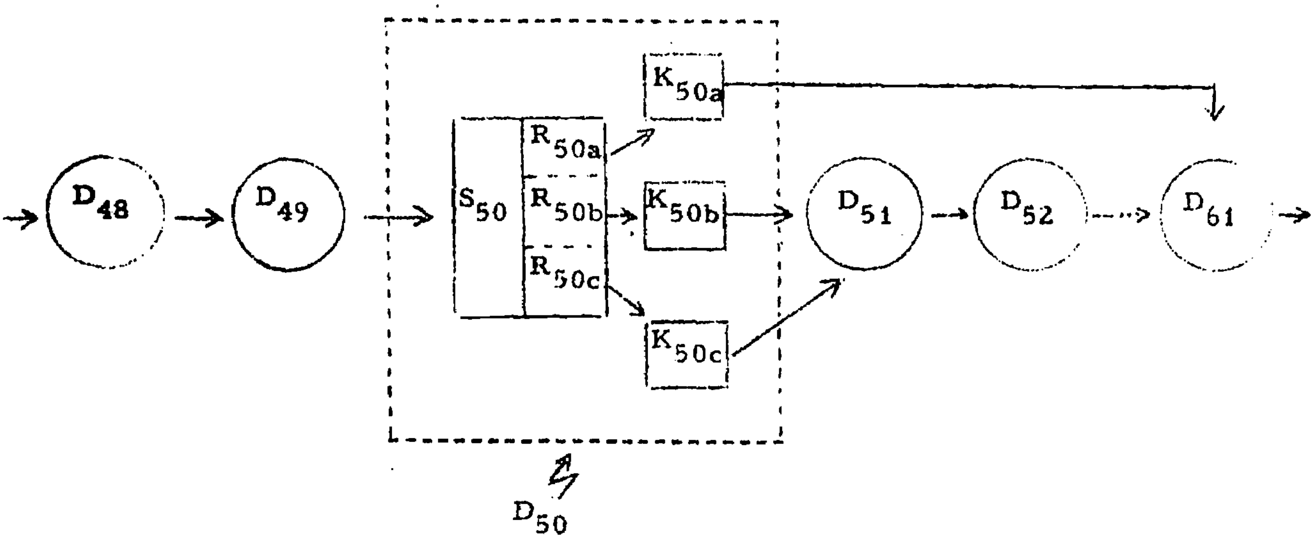


Figure 9.8 Macro-branching model 3: Sequence differentiation of the rapid track type

Note: The student has reached didule no. 50, which constitutes a pre-checking didule for the next study section. If he chooses a wrong answer (b or c), he simply goes on to the next task. If, however, he answers correctly (a), we perhaps estimate that the student already has the knowledge the next section is supposed to give. He can then make a jump forward (skip the material he already knows) and begin, for example, with didule 61.

Box 9.4 Rapid track model: Example of a pre-checking didule

41. To be able to go through our next section in German grammar, you must be quite sure about what is meant by "subject", "dative object" and "accusative object".
Mark the subject with an S.
Mark the accusative object with an A.
Mark the dative object with a D.

a. The girl gave the boy a ball.
b. He bought an ice-cream.
c. He gave it to her.

Solution to No. 41:

a. The girl gave the boy a ball.
S D A

b. He bought an ice-cream.
S A

c He gave it to her.
S A D

Instruction:

If you made a mistake, or if you do not feel sure about it, go on with No. 42 next. This will give you more practice with parts of the sentence.

If you did not make any mistakes and feel certain that you can recognize the "subject", "accusative object" and "dative object", go on to No. 71.

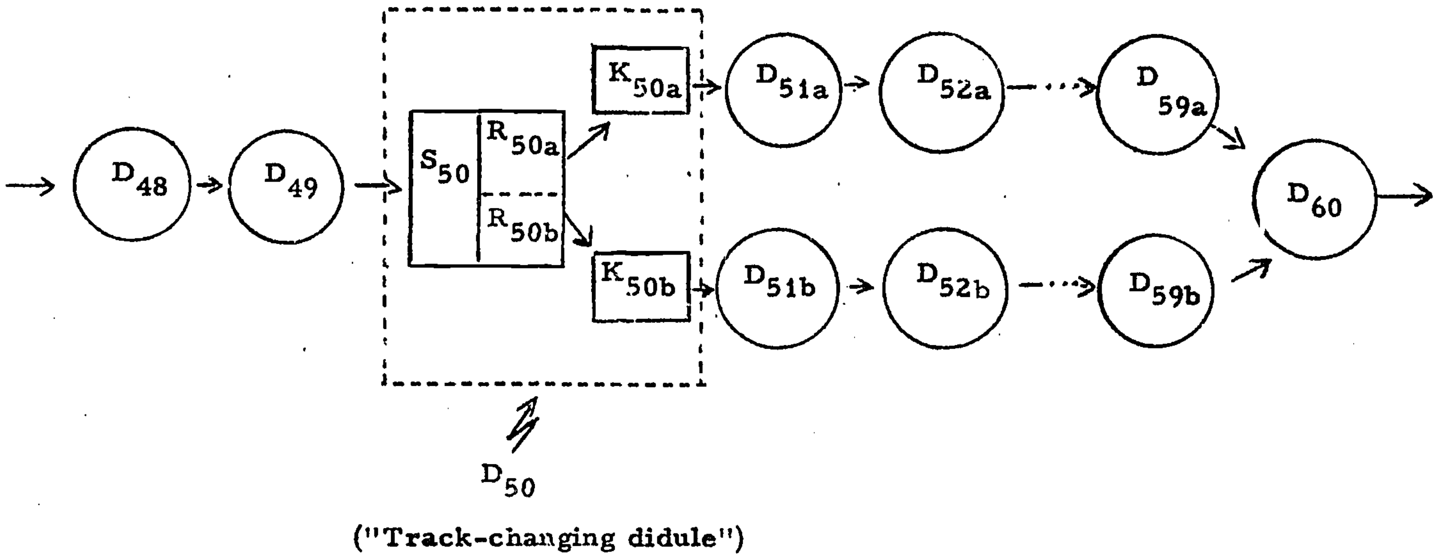


__Figure 9.9__ **Macro-branching model 3: Parallel track type**

Box 9.5 Choice according to direction of interest or attitude: two examples

Example A:

50. In our study of developmental psychological principles and their importance for the teacher's handling of the student in school, we shall now give a series of concrete illustrations. Here you should choose the section you read according to your interest or area of experience.

Instructions:

If you teach in grades 1-3, study next tasks 51-60.

If you teach in grades 4-6, you can skip the next tasks and concentrate on Nos. 61-70.

If you teach in grade 7 or higher, you can concentrate on tasks 71-80.

Example B:

100. When we describe the target for our teaching, it is usually not enough to say what kind of behavior the course is intended to teach. We must also state clearly how well the student should be able to do. In other words, we should state a lower limit for an acceptable performance. Now choose the pages you will read, depending on your attitude.

a. "Show me how I should set about describing the limits for acceptable performance." - turn to p. 103.

b. "Much of what I teach cannot be evaluated or measured." - turn to p. 101.

(The students who choose p. 101 will get the starting-point further clarified and motivated. It is hoped in this way to avoid possible misunderstandings and, if possible, to create a more positive attitude to the suggested procedure. These students are then directed to p. 103 to continue. - A procedure closely corresponding to this example will be found in Mager, 1961.)

9.4 TWO SPECIAL ARRANGEMENTS

9.4.1 The "Tail Model"

If the completely student-adapted model belongs to the uncertain future, what is called here the "tail model" belongs to the past history of the teaching machine. The first well-known experiments with teaching machines were made in the twenties by Sidney L. Pressey, Professor of Education at the Ohio State University. The machines he used were primarily intended for the correction of tests. They saved the teacher the work of correction by adding up the number of correct answers to test questions which the student answered by pressing buttons.

According to Pressey, these machines could also be used for teaching purposes. In this case, the machine did not go on to the next question before the preceding problem had been correctly solved. The student had to go on attempting until he found the correct alternative answer, Since the student worked actively and always got the right answer. Pressey maintained that this type of work had considerable value for effective teaching. The ideas of creating a totally self-instructional course in the form of a chain of small tasks, to arrange course material in an instructionally detailed sequence, to work with small steps and try to keep the error rate low; - these ideas did not lie within the scope of Pressey's aims, simply because his teaching machines were not primarily intended for teaching in the ordinary sense of the word, but for checking results and a certain amount of "post-teaching". The real teaching, the basic inculcation of information, was done in other ways, e.g. in the form of traditional lessons and by reading textbooks.

When the idea of completely programmed courses were worked out later, many thought Pressey's technique primitive and ineffective by comparison. Nor was it built up from the thorough preliminary work which is nowadays considered natural in preparing the material for a self-instructional course. But it must be remembered that he had a different purpose in mind. It was not a question of complete study material, but material for checking and correcting. However, Pressey has argued, with some success, that such "tail models" may have a special value. In many cases, we have neither the time nor the possibilities for constructing completely programmed courses. In some cases we are perhaps more interested in giving the student good habits of study and the ability to work with refractory material than making certain that, by pedantically thorough spoonfeeding, certain subject-matter has been completely learnt. It would then be quite natural to let the students work independently with texbooks and other source material and, after they have done this, check and correct their work by a device of the "tail model" type. On the other hand, if one does construct material of this "tail" type, one should naturally not deceive oneself or others into believing that one has a completely programmed course with its special advantages and area of use.

9.4.2 The "Intermittent Model"

A compromise between Pressey's "tail model" and a more completely programmed course is the "intermittent model". In the preparation of the study material one then differentiates between the subject-matter, the instructions for treatment of the subject-matter and the checking tasks. The newly constructed study material thus mainly takes the form of a detailed study plan interspersed with self-correcting tests, while the actual material for study is taken by the students from a variety of other sources, to which he is directed from his study compendium. The source material can consist of different parts in textbooks and reference books, diagrams, tables, maps, etc. The study compendium gives him directions as to where to find his material and how it is to be treated. When he has followed the instructions and used the material in this way, he goes back to the compendium where he is tested on his knowledge. If the result is satisfactory, he is directed to new material. If it is unsatisfactory, he is directed to study the earlier material again or to go to another source which in principle presents the same material to be learnt in another form.

The change-over between reading the instructions, independent work from sources and self-testing afterwards which the "intermittent" model offers should in many cases give the teacher a useful instrument in his striving to create good, independent habits of study. However, there may be a risk of lazy reading and direct copying, and this should be borne in mind when the material is constructed. It will naturally be important to formulate the instructions in such a way as to encourage a critical and active form of study. The method may also mean that the individual student gets inadequate help in his studies, unless special preparatory training has got rid of the difficulties.

Bot the "tail" and "intermittent" models can be said to consist mainly of checking didules. In the tail model, the whole checking section comes at the end of the work, and the necessary subsequent direction of the student is left entirely to the tutor/teacher. In the intermittent model, this checking takes place at suitable stages in the work sequence. On the basis of the test result the student is then directed to new tasks without the immediate intervention of the teacher. Self-instructional study material, consisting mainly of source material, instructions and checking didules, very closely resembles the kind of study material traditionally used by correspondence schools. It should be possible to increase effectivity in the technique of teaching by correspondence by following, to a greater degree than has been customary in the past, the stages of preparation we have outlined above for constructing self-instructional material (and also, of course, by submitting the material to the empirical testing procedure which we shall deal with later on).

9. 5 CHOOSING A "FLOW MODEL"

9. 5. 1 Starting from the Subject-Matter

In one of the many introductory works on programmed teaching published in the USA, the author (Cram, 1961) concludes his chapter on linear and branching programs with a self-test (p. 64) which, somewhat shortened, looks something like this:

Which style of programming would you consider first if you were to program a lesson or book on the following topics?

1. Household budgeting
2. How to mount a butterfly
3. How to find the square root of a number
4. Methods of psychoanalysis
5. Should you be in a mental institution?

The reader could well ponder a moment on possible answers and motivations. It would then perhaps be of interest to compare your own conclusions with Cram's suggestions and reasoning, of which we give a slightly summarized version in Box 9. 6. We do not maintain, obviously, that Cram's suggestions are necessarily better than the reader's! It depends on the special purpose of the teaching, the special group of students one has in mind and the concrete form the flow model takes, whether one or other type of model will be most effective for a given subject area. In other words, it is not necessarily the subject which determines the flow model. But in the choice between different models, the subject naturally plays a large part; and the points of view put forward by Cram can perhaps be summarized thus:

(a) If the subject matter has a very fixed structure and consists mainly of facts, definitions and basic skills founded on such facts and definitions, a linear approach is natural. Many mathematical subjects are examples of this. The example given above ("How to find the square root of a number") is a case in point.

(b) If the subject-matter contains a great many comparisons, assessments and opinions, i. e. matter apart from the basic facts and definitions, the branching technique is often very suitable. It is easier in a branching program to work from the student's previous understanding of the subject and to deepen and/or correct it. The comparative discussion of various psychoanalytical methods mentioned above is an example of this.

(c) If the subject matter most relevant to each individual student varies within the framework of a larger area of subject matter, the branching technique can quickly lead the student's reasoning to what is relevant to him personally. An example of this is the subject about household budgeting.

(d) If the material is suited for treatment in a personal way or in the style of popular journalism, the freer branching technique is often suitable. It allows more easily for personal commentary and author-student interaction on a basis of individual reactions. The above-mentioned example "Should you be in a mental institution?" might illustrate this type.

9.5.2 On the Basis of Terminal Behavior Characteristics

Unfortunately the question of the "flow model" has often in discussion become too closely bound up with the type of response reaction. The reason is, of course, that many branching programs have for practical reasons used multi-choice alternatives. This is certainly true of the well-known Crowder programs. Even if the connection as we have pointed out above is not logically necessary, it must be taken into consideration, since it is such a usual and simple one.

It is quite easy to find criticisms of the multi-choice technique. We have already referred to some of them in passing when we were discussing different media of presentation. The following criticisms are among those most frequently directed against the alternative choice method: (a) The student can be tempted to guess without thinking out the problem. (b) The knowledge registered is of a fairly passive kind. The activity he engages in can easily be superficial. It is so easy to tick an alternative or press an answer-button. (c) The correct answer can be obtained by means of elimination. That the student has eliminated a couple of obviously wrong alternatives, does not necessarily mean that he has understood the correct answer. The likelihood of being correct is often "unnaturally" great. A lucky guess or elimination also prevents the student from getting the benefit of the error treatment which would otherwise usually act as a corrective. (d) The continual reading of plausible incorrect alternatives can reduce learning effectivity. If we work with five alternatives, the student reads four times as much incorrect information as correct information. This can lead to unnecessary confusion for some students, at least in the early learning phases before knowledge is properly absorbed. (e) The use of the multi-choice technique can in certain cases also have a negative side-effect on the work of constructing the program. As the constructor thinks that he has guarded against error reactions from the student (by error treatment), he is perhaps less inclined to test the program empirically, to make error analyses etc.

Can the multi-choice technique be justified, in spite of objections of this sort? A study of the characteristics of the terminal behavior can be one deciding factor when answering this question. In many cases we prefer a more "spontaneous" solving of a problem as the behavior in the terminal situation. If so, it is also natural to make the same type of demand in the teaching situation. Not to demand a "self-constructed" solution in such a case often means setting too low a target. In other cases, however, it is sufficient for the student to recognize the correct alternative. For example, a doctor who reads a cardiogram should be able to distinguish between healthy and unhealthy curve patterns, but he need not necessarily be able to draw them. In other words, in cases where ability to distinguish between different complexes of stimuli is central (discriminatory learning), the multi-choice technique is admissible and natural.

It should perhaps be added, that the multi-choice technique in some instances only superficially indicates an immediate choice procedure. In some cases, for examples, the solution requires that the student, in order to be able to make his choice, first constructs a solution (as when dealing with more complicated problems of calculation). In these cases, the difference between both types of response should not be particularly great, and the risk of the student's remembering some of the incorrect answers is minimal.

Two things should, however, be borne in mind by the constructor. Firstly, there is nothing which says that a whole program must consist of multi-choice alternatives just because it is practical to use multi-choice alternatives in the checking didules (so that branching can easily be introduced in certain sections of program). There is nothing to prevent multi-choice questions being used at particular points to channel students into separate streams, while questions which demand self-constructed answers (taking into consideration the type of terminal behavior) are used in the other parts of the program. Secondly, it is quite possible to introduce branching on a basis of self-constructed answers (even if in some cases it can be less practical). A student who has given incorrect self-constructed answers to two or three questions may be branched off, for example, to a remedial section. One who has answered a couple of specially difficult questions of the construction type correctly can skip a section. One who gives a certain type of answer is directed to a special review, and so on. It should be obvious that these branching possibilities based on constructed answers exist, but the fact has sometimes been forgotten in the heat of the discussion for and against the special Crowder technique.

9.5.3 On The Basis of the Characteristics of the Target Population

Although the type of subject matter and terminal behavior are important facts to be considered in choosing the "flow model", the most significant factor is usually the characteristics of the group of students. If the target population is homogeneous as far as previous knowledge, intelligence, experience and interests are concerned, it is often natural to work with linear program. If it is markedly heterogeneous as to previous knowledge, checking didules should be inserted at an early stage in the course material and "remedial courses" given to those who lack the knowledge to proceed directly to the main matter of the course. If the group is very variable in intelligence, it is perhaps a good thing to insert, in certain sections, parallel branching with greater or lesser density of information. If there are subgroups with special experience and interests, one could similarly use branching to illustrate a particular problem from a variety of personally relevant viewpoints. Procedure in these and similar cases has already been outlined in dealing with the various models.

In this connection, however, we should urge caution. If one has observed that the group of students is heterogeneous and has for this reason introduced branching, one can sometimes be tempted to go too far in this direction and so do unnecessary extra work. This is perhaps not so true when it is a question of special previous knowledge. In that case it is often a fairly simple matter. Either the student has the previous knowledge and does not need to be taught it, or else he has not and must work through a special section. But the risk is more obvious when it is a question of different levels of intelligence. Although it is often quite true that a more intelligent student may go successfully through the program using fewer steps, it can sometimes be just as well to let the more intelligent go through every task all the same. The learning process is often more stable in this way and the time gained in performing fewer tasks in anyhow often minimal.

Box 9. 6 Motivation for choice of "flow-model" (after Cram, 1961, p. 65; cf. text above)

Here is the style I would consider first:

1. Household budgeting. I would use a branching program, because the rules for budgets vary with income and needs and therefore are not suited to a restricted linear approach.
2. How to mount a butterfly. This suggests a linear approach, since the procedure is fixed and would be memorized.
3. How to find the square root of a number. Again, I would try a linear approach for the same reason as in No. 2.
4. Methods of psychoanalysis. Here it would depend on whether it is a tabulation or a comparative discussion. In the first case I would try a linear approach, in the second a branching technique.
5. Should you be in a mental institution? One could have a lot of fun with this one - a branching program could consist of situations and a variety of ways of reacting to them, each branch leading closer to a self-imposed diagnosis!

9. 6 PREPARATORY STRUCTURING OF SUBJECT-MATTER

9. 6. 1 General Viewpoints

Some early empirical studies (such as, for example, Evans, Glaser & Homme, 1962; or Roe, 1962) showed that in general a carefully established sequence of subject matter can be instructionally more effective than a less carefully established one. But, in a way, this is self-evident. However, what we have little empirical knowledge of is which type of sequence arrangement is instructionally most effective for different purposes.

Most educational psychologists would nevertheless agree on some very general formulations about sequence of subject matter: (1) Complex concepts are usually built up of simpler concepts, and more complicated relationships often represent a combination of simpler relationships. Therefore a logical progression from simpler to more complicated phenomena is normally educationally more effective when it is a question of training a student to master a range of concepts. (2) Distributed learning often means longer retention, and integration and generalization are made easier if the student has the opportunity of working with a certain section of subject matter from different points of view and putting it in relation to a series of other subject areas. It is therefore often an advantage to use a "spiral" sequence (cf. Glaser, 1962 a), in which one deals with the easier sections of several parts of the subject matter before the more difficult sections of the same parts (as outlined very schematically in Figure 9. 10).

But although we can perhaps agree on such relatively generalized principles, we know too little about how to translate these principles into concrete arrangements. We are in many cases uncertain as to how far individual variations are important here. More applied learning research of a specific type would probably be useful here. It could be helpful to study the working sequences chosen by experimentees themselves when they have been informed of the terminal behavior the course is intended to teach. The experimentees should then be allowed to make their own decisions on the learning situation and to "steer" it sequence.

In certain cases such experiments are naturally not very fruitful, since students without previous knowledge of and with little interest in a particular subject area will probably often use a planless trial and error technique. Experiments with "student-steered" learning can probably never be a sufficient source of information. But they are definitely

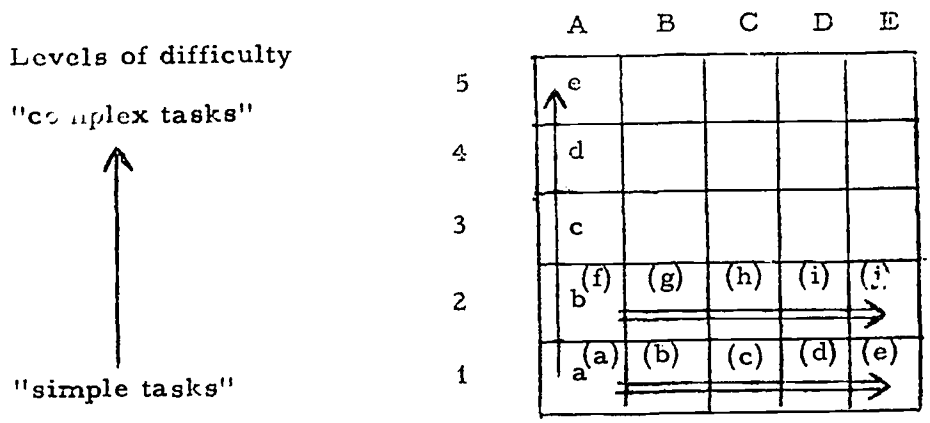


Figure 9. 10 Schematic outline of didactic "spiral progression"

"Simple difficulty progression" means that the student, in each separate part of the subject matter (A, B, C, etc.), goes from easier to more difficult tasks: steps a, b, c, d, and e. The single arrow shows such a sequence.

"Spiral progression" means that the student goes through all the requisite part areas (subject matter areas) at a low level of difficulty before going on to a higher level of difficulty: steps (a) to (j). This form of procedure is indicated by the double arrow.

worth trying, as far as research is concerned, taking into account the fact that most didactic experiments have been started in a very "dictatorial" way, with a number of rough-hewn types of sequence handed out by the leaders of the project, and their effectivity assessed afterwards by the average result. Programmed teaching is, of course, adapted to the students to a much greater extent than most conventional teaching metods, as the programs are revised as a result of empirical experience. But it would be even more adapted to the student, if the construction of the program could be influenced by the student at an earlier stage. This would presumably be useful both for the individual course and for our knowledge of basic teaching principles. One of those who have experimented along these lines is Mager (cf. Mager & Clark, 1964).

But even if the programmer does not at present know as much as we would like about the instructionally most suitable sequence of material, he is forced, like the lecturer, teacher and textbook writer, who are all faced with the same problem, to come to a decision about sequences and to do so from the best possible hypotheses. We have already dealt with a number of the relevant viewpoints in this chapter. The question of sequences pursues the constructor through several stages of his work and crops up in the following forms:

(a) Preparatory macro-sequence. The constructor must at an early stage make up his mind about suitable flow models and the main sequence of the total subject-matter. The has been the main subject of the present chapter.

(b) Micro-sequences. During the actual writing of the program a large number of micro-sequences must be built up, within the framework of the main sequence, for the successive learning of single concepts and functions. This procedure will be touched upon in the next chapter.

(c) Revision with special regard to sequences. After the first detailed work it is often advisable to carry out a series of checks regarding sequences: Have we sufficient and suitably spaced repetition? Have we provided for continuity? etc. Questions of this kind will be discussed separately.

(d) Revision of sequences during the try-out phase. The constructor naturally gets some idea of the effectivity of the sequence arrangement during the successive empirical try-outs of the study material on typical representatives of the target population. Re-arrangement of sequences may then be necessary because of error analyses and analysis of final results (cf. separate discussion).

9. 6. 2 Some Examples of Concrete Aids

Transformation and completion of the S-list and the C-catalogue: "Basic text", "didactic statements" and "examples". From the analysis of the subject-matter we obatined a C-catalogue (a collection of fundamental concepts within the subject area) and an S-list (a collection of "statements" about the concepts and their mutual relationships). The constructor can now "translate" these concepts and statements into a connected "basic text", i. e. a very brief, but complete text ("condensed textbook"). This gives the constructor one starting-point for his further construction work. At the same time it might be used for certain analyses of "information amount" and "information increase" (which we will not deal with in detail in this context; cf. , however, e. g. Weltner, 1971). Such a "basic text" may, of course, take on various forms. It might be given a fairly "target-free" character, whereby the emphasis is upon brief, complete information, written without consideration of any particular target group. But it might also be given a "target-directed" form. In this case the purpose is not only to get a connected text, but to "translate" the concepts and statements (from the C-catalogue and S-list) into "didactic statements" (DS), i. e. preliminary formulations more suited to the age and experience of the particular group of students. These should contain "critical words" which can be regarded as the kernel of the new information, around which the student's response in the didule should center. The individual units of information in the next stage of work can then be constructed using these "didactic statements" as a basis. In this case, it may sometimes be unwise, however, to complete this target-directed basic text (or DS-catalogue) at one time (especially if we deal with a very large subject-matter area), since one can get into the habit of making formulations in certain ways, which may not be practical bases for the writing of didules. It can therefore be advisable to work out only a part of this catalogue at a time and then try to translate that into didules before going on to develop it further. At this stage it is also desirable to collect numerous and varied "examples" of the main didactic statements.

Didactoplan. Each main section of the planned course contains several "didactic statements". The order in which these are to occur must be preliminarily established. It is natural at the same time to indicate possible branching as the course progresses. It can be valuable to illustrate this more detailed structure diagrammatically. We then obtain a relatively detailed flow-chart, which could be called a "didactoplan". The working sequence is indicated by arrows. It is perhaps as well to differentiate between those didactic statements which everyone could be expected to handle in the same way ("the main course"), those which will supplied to certain students only (extra or remedial courses), and those supplied in different ways to separate groups of students (parallel courses). Various geometrical symbols can be used, e. g. circles for "common" units, triangles for specially directed units, and squares for units which vary in form for different groups of students. (The chart thus obtained can, in addition to its function of assistance in the writing of the program - after due revision and additions - be used as a basic scheme for mapping the students' reactions to the course; cf. separate discussion below.)

The DS-catalogue (or target-directed basic text) and the didactoplan will be the direct starting point for the working out of the concrete details, which can now be started on.

10. WORKING OUT INSTRUCTIONAL UNITS: INFORMATION COMPONEN

10. 1 INTRODUCTION: COMPONENTS AND TYPES OF DIDULES

As we have already had reason to point out, in many self-instructional materials the "instructional unit" is characteristically made up of three main components: the presentation of new instructional information, the response request and the result indication. Our task now is to examine more closely a number of problems that arise when the designer of the material proceeds to transform his preliminary plans into concrete instructional units. We shall study each of these main components in turn.

We should, however, emphasize at the outset that the designer is by no means tied to working out a didule of this special three-component type (stimule + respule + corrule) even if this still may be the most common kind and in its pure form often exemplifies the problems that may be encountered in the self-instructional teaching situation. In other words, we can regard the three-component didule as a natural basic pattern which we should, however, be free to modify in various ways. This may apply to both "shortened" and "extended" didules (cf. Figure 10. 1).

"Shortened" didules, for example, can consist of instructional units without the corrule-component. In certain cases we may consider any separate result indication unnecessary, since the program is of such a type that the student is more or less certain to answer correctly anyway. Or by way of experiment we may wish to test the effect of various feedback patterns (in which the answer to certain sections is given but not to others). In other cases the "shortened" didule may lack any request for an explicit response. On the basis of a special test we may sometimes consider the implicit reaction to be equally effective and at the same time quicker. Didules that lack any proper new instructional information are quite common and with new response requests serve to consolidate further previous information.

On the other hand "extended" didules introduce new types of components. At present the most common additional components seem to be those that contain (a) a special instruction to the student (to move about in the program in a certain way, to study certain material outside the program, to operate his apparatus in a particular way or similar), or (b) an imitation request (the student is to repeat the answer in order to consolidate it further in his repertoire).

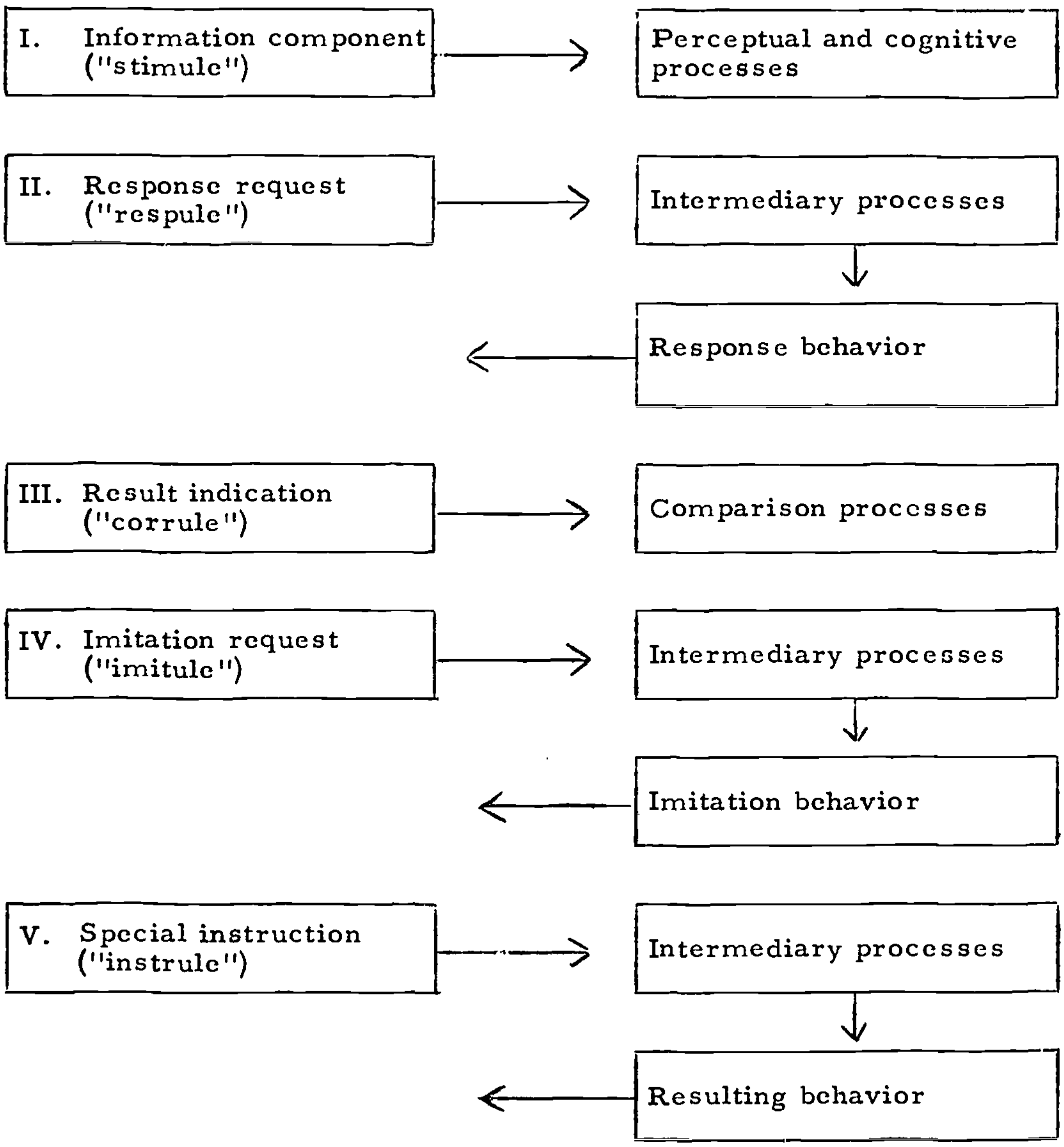
Instruction components are common especially in certain types of branching program, for example in the interplay between student and computer. In linear programs explicit instructions are rather rare during the course of the work: of course, the end of every exercise implies in some ways an instruction to go on further (to turn the knob or something similar). Imitation requests occur above all in those types of program where the border-line between a correct and an incorrect answer is less distinct (with the possibility of the continuous variation of "better and better" response reactions) and where the extra imitation stage therefore offers the opportunity of "polishing" the response behavior further. We probably find the most typical examples of this in language programs of the kind presented in our language laboratories.

A very common language laboratory didule (twin-track arrangement, cf. Figure 10.2) consists of four components: (a) stimulus material on the teacher's track, (b) response request, marked by an instruction + pause or simply a pause on the teacher's track (at which the student reacts on the student's track), (c) a model response given on the teacher's track as feedback together with (d) an imitation request, marked by a pause on the teacher's track (at which the student repeats the model response on the student's track).

It may be worth mentioning in passing that a "didule" ("instructional unit") in the sense indicated here does not necessarily involve simultaneous presentation. The didule is the program's contribution to a fundamental interactive unit: an interaction between the instructional material and the student, having a distinct initial-final character (the unit begins with the presentation of the information and the task, continues with the student "returning" his answer and most usually ends with the feedback of the program in the form of result indication). This instructional unit usually, however, corresponds to <u>two</u> presentations: as a rule components I and II are presented first (cf. Figure 10.1), and <u>then</u> either component III on its own or components I + II + III together. The term "frame" has sometimes been used in the sense of "simultaneous presentation" (a sense which, after all, is closest to its basic meaning), and sometimes in the sense of "didule". This varying usage is, as was indicated above, one of the reasons for avoiding this term and its closest equivalents in other languages. A concrete illustration of a didule with a typical two-stage presentation is given in Box 10.1.

An instructional unit
in self-instructional material:

Student reactions:



<u>Figure 10.1</u> Outline sketch of some part-components in an "instructional unit" (didule) in interplay with a student.

(Components I-III are fundamental, while components IV-V only occur in special contexts.)

TRACK 1 (model track)	Stimulus material ("stimule")	Instruction+pause or only pause ("respule")	Key answer ("corrule")	Pause ("imitule")
TRACK 2 (student's track)		Student's response		Student's imitation
	Phase 1	Phase 2	Phase 3	Phase 4

Figure 10.2 A typical four-phase didule in language instruction (twin-track arrangement).

Example:

The student's task is to put in "ne ... que" in affirmative French sentences.

Phase 1: Nous lui donnons 100 francs par mois.
Phase 2: Nous lui ne donnons que 100 francs par mois.
Phase 3: Nous ne lui donnons que 100 francs par mois.
Phase 4: Nous ne lui donnons que 100 francs par mois.

The student makes a mistake in his first response (phase 2), after which the answer (phase 3) is drilled in by the student repeating it (phase 4).

Box 10.1 Example of a didule, divided into two presentational units.

Presentational part A:

11. According to the National Board of Education's regulations the following applies to the size of the school site: "The size of the school site must be calculated on the basis of 1000 sq. m. per class when the school premises are developed to their maximum. In the central parts of towns the area can be reduced to 800 sq. m. and if the site is in or by a park, the use of which can be granted to the school, to a minimum of 600 sq. m. per class. For schools in towns intended only for the junior stage a site area of 500 sq. m. per class is accepted".	I Information section
How large a school site should be calculated according to the National Board of Education's directions for a school with combined junior and intermediate stages in central Malmö, which, when fully developed, is estimated to take 30 classes? Answer:	II Response request

Presentational part B:

Correct answer: 24,000 sq. m.	III Result indication
If you answered correctly, go on to exercise 15. If you answered wrong, go to exercise 12.	IV Special instruction

10.2 THE PROBLEM OF STEP SIZE

One of the most persistent refrains in the programmers' message has been the advice to work in "small steps". The principle of "small steps" is considered to be one of the very pillars of programming. Both theoretical reasons and empirical results suggest that there is also much truth in this. Smaller steps mean, among other things, a better focus on what is essential, more possibilities of activating the student, and greater ease in ordering suitable sequences.

What is correct as a main principle should not, however, hide the fact that in the discussion on programming this demand is more often made with parrot-like persistency that with analytical clarity and precision. What exactly is meant by "small steps"? How does one distinguish "small steps" from "large steps"? In other words how does one measure the size of a "step"? When challenged thus, the advocate of "small steps" will sometimes begin to falter. In any case it is easy to find in specialist literature widely differing opinions on how to assess what "small steps" are. It should be of advantage for the discussion if the existence of these alternative possibilities of assessment were more generally recognized and it were explicitly stated which of the possible points of view have been adopted in any particular case.

It may perhaps be wise to distinguish between "apriori"-criteria and "aposteriori"-criteria. The former represent view-points which can be applied to the program material as such without first studying individual students' reactions. The latter, one the other hand, are based on an empirical assessment. "Apriori"-criteria can in their turn be divided into two categories, linguistic-formal and conceptual-psychological assessment types. Let us take some examples of these various types of assessment.

(a) The number of words presented to the student in the didule is perhaps one of the most clear-cut linguistic-formal bases for assessment. Quite plainly the abundance of words in the units of the Crowder program is one of the reasons why most reviewers say that Crowder works with "larger steps" than Skinner. Crowder's stimule and respule phase as a rule takes up nearly a printed page, while the corresponding components in a typical Skinner didule take up only one or two sentences (for example, one stimule sentence and one respule sentence).

(b) The average length of response expected from the student is perhaps a somewhat less common, but quite feasable basis for assessment.

An exercise which demands that the student shall write down ten terms that are used in a certain field is, in a certain sense, obviously "larger" than one that only demands that the student shall tick one of ten given terms, the one, for instance, which does not belong to a particular field, even if the quantity of words presented to the student in the didule is larger in the second case. The assessment can, however, still be made on purely linguistic-formal premises.

(c) The number of response requests in relation to the number of new concepts or in relation to the number of new statements about concepts. It is evident that, when starting from a given number of units in the C catalogue and S list (cf. the section on subject-matter analysis above), one can construct a comparatively small or large number of didules. The more didules one has made, the smaller, in a sense, the steps must be. This is, then, primarily an example of a conceptual-psychological criterion. In this connection we should be able to speak of varying degrees of "concept density" (or more generally "information density"). When, in empirical experiments, the effect of the size of the step has quite simply been studied by starting with an already existent program and eliminating a certain number of didules from it (presumably those that do not destroy the sequence too much, i.e. review items and practice items) and then comparing the educational effect of the longer program (with "smaller steps") and of the shorter program (with "larger steps"), it is precisely on "information density" that the size of the step has been assessed. (Incidentally, these experiments have as a rule shown the advantage of comparatively small steps - in this sense - for the learning result. The longer program has, in other words, often been more effective with regard to the level of knowledge. But at the same time it has sometimes - but not always - taken more time, which makes the overall results somewhat less distinct.)

(d) The number of stages in the intermediary process between perceived response request and final response behavior. Usually we do not with any certainty know very much about what the intermediary process looks like in individual cases. It is, however, easy to establish that certain demands on the intermediary process are appreciably smaller than others. Sometimes it is a matter of the student just "copying" given information: repeating a phrase in a language laboratory, for instance, or writing down a new term. In other cases, however, a long series of intermediate activities have to precede the final response, as, for example, when the student's task is to solve a complicated mathematical problem. The more complicated the intermediary processes are, the larger, in a sense, is the step which the student is to take.

The four examples just given are all of the "apriori" type. Let us also give some examples of "aposteriori" assessments.

(e) The average working time of the student group per didule. The faster the students finish a didule, the smaller, in a sense, the step can be said to have been.

(f) Frequency of mistakes. When Markle et al. define a small step in the following way: "A small step is a step toward mastery that the student is capable of taking without making errors" (1961, p. 10), they obviously go entirely by the occurrence of incorrect answers, and they also separate large steps from small ones on an all-or-none basis. A small step is a step which the student is able to take; a large step is a step he cannot take.

(g) Reduction of mistakes after the addition of information. An interesting, but rather specialized interpretation is offered by Björkman (1963) when he asks himself whether by small steps is meant tasks with low empirical information value (small reduction of uncertainty). In order to assess this reduction of uncertainty one ought to investigate whether the student can give the correct answer to the response requests before the information section of the didule has been presented, and similarly whether he can do this after the information section has been presented. Tasks in which the difference between the frequency of correct solutions before and after the presentation of information is small may be said to imply, in a sense, small steps. In this case we can speak of small steps on the one hand when practically everyone is able to solve the exercise in advance, and on the other hand when practically no one can solve the task afterwards. Even if the suggestion that we should study the probability of the problem being solved before information is given, is in itself interesting, it is fairly evident that as a rule the programmers do not use the term in this sense. For if you use the definition discussed by Björkman, the best-designed programs obviously prove to consist of maximally large steps!

For the sake of illustration, let us look at our example of a didule in Box 10.1 above. Reasonably enough most people answer the question correctly. So according to Markle's conception mentioned above -

which is probably representative for several programmers - we are dealing with a small step. If, however, we first tried out the exercise without the information section and only asked how large a school site should be reckoned to be according to current regulations for a school of the type quoted, in typical target populations (without previous special knowledge of school building regulations etc.), we should probably receive extremely few correct answers. (We would otherwise have either removed the exercise after our first try-outs or included it in a "special branch".) Thus the "reduction of uncertainty" is likely to become large (perhaps from nearly 0 % correct answers before the presentation of information to nearly 100 % correct answers after the presentation of information). So according to the definition discussed by Björkman, our students have taken a large step. (Cf. further our discussion below.)

There is obviously an interesting field for research here: what is the empirical relationship between the various types of assessment of the size of the step, and what is their relationship to final effectiveness? Can a certain combination of assessments ultimately be shown in an empirical way to be particularly significant for instructional purposes?

10.3 THE PROBLEMS OF PROMPTING

10.3.1 General Character of Prompting

As we had reason to point out above (chapter 2), different types of stimuli occur in a teaching situation: focal, correlative, and unsystematic ones. Focal stimuli represent the central information which we wish the student to acquire. Correlative stimuli are of a "concomitant" nature. They are not intended to be drilled in but can illuminate the focal subject-matter and make it easier to learn. Unsystematic stimuli are various kinds of influence from the environment or in the subject-matter that can be classified neither as focal nor as correlative.

The effectiveness of the information component of the didule depends to a large extent on a suitable dosage with these types of stimuli. Most didules should contain vital focal stimulation - but no more than the student's attentiveness can cope with. Furthermore, the didule should contain as few unsystematic stimuli as possible. All superfluous material that serves no specific educational purpose should be removed. A moderate dose of "correlative" stimuli, on the other hand, is often valuable. These correlative stimuli not infrequently have the character of "hints", i.e. stimuli that make the correct answer more likely.

Historically speaking, the extreme frequency with which many programmers use the hinting technique or prompting is connected with Skinner's theories on behavioral shaping through the gradual reinforcing of certain elements in the already existent behavioral repertoire. The skilful animal trainer "shapes" the animal's behavior by rewarding the animal when it comes close to a movement that makes up an element in the desired behavioral chain. By systematically rewarding all desired behavioral elements one can gradually produce the entire behavioral sequence desired: the pigeon learns to walk in a figure - of - eight or to pick at tangents in a certain pattern. When these ideas were transferred to the programming of verbal material for human beings, it therefore seemed reasonable to regard as justified all stimuli that make the desired reaction likely. Once one has produced the correct reaction, one can in fact "reinforce" it and successively bring it out by more adequate means.

The point can also be formulated as follows: The student's terminal reactions must of course be given in their proper contexts and on the correct basis. But when one begins to teach the student the reaction in question, one may be satisfied with his being able to copy (repeat orally or copy out in writing) the correct answer, or with his being able to supply it when one has given him a start or with his being able to supply it in a context that is approximately right. Let us take an example from the world of the infant. Naturally one wants the child to be able to say the word "gee-gee" when a horse is really there. But at first the mother and father are exceedingly proud if the child can produce the word "gee-gee" at all by mimicking, or when it utters a happy "gee-gee" after the mother ha i en it a start with an encouraging "gee...". It is also great fun when the child starts to point at certain moving objects - whether they are dogs, cats or horses - and call them "gee-gee". But in the end one wants , of course, a more correct and precise terminal reaction. Then "gee-gee" has to be a horse and nothing else.

In programmed instruction (as of course in other teaching) we can often obtain in abbreviated form this gradual process of shaping and becoming more accurate which we observe in the child's way of dealing with our conventional world of symbols. When we want to teach our student a new, difficult term, we may perhaps let him just copy it using a model within his field vision. Then we may ask the student to remember it - at least from one didule to another and if we give him a start. We gradually teach him then to use it correctly, to start with in almost self-evident contexts (where the logic of the context does not allow many alternative solutions), but later in a more independent manner. All the technical moves we employ in the early stages of the learning process in order to make it easier for the student to produce the correct answer reactions (whether we do it by means of more formal tricks as in nursey rhymes, or by means of rather more logical aids) may be called by way of summary "hinting techniques" or "prompting".

Three main rules may be wort remembering when using these aids: (a) Do not give more prompting than necessary! (b) Whenever possible choose logical and meaningful hints rather than formal and mechanical prompts, and avoid mechanically repeating the same type of hinting technique! (c) Do not assume too much previous knowledge and too large a common background of experience when selecting illustrative prompting!

10. 3. 2 The Problem of Over-Dosing Prompting

The first rule mentioned may seem self-evident, but the fact is that prompting has often been regarded as such an integral part of programming technique that certain program writers seem to use special hinting procedures as a regular work-routine whether it is called for or not. Thus there are a number of programs that keep on and on informing the student which letter his answer-word begins with (or ends with) or how many letters it contains without the programmer seeming to have really investigated whether all these hints are necessary. As a rule it should be advisable to use only a minimum number of hints in the first version of a program and then to increase the hints only to the extent that the first empirical tests show to be necessary (for example, on account of a too high percentage of mistakes in certain exercises). Admittedly, it is easy by constantly giving hints to guarantee a low percentage of mistakes, but the latter is no end in itself. A too regular use of hints may accustom the student to a passive attitude in his studies and/or to a distorted kind of attentiveness (concentrating on the "form" of the instruction rather than its "contents") so that there may also be a risk of the overall benefit diminishing.

One way of not over-dosing the prompting can be to individualize it in such a way that the student first receives the opportunity to give his response reaction without prompting. A hint is introduced at a second stage. If the student does not succeed in answering correctly the first time, he can usually manage it the second time. But if he has already answered correctly, he does not need to bother about the hint, but can go on to the next exercise. This two-step technique (with no prompting until the second step) can be built systematically into a program and machines have even been specially designed for simplifying a two-step presentation of this kind (like the Didak 501").

10. 3. 3 Formal-Mechanical vs. "Thematic" Prompts

As our second rule suggests, over-dosing might well be particularly objectionable if it is a matter of formal and mechanical hints. These methods include underlining the most important words in the information section or stressing these words in some other way by, for example, printing them in italics, using capital letters or placing them in inverted commas. Special techniques of this sort are not in themselves objectionable, of course. Indeed they are sometimes particularly effective as focusing aids. But if such a procedure is used as a matter of routine so that the important words that the student is to reproduce in some form in his response are underlined in didule after didule, the risk arises that the student will quite soon adopt a special approach to the answers which is irrelevant to the subject-matter ("The idea is obviously that I am meant to fill in the words that are underlined in the text.") A response technique of this kind may give him many correct answei but little knowledge.

Programmers sometimes tend to show with some delight how it is possible to produce correct answers from a school child in very complicated fields that the child was not familiar with before. It is fairly obvious this is possible if one uses a hinting technique of this kind, but little is gained after all if one receives a correct answer which is not accompanied by increased knowledge or understanding. A very drastic example may perhaps make this plain. Read the following "complicated" exericise and try to fill in the right answers!

Example 10.1

The longer you let the TABLATE dismeliate in hexicave dacrane, the more difficult the adclosion of the plasylene becomes.

In order to facilitate the adclosion of the pl ..... ne it is therefore advisable not to let the T..... E dismeliate in hexicave dacrane for too long.

As in many programs the student's task is to fill in the missing words. First and foremost the first and last letters are given as hints. In addition the key-words are specially indicated (by capital letter and italics respectively). Did you succeed in solving the exercise? The correct answer should read, as the reader has of course seen, as follows: "In order to facilitate the adclosion of the plasylene it is therefore advisable not to let the TABLATE dismeliate in hexicave dacrane for too long." Fine! But did you understand anything contained in the exercise? There is every reason for your not having understood it since the sentences are strings of nonsense words.

This fact that one can perfectly well supply a correct answer without gaining any knowledge if the hints are too obvious should stand as a warning. We must beware of teaching our students to answer mechanically or on an incorrect basis. The habit of mechanically following hints instead of using critical reflection is after all the very opposite of what most of us want to teach. We do not want conformistic puppets that have learnt to respond according to a mechanical pattern. Instead we should try to promote critical thinking, power of combination and curiosity. But is it at all possible to achieve this with programmed study-material? I believe that one can do it, but I believe that it is very important to fight the frequent tendencies towards the mechanization of program production according to certain trade routines. Included in these trade routines are quite obviously the so-called "formal prompts", the mechanical and formal hints which may sometimes be justified, but which should never become a standard technique used in a routine way time and time again. This in no way has to mean that prompting is rejected altogether. It only means that one preferably chooses hints of a more meaningful character (sometimes called "thematic prompts"), hints that make use of empirical illustrations, analogies and logical connections instead of mechanical and formal tricks.

The following simple example adapted from a physics course illustrates this kind of more meaningful prompting:

Example 10.2

Now that we know that most metals expand or contract according to changes in temperature and that the oscillation rate of a pendulum depends on its length, we can expect that if there is a very great drop in temperature a pendulum clock ....

The two facts mentioned by way of introduction have presumably been taught previously. But in the special exercise the student is guided by logical prompting towards actually making a small "discovery" himself. Exercises of this type often lead to both better working technique (familiarity with logical and critical thought) and greater satisfaction. The degree of difficulty has, of course, to be adjusted to the students' knowledge and other background factors for we are naturally anxious that the student will really succeed with the exercise. We check this point especially in the test phase. If an exercise proves to be too difficult, we must take the prompting more obvious. The exercise quoted above about the pendulum clock becomes easier if, for example, we describe the background facts in greater detail and if we state more distinctly the alternatives which the student has to choose between:

Example 10. 3

We know that most metals expand when heated and contract when cooled. We also know that a short pendulum swings faster than a long pendulum. How is a pendulum-clock likely to be affected when there is a very great drop in temperature? Will it become too fast or too slow?
Answer: It will become ....

The exercise has now become easier without our waiving the rule that it is preferable to work with logical rather than with formal and mechanical methods.

One of the most natural types of prompting is the example. We recommended compiling, a rich and varying collection of example cards as an important ingredient in preparation work.

It is usually as well to give an example of every new "didactic statement" including the easiest of them.

Example 10. 4

To take the SQUARE of a number means to multiply the number by itself.

The square of 3 is equal to 3 x 3 or 9.
The square of 6 is equal to 6 x 6 or 36.
The square of 5 is equal to ... x ... or ...

Example 10. 5

Instead of writing out the words "square of" you usually write a small figure two to the right above the number you are to take the square of.

The square of 3 is thus written as 3^2

$5^2 = 5 \times 5 = 25$

$7^2 = 7 \times 7 = 49$

$4^2 = .. \times .. = ...$

Of course it is possible to give the same information by means of a shorter procedure and without the prompting contained in the examples, as here for example.

Example 10. 6

To take the SQUARE of a number means to multiplay the number by itself. A small figure two is usually written to the right above the number you are to take the square of.

$4^2 =$ ....

It is however, clear that the percentage of mistakes in the latter case (among students who did not previously know the concept concerned) will probably be considerably greater and the instruction is also likely to be less effective when measured by retention over a period of time. Not infrequently the program writer feels detailed exemplification to be "repetitive" and "childish" because he is himself well-versed in the matter. The program reader in the particular target population often feels the exemplification to be necessary and interesting. But this is difficult to judge in advance. Only empirical testing can show definitely what the students' reaction is.

In some cases one can make a simple additional branch of the "fast track type" (cf. chapter 9 above), i. e. let the students that require them have more examples than the others. Box 10. 2 gives an illustration of this kind of procedure. In somewhat modified it reproduces a piece of an American demonstration program. In this case the student learns by means of examples (item 2 and 3) a special trick in mental arithmetic, aided by a careful step-by-step explanation. In conjunction with item 3 he receives special instruction. Anyone who thinks he can now manage arithmetical exercises of this kind on his own is sent on to item 6 in which this ability is tested. Anyone who feels uncertain is instead given some more demonstration examples first with more detailed (no. 4) and then with less detailed (no. 5) prompting. If a student who has gone straight to item 6 finds that he has estimated his skill too optimistically (in other words if he makes mistakes), he is sent back to more practice examples. (The program example given in Box 10. 2 is only intended to illustrate the possibility of providing examples in a differentiated way and not to constitute a model in any other way. In many cases one does not want to stop at a superficial presentation of a trick in mental arithmetic, but to try to give the student insight into why the trick works.)

The third rule for prompting we gave above was that one should not assume too much knowledge or too much common experience. This is of importance especially when giving examples. After all, the examples are to be gateways to new knowledge as the student passes from familiar to unfamiliar material, from concrete to abstract material. But it is of course important that what one assumes to be familiar is in fact familiar. Otherwise the examples are of no help but an unnecesssary difficulty. Here one must keep one's eyes open for individual variations in background experience and not use illustrations that can only appeal to part of the target population. In this case, too, trial testing will show to what extent one's choice has been successful.

10.3.4 Linguistic-Semantic Prompts

We have chiefly touched upon two main types of prompts: on the one hand those we have called formal and mechanical (for instance, the first letter of a word or a number of letters in a word and on the other hand more meaningful hints in the form of examples or logical conclusions - so-called "thematic" prompts. A third main type can be said in a way to come between these two: linguistic-semantic prompts. The latter make the response easier by reducing the number of possible answers with the aid of the structure of the language. In this case it is a matter of making an appropriate choice. One should avoid both sentence structures that are too "open" and allow for too many possible answers and do not therefore clarify the problem, and sentence structures that are too "closed", leaving too few possibilities open and therefore coming close to mechanical hints. Look at the following examples!

a) Cold air ....
b) Cold air moves in a (n) .... direction
c) Warm air moves upwards, cold air ....
d) Warm air moves upwards, cold air .... downwards.

We can probably agree that the first phrase, a, leaves too many answers open. We risk the student's simply not knowing what we want. "Cold air is found in the mountains", for example, is after all a conceivable answer. Most of us can probably also agree that the last phrase, d, leaves too few possible answers so that we receive a pseudo-answer of doubtful value. In this case, however, some programmers are of a different opinion and use this type of sentence without any further ado following the maxim "everything that produces a correct answer is permitted". The two other examples, b and c, represent an intermediate degree of "answer guidance". The number of possible answers is smaller than in a, but an incorrect answer is possible. In the concrete case the particular choice should, of course, depend on what precedes and follows it in the program (i. e. what knowledge there is and in what way one intends to continue the line of reasoning).

When it is a matter of teaching new systems of symbols (for example, foreign languages), one can utilize the "redundancy" of the linguistic-semantic system for educational purposes. A very specialised but interesting demonstration of this has been given by Schaefer (1963). The procedure is based on the fact that most verbal expressions contain "redundant" (theoretically superfluous) parts which can be removed without any real loss of meaning (something that we do, for instance, when writing telegrams). These parts can, for example, be replaced by nonsense words without the student losing the meaning of the text. If instead of the nonsense words we put in corresponding words in a foreign language and do this in a systematic manner these foreign words should gradually take on the correct values of association. In other words the student learns to foreign words by seeing them used over and over again in their correct context. "The context" becomes the actual prompt for what we wish to teach. What is characteristic of this technique is among other things not presenting the foreign words to start with as focal stimuli for drilling. They are instead relatively unimportant correlative stimuli in the student's world of experience. This is where the difference lies between this kind of prompting and more usual types of "thematic" hints in the form of examples or logical argument.

Schaefer's procedure was of the following nature: The students who were to learn German were given thrilling detective novels by Poe to read. In these certain of the words in the native language (English) were exchanged for corresponding words in the foreign language (German). In an initial phase this was done very cautiously. It was only a matter of odd words that bore little meaning (for instance, articles and pronouns). In a second phase the foreign elements were increased in number. Among other things the special foreign word-order was introduced. It was thought, however, that the students would be so fascinated by the tale that they would continue reading although the text was now somewhat more difficult. In a final phase further foreign elements were introduced including central, significant words. Short textual excerpts from the three phases are given as examples in Box 10. 3.

Obvious objections to a technique of this kind are, of course, that the linguistic structure often becomes artificial and that pronunciation instruction is neglected in Schaefer's arrangement. Both languages also have to be comparatively "isomorphous" (have a comparatively similar structure) if the technique is easily to be applied. But one cannot escape from the fact that the students learnt a not inconsiderable German vocabulary in a short time by this method (which Schaefer was easily able to prove by means of tests afterwards), and that they did this without any feeling of having used up energy to learn something new. Several of them even asserted that they had not learnt anything (they had only read a thrilling book!) and they were themselves surprised at the result of the test. - Plainly a technique of this kind which systematically utilizes linguistic "redundancy" in prompting, is worth further research even if in its present shape it would hardly be acceptable for more general use in language teaching.

The types of prompting discussed here - syntactic guidance, formal and mechanical provocation and logical hints of meaningful content - are often used parallel to one another whereby the increased "context specification" at the same time means a reduction of the number of possible answers ("field of choice"). A theoretical illustration of the gradual restriction of the field of choice when introducing new stimuli in a response request complex is given in Box 10.4. The smaller the logical field of choice is, the greater the "potential strength" of the prompting can be said to be. The real strength cannot, of course, only be presumed on the basis of logic since this also depends on the student's individual cognitive field. Even potentially very strong prompting becomes psychologically ineffectual if the student does not possess the right background experience.

Box 10. 2 Fast track arrangement for the variation of prompting (more or less exemplification for different students).

1.	We shall now teach you a trick in mental arithmetic that enables you quickly to work out the square of a two-figure number ending in 5. When you have gone through a couple more exercises you will be able to say what 55 x 55 or 95 x 95 are in a few seconds. Go on to the next exercise!	
2.	You can work out what 35 x 35 is in the following way: a. First note between which multiples of tens the number 35 comes. It comes between 30 and 40. b. Multiply these two multiples of ten: 30 x 40 = ... c. Add 25 and you get the final answer ...... Don't you believe me? Check it in the usual way!	2 b. 1200 2 c. 1225
3.	Now try with 65 x 65! a. 65 comes between the multiples of ten .... and 70 b. Multiply these numbers: ..... x ..... = ... c. Add 25 and the final result is .... Can you work out in your head what 45 x 45 is? Or what 85 x 85 is? If you can, go straight on to exercise 6. If you feel uncertain, continue with exercise 4.	3 a. 60 3 b. 60 x 70 = 4200

Box 10.2 (continued)

4.	You multiply 45 x 45 in your head in the following way: a. 45 comes between two multiples of ten, i.e. between ...... and ...... b. When you multiply these multiples of ten by one another, you get the number ...... c. When you then add 25 to this number, you get the product of 45 x 45 or the number	4 a. 40,50 4 b. 2000 4 c. 2025
5.	55 x 55? a. 55 comes between the multiples of ten ......, and ..... b. Multiply ...... by ...... and you get ...... c. Add ......, and the final results is	5 a. 50,60 5 b. 50,60 3000 5 c. 25 3025
6.	Work out in your head! a. 15 x 15 = ... b. 85 x 85 = ... c. 95 x 95 = ... If you have made a mistake, go back to exercise 4!	6 a. 225 6 b. 7225 6 c. 9025

Box 10.3 Utilizing linguistic redundance in prompting

First phase:

"True! - nervous, very, very dreadfully nervous, ich had been, and am; but why will you say that ich am mad? The disease had sharpened meine senses - not destroyed, not dulled them. Above all was der sense of hearing acute. Ich heard all the things in dem heaven and der earth. I heard many things in hell. How, then, am ich mad? Hearken! Und observe how healthily - how calmly ich can tell die whole story."

Second phase:

Der second und third day went by und yet showed himself mein tormentor nicht. Again could ich as free man breathe. Das monster was apparently in great terror run away! Never again would ich es see! Meine happiness was complete! Die guilt der black deed disturbed mich but little. Some questions were asked und readily answered. Eine search was even undertaken, but, of course, could nichts be found. Ich looked einer safe future toward."

Third phase:

Die slope seiner Wände wurde von Moment zu Moment smaller, und der bottom der Vortex seemed sich gradually zu lift. Der sky war klar, die Winde hatten sich died, und der moon went brightly im Westen down, als ich mich auf dem surface des Ozeans facing die coast von Lofoden found ...."

Box 10.4 The potential strength of prompting stimuli as a function of the number of possible choices: Theoretical illustration.

By adding new stimuli to a response request complex, we can limit the number of reasonable possible answers. Different types of stimuli often combine in reducing the field of choice. The examples below (which in themselves are hardly instructional models) provide a theoretical illustration of this situation:

a) In 1964 both .... and .... were shown in New York.

Type of prompting: (i. a.) syntactical structure
Field of choice: noun

b) In 1964 both Ma .... and Mu .... were shown in New York.

Type of prompting: syntactic and formal
Field of choice: nouns beginning with Ma and Mu respectively.

c) In 1964 both .... and .... were presented by the Old Vic Company in a special performance in New York.

Type of prompting: syntax and specific category of contents.
Field of choice: nouns connected with the Old Vic Company.

d) To commemorate Shakespeare in 1964 both .... and .... were presented by the Old Vic Company in a special performance in New York.

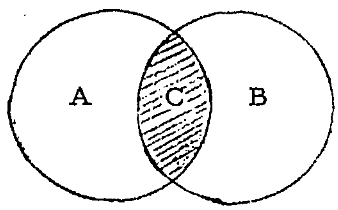
Type of stimulation: syntax and two categories of contents.
Field of choice: nouns connected with the Old Vic Company and with the commemoration of Shakespeare (probably dramas by Shakespeare).

e) In order to commemorate Shakespeare, in 1964 both Ma ..... and Mu .... were presented by the Old Vic Company in a special performance in New York.

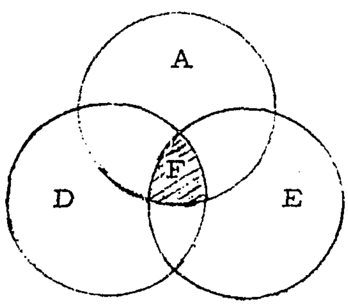
Type of prompting: syntax, form, two categories of contents.
Field of choice: nouns beginning with Ma and Mu respectively, connected both with the Old Vic Company and with the commemoration of Shakespeare (intended answer "Macbeth" and "Much Ado about Nothing").

Box 10. 4 (continued)

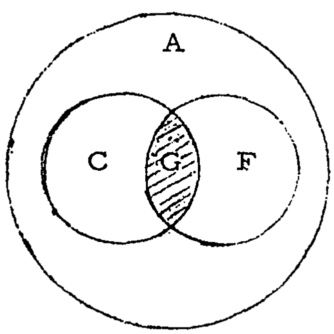
The reduction of the size of the field of choice can perhaps be seen most plainly in a few diagrams:



A = noun
B = words beginning with Ma and Mu
C = nouns beginning with Ma and Mu (field of choice in version b)



A = noun
D = something relevant to the Old Vic Company
E = something relevant to the commemoration of Shakespeare
F = nouns that are relevant both to the Old Vic Company and to the commemoration of Shakespeare (field of choice in version d)



A = as above
C = as above
F = as above
G = nouns beginning with Ma and Mu respectively, relevant both to the Old Vic Company and to the Commemoration of Shakespeare (field of choice in version e)

10.4 FADING TECHNIQUE

Our example in Box 10. 3 of the use of linguistic redundancy illustrated not only prompting but also gradually increased demands. The concepts "vanishing" and "fading" (sometimes used in the same sense, sometimes with different meanings) have played an important role in the American discussion on programming technique. We have to note that this fading can refer to both the prompts (fading of non-focal stimuli) and the central instructional material itself (fading of focal stimuli). Both methods can have good instructional effects.

The fading of non-focal stimuli becomes particularly important if they are of a mechanical and irrelevant nature. If in some connection it has been thought desirable or necessary to encourage the correct answer by means of technical devices, t may then be important to guarantee that the student also learns to give the correct answer without the help of such mechanical aids. But even when one uses more meaningful prompts it is important gradually to fade away aids in reasoning, for example, so that the student can then quickly give the correct answers on his own.

In these latter cases fading consists quite simply of a gradual shortening of the explicit chain of reasoning. This is often a central task for the "micro sequences" that one tries to construct within the program when one ntroduces a new concept or a new didactic statement. Each concepts is usually introduced by means of a small chain of didules. The chain is, then, started by relatively detailed didules where the response request is easy to fulfil with the guidance of the material that is actually found in the information section concerned. Then this prompting is gradually decreased so that when the student has reached the end of the chain he can manipulate the new content on his own as he wishes without the help of prompting information. (The three latter exercises - 4, 5 and 6 - in Box 10. 2 above illustrate a very short chain of this kind. Exercise 4 gives ample prompting, exercise 5 less, and in exercise 6 the student has to manage on his own. All assistance in reasoning is removed.)

The fading of focal stimuli has a partly similar function, but is mainly used when we are concerned with whole structures of focal stimuli simultaneously. In such cases one part of the structure can be said to support another. A technique of this kind may be suitable for drilling in a comparatively large amount of material with a distinct overall structure: a poem, a geographical map or the like. The poem can be learnt by heart from a series of successive presentations, in which the student always reads out the whole text, but where the material presented is reduced by degrees. At first only a few odd, redundant words are removed, then more meaningful words and finally whole lines.

Usually the fading takes place in stages, during which the student's attention is directed towards central parts of the existing structure while having to answer questions. In such cases one frequently uses a bundle of "information appendices" to the program, both because the actual maps or diagrams are often unwieldy and thus not suitable to be fitted in a normal way into the information sections of the didules and because an individual map or an individual diagram frequently has to be used in a whole series of didules. Let us give a concrete example: our student is perhaps to learn by heart a road map of Central Europe. As an aid he has both a number of map appendices for the area and a "work book" with continuous didules in which questions are asked and answers are to be written in. The first map appendix is a detailed reproduction of the main roads and cities of the area with names and cartographic symbols clearly marked. The student becomes familiar with the map by answering questions in a series of didules about the relations of different places and roads to one another and about their position in relation to certain geographical key points (rivers, mountains etc.). Then he is directed to a different map appendix. On this one quite a number of the names have been removed. The student answers new questions and now he has to put into action knowledge acquired by memorizing as well. At a third stage he receives a map with even less information etc. Finally he perhaps works with a skeleton map on which only certain country boundaries or basic geographical indications are left. But by now it is quite probable that he has mastered the map, acquired a "cognitive map", i. e. that he has "learnt" the area.

10.5 SOME OTHER POINTS ON THE CONSTRUCTION OF THE INFORMATION COMPONENT

Apart from the points alreadymentioned about the size of steps, prompting and fading, many other points - both very general and very specialized - about the information component could be referred to. We shall, however, content ourselves with giving a few pieces of practical advice:

(1) Introductory information. The first piece of advice could be formulated in the following way. Do not forget that the students are often confronted with a new and previously untried instructional situation! Try to arrange an introductory section that teaches the student the special work technique required and that accustoms him to the new method of working.

(2) Information focusing. Do not present more new information in a particular didule than the student can manage to absorb! The inexperienced programmer is likely to "lecture" rather than give instruction in stages. He collects too many facts in one complex unit with the result that the student does not notice and work with more than part of the information. Sometimes programmers have been advised never to present more than two new facts in one didule or never to write didules with more than two sentences or more than 50 words long. Such rules of thumb ought, however, to be taken with a large pinch of salt. In certain types of program they may possibly serve as a reminder of the need for information focusing, but they should of course never be regarded as absolute norms. External limits to the size or content of didules cannot possibly say anything about the instructional value of the didule. Different groups of students and different goals often require completely different methods in these respects. Research findings showing that didules of more than two sentences or more than 50 words cannot function well do not exist.

(3) Focus on differences. A piece of advice of a more specific nature is that, when it comes to teaching the student to distinguish between different complex stimuli, it is probably more efficient usually to present the distinguishing details of the different objects together (simultaneous difference presentation) than to present the complete objects separately (separate object presentation). The former method means a cleaner focus on the differences the student is to be able to distinguish in the terminal situation and therefore it probably often means better conditions for a behavioral transfer to a comparable situation in reality.

To take a concrete example: if the student is to learn to distinguish between a number of different plants (easy to mix up for anyone who is not used to them) it is probably less efficient to present them in pictures one after the other with descriptions of their characteristic features attached, than to present their distinguishing details side by side (for example one picture of the shapes of the leaves of the plants, another of the position of the flowers on the plants etc.)

(4) Student-adapted language. Use language that is well-adapted to the tar ' population! Certain programmers give the advice that one should examine the readability of the language with the help of some of the current standard formulas (cf. Fry, 1963). Words with several syllables, sentences with many words and words that are not among the most frequent ones of the language then give an index of decreased readability. But even if such standard guides can sometimes be of some interest one ought to avoid applying them as a routine. It is certainly not always the short word or short sentence that gives information most precisely or with the best educational efficiency. And above all: we do not by any means want to stick to the 3000 most frequent words of the language. How should we then ever go beyond the children's stage in our instruction? How should we then be able to teach in subjects with scientific terminology? What is important in programming is of course not to introduce new and difficult words without explaining them and testing whether the explanations are adequate for the target population in question. Anyone who has heard ten-year-old boys discussing motor cycle engines and types of aeroplanes with a most advanced terminology and great competence, understands that it is not the brevity or average frequency of the word in the language that decides its fitness for use. More decisive is the interest in the subject and the "individual frequency" of the word -- factors that a good program has a considerable chance of influencing.

(5) Balance between inductive and deductive forms of presentation. The designers of the Ruleg system (cf. above) are of the opinion that one first ought to present a rule and then illustrate it. In their experience it leads to the most rapid acquisition of knowledge. In many contexts this method is also quite natural. At the same time we should not, however, forget that speed in learning is often not our only goal. We are often anxious that our student shall learn a good work technique with interest and skill in "discovering principles". For that purpose the

opposite method is probably more suitable usually. Through a series of examples we lead the student towards formulating his rule or at least an approximate rule on his own. A combination of the two methods is probably often to be recommended. An alternation between deductive and inductive strategies also diminishes the risk of monotony in the program.

11. WORKING OUT INSTRUCTIONAL UNITS: RESPONSE REQUEST AND RESULT INDICATION

11.1 THE RESPONSE REQUEST

We have already had reason to give certain views on the construction of the response request, both when discussing the coice between different flow models and when discussing the information component. In this section we present a few pieces of advice by way of summary together with some additional comments.

11.1.1 Overt vs. Covert Response Behavior

The external, overt response reaction plays an important role in the arguments used by e. g. Pressey and Skinner. There is no doubt that programs with external response reactions have often shown to be very effective. But is such an external response reaction necessary? A series of studies in which programs with and without external response reactions of this kind have been compared does not seem to give a clear affirmative answer to this question. Students can obviously learn from programmed material without writing out answers - something, incidentally, that only astonishes a few stubborn dogmatists.

On the other hand, we have to reckon with a series of "positive side effects" of the external response reaction (quite apart from its importance for immediate instructional effectiveness): (a) In the long run it can be an aid in holding the student's attention and providing motivation. It can also be an external guarantee that the student will not remain, completely passive. (b) It provides us with continuous achievement reports on the work of single individuals which are of value for individual diagnoses and individual guidance. [1] (c) The achievement data gives us a good basis for the further development of the instructional material, as it easily reveals on which points the latter has been less efficient. (d) For certain students who easily overestimate their ability to learn and (e) for certain types of exercises such as, for example, manual-perceptual ones, the external response reaction is probably of special value.

Thus our final word of advice on this subject is: when any of the five special points mentioned apply to the concrete instructional situation, it is probably wise to work with overt response reactions. In other cases, however, attempts with implicit response requests may very well lead to

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1) The value of achievement reports for individual diagnoses has been heavily stressed, and it has even been claimed that the systematic use of such reports would be a valuable alternative to current intelligence tests, among other things, making prognoses of success at school (cf. Sorensen, 1963).

equally effective instruction (and probably also to the material being dealt with more quickly). This is, however, a field in which more research plainly needs to be done. Obviously, the decision depends on a series of other factors, such as, the degree of difficulty and relevance for the terminal behavior of the response requests (cf. Box 11.1, se also Cook, 1962 a).

11.1.2 The Meaning of Errors

A common piece of advice is that one ought to formulate the response requests so that the percentage of errors is kept low, according to certain programmers below 10 %, according to others as close to 0 % as possible. The reason for this is, among other things, that one wants to create a positive climate of learning, where the negative and external motivation for working (working to avoid discomfort, for example, in the form of low marks or the teacher's disapproval) is replaced by a positive and internal motivation for working (working because it is fun, because it is satisfying to take new steps forward, to succeed). Thus one avoids, it is thought, both a general anxiety that at least in certain cases can lead to impaired intellectual achievements and the risk that the negative atmosphere also infects the readiness for and interest in instruction in general (with a resultant, more general unwillingness to study).

Another argument wich is usually put forward is that it is better to get the correct answer immediately which one can then strengthen and refine further, than to start with an incorrect answer that one then has to 'work away'. Many proponents of programming have claimed the importance of keeping the percentage of errors down, including Skinner. Others, however, like Pressey and Crowder, are of a partly different opinion (Crowder uses, as we know, systematic error instruction in his programs).

There is probably a lot of truth in the arguments in favor of low error rates, and certain studies also indicate that a high percentage of errors within a program leads to decreased effectiveness. It is a common layman's reaction to self-instruction programs to say that the exercises are "too easy". This reaction is the result, among other things, of confusing the aim when writing a didule in a program with the aim when writing an examination question. The purpose of the examination is to decide the knowledge level of the individual, i.e. what the student has already learnt. The main purpose of de didule, on the other hand, is in most contexts instruction and not checking instruction. If one judges the kind of didules that most students can deal with immediately as being too easy, one ought, to be consistent, to judge those passages in a lecture that a sufficiently large number of people

Box 11.1 Type of response, information level, and terminal relevance - an experiment

REF.: Eigen, L.D. & Margulies, S.
Response characteristics as a function of information level.
Journal of programmed Instruction, 1963, 2 (1), 45-54.

PROBLEM:

Skinner and others have laid great stress on the student being allowed to give "external" (overt) responses to the study material. Investigations in which comparison has been made between the effectivity of programs where the student has given "external" (overt) responses (usually in a written form) and programs where the student has only given "internal" (covert) responses have, however, not given clear evidence of "external" responses necessarily being more effective. Different investigations have come to different conclusions on this point. Could the position possibly be that the problem of the "external" or "internal" type of answer has to be seen in relation to some other variables if anything more definite is to emerge about the effectiveness of the type of answer? Might, for example, the degree of difficulty of the material (or the "information level") be of importance in this connection? Is the relevance of the response request to the terminal behavior of any importance?

METHOD:

Three major variables were studied:

a. overt versus covert responding (half of the group of students had to give written answers, the other half was instructed only to "imagine" the answers),
b. information level (part of every student's instructional material had a "high", part of it a "medium" and part of it a "low" information level), and
c. the terminal relevance of the response request (some of the questions in the test concerned things to which the students' attention had been immediately drawn in the program through response requests, while other questions concerned things that admittedly had been presented in the program, but to which no response requests had been linked).

"The information level" was defined by the authors as a measure of the "information" required to make a decision, and was computed as a function of the number of alternatives from which the decision is to be made. This can be said to be a way of operationally describing an aspect of the degree of difficulty in a piece of material. The study material used was very specialized and consisted of drilling in combinations of letters. Meaningless combinations of consonants (ZBX or VRT) could then be said to have a "high information level" or to represent "difficult" material (the number of possible combinations of letters is large), whereas meaningful words of a certain form (CAT, FAT, HAT) could be said to have "low information level" or to represent "easy" material (the possibilities of choice are relatively few).

SUBJECTS:

362 students from the U. S. grade seven and eight.

RESULTS:

The main result was that "external" responses proved to be superior to "internal" responses in certain cases, but not in all. The "external" reactions were superior only when the response requests in the didules where the information was presented, were terminally relevant. In other words: if the student's attention was not focused by the response requests to the material that was relevant for the terminal test, it was of little importance if the type of answer was external or internal. But the more distant the new material was from the students' repertoire (that is to say the more difficult it was), the more important the requirement of an overt response seemed to be for educational effectiveness.

DISCUSSION:

If the results can be shown to be valid for types of subject-matter other than the relatively specific material the authors of this paper had worked with, the conclusions could be of importance for clarifying a few somewhat obscure points in the theory of programmed material. The varying results in different studies where one has examined the value of "external" responses might very well depend on these investigations having insufficiently taken into consideration the influence of the information level and the terminal relevance.

The studies that have not found external responses instructionally more effective, can thus be thought to have worked with programs of relatively low information value and/or programs with response requests with relatively small terminal relevance.

Apart from this, the results can also have more specialized practical consequences for program designers. If a program contains material of a highly varied information level, it may be desirable to use different types of response requests (external reactions only where there is more difficult subject matter). It is also conceivable that the group's acquaintance with the terminology and problems of the field fluctuates a great deal and that this can be a reason for working with parallel tracks where only one group of students - those having less experience in the field - is working with external response reactions.

Finally it ought to be stressed that the study material used in the present experiment was both very short and of an extremely specialized nature. Before drawing too extensive conclusions from the experiment it would therefore be desirable for the problem of the type of response, information level and terminal relevance to be studied from other points of departure (with different curricular material and with other operational definitions of the degree of difficulty or information level).

do not misunderstand as being too easy!

On the other hand, one should of course not stress the demand for a low percentage of errors so heavily that one thinks evercthing is perfectly all right when one has reached that goal. It is easy to keep the percentage of errors down if one is satisfied with correct answers given after too strong prompting or if one forgets the demand for the retention of knowledge. Some incorrect reactions can undoubtedly be of educational value if they are followed by the student's directly seeing what he must have done wrong or by an explanation. The distribution of errors is the often more important than the average percentage. Occasional demanding items which thus produce errors can sometimes be useful for the progress of the learning process, whereas continuous groups of exercises that the student fairly constantly answers incorrectly probably more often than not have a negative effect on the climate of learning.

11.1.3 Constructed Response vs. Multiple-Choice Responses

We have already discussed above some of the disadvantages and advantages of multiple-choice responses. We then stated that the use of multiple-choice responses as a matter of routine throughout whole programs can have basic disadvantages. The students are easily tempted to guess, they can get the correct answer by means of elimination, they are forced to read through plausible error responses, and they sometimes do not have to be able to show more active knowledge. We also pointed out, however, that the question has to be seen in relation to the relevant terminal behavior. If terminal behavior requires descrimination it may be natural to use multiple-choice responses in the program. We ought perhaps to add in brackets that the connection with the terminal behavior should not be regarded as a final factor in our decision (in one research experiment it was possible to teach children to write through perceptual multiple-choice training!). Our most important statement was perhaps that we by no means have to limit ourselves - as many programmers seem to have done - to working through whole programs with the same response technique. On the contrary, the different methods probably complement each other in many contexts in an excellent way.

Thus it may be natural to work with self-constructed responses as a main method (and generally speaking it encourages less guess-work and is more demanding), while at the same time one inserts multiple-choice exercises as soon as there seem to be special reasons for doing so.

Sometimes multiple-choice exercises may for example make the "sorting" of students easier at the branching points within the program. Students who choose one alternative obtain one type of continuation, whilst students who choose a different alternative are directed along a different path.

In certain connections the multiple-choice technique can be used for purposes of <u>dramatization</u> (when the answer in itself is fairly obvious, but where the choice can contribute directly to the student's attention towards some striking aspect; Basescu, 1962):

<u>Example 11.1</u>

Which is simpler to write?

a. 8+8+8+8+8+8+8+8+8+8+8+8+8+8+8 = 120

or

b. 15x8 = 120

A very natural use is to let the multiple-choice technique <u>focus the answer</u> on the aspect one is interested in. We have already had reason to demonstrate that the linguistic structure can be "open" in different degrees, in so far as it can offer varying numbers of response possibilities. Look at the following three versions of a response request:

<u>Example 11.2</u>

Version a
Crowder has published ________________ programs than Skinner.

Version b
Crowder has published m_re programs than Skinner.

Version c
Crowder has published________________(more/fewer) programs than Skinner.

The first version is obviously too "open", i.e. it makes too many interpretations possible. We run the risk of obtaining too great a number of varying types of answer: "longer", "better", "worse", "with more words" (the correctness of which is sometimes difficult to judge) besides the answer ("more") that the programmer thought of. The second version is on the other hand too "closed". Response requests of this type are unfortunately not all that uncommon in published programs, but usually give the student too easy a time. The third version on the other hand has by a simple device utilized the choice technique to focus the response on the desired fielt <u>without</u> thereby reducing the degree of difficulty to the level of pseudo-response.

11.1.4 Relevance

The response request ought to be relevant - both for the didule in which it occurs and for the criterion behavior that we want to arrive at. It is especially against the latter important rule that less experienced program writers sin. They have admittedly learnt to "cut holes" in sentences, but not always to place these holes in a meaningful way. It is easy to produce something that "looks" like a program. It can be made with scissors and glue if we cut a text-book into twosentence pieces that we call "frames" and in every two-sentence piece of this kind cut out a word that we place in the margins and call "reinforcement"! It is not unlikely that some pseudo-programs have been constructed in a somewhat similar way - in cosy teamwork over a late-night supper. Our procedure recommended above of starting with didactic sentences with specially marked key-words can be <u>one</u> aid in the designing of criterion-relevant response requests.

As Holland, among others, has shown (by working with different versions of his and Skinner's psychology program) it is quite possible that one and the same basic didule text can be of entirely different educational efficiency depending on where the "hole" is made. If we demand student reaction to trivial words, we get a low percentage of errors. If we demand student reaction to non-trivial but unprepared words, on the other hand, we obtain a high percentage of errors. But in both cases the probability of obtaining a positive instructional effect is small. In the former case we lead the student's attention to non-focal parts of the information (and it ought to be one of the main tasks of the programs to focus correctly). In the latter case we confront him with ambiguous and sometimes completely impossible tasks, which slow the work down and lead it in the wrong direction. The response request ought to be formulated so that one can so to speak obtain a written guarantee from the student that he has observed the new points that one wanted to show him in the didule in question.

Example 11.3

Version a

If we leave out a . . . . in a descriptive test for the student to fill in, the word ought so to be chosen that it shows that . . . . has noticed something essential and that not too many possibilities of choice are left open. The response request ought in other words to be non-trivial and unambiguous.

Version b

If we leave out a word in a descriptive text to be filled in by the student the word ought so to be chosen that it shows that . . . .
. . . .
and that not too many possibilities of choice are left open. The response request ought in other words to be . . . . and . . . .

Version c
If we leave out a word in a descriptive text to be filled in by the student, the word ought so to be chosen that it shows that the student has noticed somthing essential and that not too many possibilities of choice are left open. The response request ought in other words to be
. . . . (trivial/non-trivial) and
. . . . (unambiguous/ambiguous)

In all three cases the same text is given. In version a one has sinned against the demand for non-triviality, and we have no guarantee that the student has really noticed the main point in the information. In version b on the other hand the response possibilities are innumerable, and to be sure that the students will answer as planned we have to ascribe gifts of telepathy to them. Only if the exercise were of a repetitive nature could such a formualtion possibly be pardoned, but even then a clearer form would be preferable.[1] Most people can probably agree that version c is the only one that is fairly fit for use.

A way of more easily avoiding the risk of working with trivial response requests is to keep apart what we have called the information component and what we have called the response request more distinctly than has been usual in program writing. This division does not have to be made entirely in the external arrangement even if it can sometimes be useful (cf. Box 11.1 above). But it is valuable if it is kept in the designer's mind. In that case one would never think of having such response requests as in example 11.3, version a. Such a response choice can only occur if one has got stuck in "hole-cutting" routines.

11.1.5 Position

The position of the response request is important, particularly in two respects: The external position within the didule is often of decisive importance for the focusing of attention. The psychological position as the second link in the chain of association must be seen in realtion to what is desirable in the terminal situation.

As regards the external position one can give the general recommendation that the response request ought as a rule to be placed near the end of the presentational unit. Otherwise one runs the risk that when the student has given his answer he will fail to devote sufficient attention to the remaining parts of the didule. Example 11.3, version a illustrates this

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1) The extremely chopped up sentence structures which one sometimes sees in repetition didules and which remind one of the more scantily worded versions of "Three blind mice" can in fact usually be replaced to great advantage by open questions. "Cutting holes" should not become an end in itself and degenerate into a guessing game between program designer and student.

as well. There is nothing here that guarantees that the student will not simply skip the last two sentences when he thinks that he has completed the exercise ("filled in the holes").

As regards the psychological position as a second link in a chain of association we can refer to our argument about "reversible" associations above. Two recommendations are relevant in this connection. If the analysis of the goal shows that the chain of association in the terminal situation ought to work well in both directions (which is usually the case when learning foreign languages or in the study of other systems of symbols), both directions ought to be practised in the response requests. If we teach English-French vocabulary to English-speaking students, the French terms ought thus to be practised both in the response position and the stimulus position, provided we do not exclude in advance the possibility of using both directions in the terminal situation (thus if we were, for example, only to need to translate into English).

The second recommendation in this connection touches on the question of which of the two directions we ought to practise first. There experience tells us that learning probably occurs more quickly if one starts with putting the best-known and most meaningful part (the simplest part, so to speak) in the response position, thus in our example the student's own language. It is probably also advisable to give the student ample opportunities for practising this one direction before going over to practising the other.

11.2 THE RESULT INDICATION

A result indication can be given in different ways:

(a) By means of a signal from the machine (for example a red or green light) the student can see whether he has answered right or wrong.

(b) The machine can work so that it does not go on to the next exercise until the student has managed to solve the preceding exercise correctly (for example, by pressing the right button that represents the correct response alternative, or by arranging his letter or figure levers so that the combination coincides with the solution code built into the machine).

(c) The student can simply see or hear the model answer himself, as soon as he has made his own response attempt, and thus compare his own achievement with the model answer.

(d) When he makes a mistake, the student can obtain special error instruction, which, starting with the particular type of error he himself showed, explains the point more closely.

(e) The student can also get more specific "rewards" or "punishments". The machine can "lay" a toffee or make a pronouncement of judgement (the computer can, for example, with the aid of a teleprinter, produce all sorts of exclamations ranging from "Brilliant!" to "Block-head!").

The most common procedure at present is probably that the student can see the model answer (alternative c). In most contexts this probably also has considerable advantages over the other possibilities. In the first place it is considerably easier to arrange. Machines that do not go on until the correct answer has been given immediately become more complicated, expecially if one wants to work with constructed responses. The comparison with the model answer also gives more information than, for example, the arrangements when the student only finds out if he has made a mistake or not. (If he has made a mistake, he finds out through the model answer what he should have answered, too.)

Error instruction naturally gives even more information and can sometimes be of value. We have to remember, however, that as a rule we wish to obtain a low percentage of error. The error instruction is then quite likely to be of less importance. Furthermore, one can of course make mistakes in many ways and it can be difficult to foresee all possibilities and to write special instuction for all reasonable types of error. 1)

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1) The alternative answers ought in theory to represent all possible, non-trivial sources of misunderstanding. If one tests the study material <u>without</u> alternative answers, the student's "spontaneous" error reactions ought in other words to correspond either directly to the categories of error instruction the program contains or to be of a trivial nature. To be able to choose suitable alternatives when constructing a program one ought therefore to start with an empirical analysis of the types of error the students make when they give selfconstructed answers. Such a method is, however, probably rare in practice at present.

Finally the existence of error instruction is in itself no guarantee for the student having understood the point. In a typical Crowder program the student gives the correct answer sooner or later whether he has understood or not (a drastic demonstration of that is given in Box 11.2).

The special reward effects in the form of real or symbolical toffees may be fun and thus in certain situations increase motivation, but many judges of programs agree that these "external" reward effects are in principle less desirable. It is more correct, it is thought, that success is its own reward than that artificial reward effects are employed. We have had too many of those for a long time now in the world of the school.

That result indications often produce a good effect is obvious, and that effect is probably above all linked to the continuous checking of the work process. The indication immediately informs the student who is wrong that he is wrong and also what he should have answered. The incorrect answer is then immediately replaced in the student's cognitive field by the correct one, and the error does not then have any chance of persisting. It informs the careless student that he has been careless and is an immediate warning to take more care. It confirms the correct answer and thus the student often gets a comfortable feeling of having taken a step forward, an aspect that frequently ought to give the whole work situation a positive character (since correct answers are in most cases considerably more common than wrong answers).

Is the immediate result indication necessary? Some experiments indicate that this is not necessarily always the case. Certain experiments with programs without result indications have shown equally good instructional effect. The main cause for this is probably that the programs are usually designed for the students to obtain a low error percentage. This means that in the result indication the student is very often informed about something he in fact already knows. In that case the feeling of making progress can hardly be increased. The greater the probability of a correct answer, the less important the result indication probably is. But in the special contexts when the student makes mistakes the immediate check can of course still be of importance.

In fact, individual differences probably assert themselves to a considerable extent. Thus the relation between the individual's expectation of success and his actual success are quite likely to become of importance for the motivational value of the result indication. On this point findings from research on aspiration levels might well be taken into consideration.

Can partial series of result indications be more effective? This question has been raised by several programmers. It is mainly based on findings from experiments with animals when admittedly 100% "reinforcement" makes for most rapid learning but when in certain circumstances, other "reinforcement strategies" (partial reinforcement according to certain schemes) have proved

Box 11.2 A problem in error instruction of the Crowder type

On his way through a program with error instruction our student meets the following presentational unit:

P. 29

"here no chadwick slumbers, domps Daisi,
I am moved in geyds, I am wlamm and gondel
my deyd is dands and my feyd is rondel,
and wopt in taris, gland in deld and yondel."

Beneath the gay surface Daisi has obviously touched on a traumatic point in her deyd, the deep split that is revealed in her claiming to be at the same time wlamm and gondel and her using the revealing expression "gland in deld". It goes without saying that a gland geyds must be of more significance and be more difficult to wop than a dands feyd, at least if one takes into consideration that a wlamm deyd can hardly be rondel.

Taking this argument into account, which of the following psychological interpretations of Daisi's motives seem to you to be most plausible?

1) She is more gland than wlamm — see p. 34
2) Her feyd is in fact dands — see p. 37
3) I need a furt r explanation — see p. 45

Our student feels a little confused. He therefore looks up page 45 and finds the following:

YOU ANSWERED: I need a further explanation

Let us sort out the problem together. The difficulty probably consists in your not having observed that Daisi talks of "deld and yondel" in the same way as she co-ordinates gondel and wlamm. A yondel taris can obviously not be geyds wopt at the same time. This simplifies the question a lot, doesn't it?

Now turn back to p. 29 and choose the right answer!

How great is the likelihood that our student will not answer correctly? If he were to answer incorrectly, how great is the likelihood he will answer correctly at the next attempt? What does a correct answer of this kind tell us about the student's understanding and knowledge?

It has sometimes been claimed that the Crowder programs, with their error instruction and their additional explanations, guarantee that the student will not be taken on to new material until he has properly understood what he has gone through. Some people have also been of the opinion that unlike other types of programs the Crowder programs do not therefore require testing in advance on students with error analysis and retention analysis. (In actual fact such tests in advance of the scrambled books of the Crowder group seem to be rare.) What objections can be made to this argument?

/ The example above, starting from a nonsense text by a Swedish author, Harry Martinson (and earlier presented in Bjerstedt, 1963) has been modelled after an idea by Markle (now available in Markle, 1969). /

to be valuable for preserving the behavior pattern. Of course, such experiments could be of interest, but the likelihood of being able in general to increase effectiveness in the human learning process by giving partial result indication does not seem very great a priori. We must not forget that the food reward based on the 'piece work' principle and given to the hungry rat is rather remote - despite the parallels some people have tried to draw - from the human communication situation where a "partial key" would probably often be regarded as something artificial.

The most important point of view, from the perspectives of learning theory, is perhaps that it is not meaningful to delete reinforcement when new things are to be learnt (and this is probably the most common task in the usual type of programs), even if such partial reinforcement strategies may be reasonable when behavior already acquired is to be retained. Such considerations do not, however, prevent partial result indication from being useful in certain cases (for example, in material with varying degrees of difficulty). In this field, too, more research might well be desirable.

NOTE ON REFERENCES

The present report is the second in a series of three (issued as "Didakometry", Nos. 30, 32 and 33). The references have all been collected in the third report. Therefore, the reader is referred to the reference list in Didakometry, No. 33.