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REVIEW OF RELEVANT RESEARCHES

# C H A P T E R   II

## REVIEW OF RELEVANT RESEARCHES

Over the past few years many researches have been
carried out with a view to determining which of the several
programme forms is relatively more or less effective.
When a form or a style becomes popular, it is not always
because the empirical evidence of its effectiveness. It
may be due to the fact that it can be easily prepared.
In certain studies, the findings cannot be generalized
much, but can only be applied to particular lesson or
sample.

In this chapter, an attempt is made to provide an
overview of studies related to differential effectiveness
of various programme forms. The criterion for inclusion
of a study is that it should deal with fundamental
variables which apply to all programmes or at least a
specifically delineated programmes, rather than answer
problems specific to a particular case. Besides, opinions
and comments of certain critics are also included in the
present chapter, with a view to presenting the defects and
limitations of research in this area.

A careful survey of the existing literature on programmed learning reveals that the articles generally belong to the following two groups: (a) general articles consisting theoretical discussions or the author's point of view or opinions and (b) experimental studies. The later group of experimental studies consists of two clusters, one dealing with comparative studies, right from the well-known studies comparing conventional instructional procedures and programmed learning materials through comparisons of linear and branching forms, and other cluster deals rather with specific experiments like programme characteristics, that is, role of overt response, role of error-control, role of prompting and so on. Studies on the techniques of programming, especially those of early sixties^ have largely been the demonstration of the principles laid down by Skinner. But, by and large, the modern trend is not so much to get involved in the debate of 'linear or branching', but rather to have an inter-disciplinary approach, wherein the programmer tries to introduce the characteristics belonging to different programme forms*

As Schramm (1964) says,

"The research leaves us in no doubt of this. They do, indeed, learn. They learn from linear programmes, from branching programsaes built on the Skinnerian model, from scrambled books of the Crowder type, from Pressey

review tests with immediate knowledge of
results, from programmes on machines or
programmes in texts. Many kinds of students
learn - college, high school, secondary,
primary, pre-school, adult, professional,
skilled labour, clerical employees, military,
deaf, retarded, imprisoned - every kind of
student that programmes have been tried on.
Using programmes, these students are able
to learn mathematics and science at different
levels, foreign languages, English language
correctness, the details of the U.S. Consti-
tution, spelling, electronics, computer
science, psychology, statistics, business
skills, reading skills, instrument flying
rules, and many other subjects. The limits
of the topics which can be studied efficiently
by means of programmes are not yet known.

In spite of many studies available in the literature,
the type of research has not yet progressed because the
studies have been limited to gross comparisons. The "vs."
in the titles of many investigations suggests the comparison
of crude dichotomies without indication of where the two
cases fall on the dimension they represent. Consequently,
a generalization of results is difficult since magnitudes
of differences in important variables cannot be specified
for either experimental material or programmes.

The recent years, of course, have seen a shift from
the conventional studies of 'programmed learning vs.

traditional teaching' type towards the actual variables of programmes. These studies involve different forms of the programmes, with variations in factors like <u>response mode</u> i.e. overt or covert, <u>nature of response</u> i.e. constructive or multiple choice, <u>programme forms</u> i.e. linear or branching and so on.

One aspect that the programmers are very conscious of is the fact that, "...the determinant of what works will always be the student, not the theory. You can always justify having some concept out of sequence by point to the research results" (Markle, 1969). That is why a person who makes a careful analysis of the litera- ture in this field comes across certain unexpected results in some experiments. For example, the studies by Maccoby and Sheffield (1958); Margolius and Sheffield (1961); Weiss, Maccoby and Sheffield (1961), etc., made it clear that more learning came from gradually increasing the step size rather than from very short or very long steps; in another study, Rothkopf (1963), using seven versions of a short programme, found the rank-order correlation between the empirically determined effectiveness and the predictions of the high school teachers and principals was MINUS .75.

Mager (1961) found that the sequence by which he proceeded bore little resemblance to the logical sequence in which the course was usually taught. The instructors

usually worked from parts to wholes, while the students typically moved from smaller wholes to larger wholes.

The above examples can help programmers to search for truth through empirical evidence rather than entertaining armed-chair speculations.

It was found that most of the studies related to programme forms dealt with response modes, efficacy of prompting and confirmation, effectiveness of branching forms, importance of construct response as against multiple choice etc. So while reviewing it was found convenient to group the studies under the following heads:

    i) Studies on overt, covert response modes

   ii) Studies on prompting and confirmation

  iii) Studies on reading forms (i.e. prog-
       rammes containing the responses already
       filled in)

   iv) Studies on constructed response and
       multiple choice

    v) Studies on linear and branching forms.

After going through the available literature in this field, an attempt has been made to draw certain general observations as to the areas which are studied more often and the areas which need further studies and investigations.

(i) <u>STUDIES ON OVERT, COVERT
RESPONSE MODES</u>

'Learning by doing' is an age old dictum which
tempts the programmer to demand 'active overt response
rather than mere thinking'. And as such, the question
of whether an overt response is necessary has become a
popular topic for research studies. Overt responding
in the form of writing answers, speaking answers, or
selecting alternatives in a multiple choice question
has been compared with situations in which subjects were
instructed to 'think' the answer or simply reading the
programme form without any blanks or with correct multiple
choice alternatives indicated. Skinner suggests that the
response should be public because when no overt, public
response is made covert responding often ceases.

According to Holland (1965), the rationale for
overt responses implies that three conditions must be
met for a difference between overt and covert responding
to appear. He states:

    a) Programmed material must be designed so
       that the subject can answer correctly;

    b) the material must be designed so that he
       can answer correctly only after engaging
       in the appropriate mediating behaviour; and

    c) the programme must be long enough for
       subjects in the covert condition to become
       careless since, under controlled condi-
       tions, they may respond consistently for
       a while.

One can mention a number of studies aimed at know-
ing whether the student should write the response rather
than merely think it or select one from a multiple
choice of answers. The great majority of the studies
found no significant differences between the amount
of learning from overt (writing) and covert (thinking)
responses. As Schramm (1964) puts it, "When a researcher
finds a difference, he has statistical tools at hand to
calculate the likelihood that his finding is due to
chance; when he finds no difference, he has no logically
defensible basis". Evans (1960), Evans, Glaser and
Homme (1960), Gropper and Lumsdaine (1961 c), Hughes (1961),
Kanner and Sulzer (1961) and Alter and Silverman (1962)
are all of this 'no significant difference' nature.

Koromondy (1960) found no significant differences
between overt and covert response modes. Sidowski,
Kopstein and Shillestead (1961) found covert responses
more efficient than the overt when both time and amount
of learning were taken into account. Silverman and
Alter (1960) found that students who simply read items
learned significantly more than students who read items
and responded actively. Leith and Ghuman (1966) found
no significant differences between the four treatments
selected in their inquiry. They noted that there was
an appreciable Response-mode Answer interaction – the
covert constructed response mode being significantly

better than the overt constructed response mode, while the two answer groups were not different.

In the study by Cummings and Goldstein (1962) it has been suggested that overt responding might be of special importance when the answer is one in which the response topography is itself a major part of the task being taught. "Thinking" of an answer was compared with written answer in a 119-item programme which contained some items with the usual verbal answers and other items which required the drawing of examples of myocardio-graphic tracings. The posttest permitted separate measurement of the effects of these two types of items. Posttest performance was better for the overt responses than for the covert responses in the case of both types of material, but the overt-covert difference was especially striking for the items which demanded drawn answers. Though the group which wrote answers scored higher on both the verbal and pictorial materials and on both immediate and delayed tests, the covert responders took less time (average 50 minutes) than the overt group (96 minutes). It may be that the complexity of the topic (medical diagnosis) made for an advantage to the students who took longer and practised writing the response.

The role of overt responding in relation to the response topography also gains support from a comparison of overt and covert responding in teaching and the

phonetic alphabet. This investigation by Csanyi,
Glaser and Reynolds (1962) in which the subjects who
read aloud the phonetic symbols in the programme did
better on a delayed posttest that required articula-
tion in response to printed phonetic symbols than did
subjects instructed to read silently, but a multiple
choice delayed posttest showed the advantage for overt
responding was not statistically significant. There
was, however, a strong trend favouring overt respond-
ing. On an immediate post-test similar to the delayed
test, the same trends were apparent, but were not
statistically significant. The delayed test neverthe-
less, indicated that overt responding in the programme
was especially important if the criterion behaviour
was production of the sound. As Holland emphasises,
this variable deserves more attention in the overt
response question as well as the constructed response
and confirmation areas. If response topography is to
be learned, it is probably inappropriate to ask the
subject to think of the response, to choose alternatives,
or to respond without confirmation.

A couple of studies can be mentioned wherein
overt responding emerges to be superior under certain
conditions only. Krumboltz and Weisman (1962), for
example, found overt responding to be superior to
thinking the answer or reading completed statements in

a 177-frame statistics programme *on* a retention test

two weeks after, but this difference was not statisti-

cally significant on the immediate posttest. In another

study by Wittrock (1963), an advantage was found for

overt responses with elementary school children with

IQ's below 120, but not for children with higher IQ's.

One year later on a retention test, this interaction

was no longer significant. These two studies, though

lend somewhat equivocal support to the importance of

overt responding, <u>highlighten</u> the importance of speci-

fications of the target population, and the necessity

of analyzing the results in terms of 'levels' like IQ

levels etc., rather than threating the entire group as

a homogeneous unit.

The fact that there are more than a dozen studies

which failed to reveal any posttest differences between

overt and covert or even no-response condition should

not be taken at the superficial level. The first thing

is that these experiments must necessarily and indi-

vidually meet the three requirements given by Holland

as the rationale for overt responses, and, they must

also show sufficient experimental rigour to give compell-

ing evidence that the study would have revealed any

differences - if such differences really exist. But

a broader generalization of the studies is made

difficult because most of the studies used unpublished

programmes, and samples and their specifications are

occasionally omitted in the reports.

One can cite a handful of studies with no obvious
deficiencies in the design of items *which* have failed to                     7
indicate differences in response modes. But the delimit-
ing aspect of these studies is that they all used relat-
ively short programmes. Alter and Silverman (1962),
for example, using an 87-item programme on basic
electricity, found no significant differences among
reading complete statements, thinking answers, speaking
answers, writing answers, or writing and speaking answers.
Their second study using the same programme compared
written responses and reading under both paced and
unpaced conditions, again showed no significant differ-
ence. Their third study with a 90-frame programme in
binary numbers also failed to show a significant differ-
ence between writing answers and reading completed state-
ments. Tobias and Weiner (1963) using same programme in
binary numbers compared writing answers, thinking answers,
and reading completed statements, *and* failed to obtain signi-
ficant differences. In the same way, Stolurow and Walker
(1962) with a 78-item segment of a descriptive statistics
programme, found no difference between subjects instructed
to think answers and those writing answers. Evans, Homme
and Glaser (1962) with a 72-item programme in symbolic
logic, found no difference between subjects writing their
answers and subjects having the answer in view below each
item. While the above studies used programmes with no
obvious lack in item design, all are done with programmes

so short that the user, particularly under controlled
*have*
experimental conditions, might not yet moved from covert
responding to not responding.

The requirement for an overt response seems
adequately supported by evidence when the items are
designed properly and the programmes are long enough.
Studies failing to reveal this effect are largely
explained by failures in meeting the rationale for overt
responding and by poor experimental procedures (Holland,
1965). For example, Feldhusen and Birt (1962) found no
differences among any of nine experimental variations,
suggesting either problems of experimental procedures
or test sensitivity. Similarly, Kormondy and Van Atta
(1962), who asked students to use the programmed text at
their own convenience in places of their own choosing with
no supervision, failed to show any difference between
writing answers and simply reading material in paragraphs
form and without blanks. The study of Kormondy and
Van Atta, however, cannot be taken as an evidence because
of the inadequacy of experimental control. However,
these studies undoubtedly raise enough doubts for some
investigators to insure that still more research on the
need for overt responses will be conducted at the expense
of more fundamental variables of programme design.

Tuel's study (1964) is, a bit different from other
studies in the sense that it aimed at determining the

relative effectiveness of overt vs. covert responding under varying conditions of IQ, sex, item difficulty, retention interval, learning time, test time, response precision, and so on. No significant difference in general achievement or efficiency of retention was found. The interesting finding is that the overt response group did learn significantly more of the difficult material for brief retention, and at moderate precision, than did the covert group, but at high precision, even this difference dropped below significance.

Another related study by Tuel and Melfessel (1965) made it clear that the overt response mode did not prove superior to the covert response mode in teaching effectiveness except for rather difficult material when only short-term retention was desired. Thus, in the interests of maximum learning efficiency it would appear that the requirement to respond overtly, now a part of most programmes should be relaxed or abandoned for all but the most difficult material or the one for which the student does not satisfactorily have the pre-requisite knowledge.

The interaction of response mode and relevance of content to answer is also demonstrated in the study by Eigen and Margulies (1963) who compared material at three difficulty levels (rather, amounts of information required to make a decision), responded to either overtly or

covertly i.e. "thinking", by tests of incidental and relevant learning. Each programme was designed to teach a string of three-letter words, some of which were more difficult than others to remember, that is, required more information in order to be reproduced. They compared overt responding with "thinking" answers and found no difference at any level of "difficulty" for those parts of their specially constructed items that were irrelevant to the answer, but the parts that were relevant showed a substantial superiority for overt responding for high and middle levels of difficulty. In short, they found that "the further the material is from the repertoire of the student, the more important is the requirement of an overt response". The fact that the two higher levels of difficulty were learned more successfully by overt responding when tested for relevant responses (but there was no difference between overt and covert responding at the lowest level of difficulty), supports the view that overt responding is important when the items are designed so that the response assures mastery of the material. However, if the material is not programmed in the sense that response and major content are independent, no difference is found between overt and covert responding.

Shah (1971) comparing overt and covert forms of construct response type or prompting (i.e. answer given in the blank) found that the group which just read the

frames with answers written in the blanks proved to be most effective both on immediate test scores and the time factor.

In a study by Lewis and Whitwell (1971), nine variations of a linear programme on addition and multiplication in binary arithmatic were prepared by combining three levels of reinforcement - reinforcement to all frames, reinforcement to key frames and no reinforcement - with three levels of response - overt response to all frames, overt response to key frames and covert response. These were worked by boys at two ability levels, high and low, within each of two age groups, 11 and 13 years, and the learning was assessed by tests of retention, transfer (to the octal system) and generalization (to substraction and division. The results showed (a) a different pattern of learning for the two age groups; (b) that for the 11 year-olds covert responses produced the most learning with subsequent reinforcement an advantage only to those of high ability; and (c) that for the 13 year-olds the combination of reinforcement and overt response to key frames only produced the most learning overall, although differences among the separate tests were also important. In short, the results as a whole do not support the Skinner-based view that the most effective learning follows from a continuously reinforced

sequence of overt responses.

Regarding the factor of time, all investigators
report that overt responding takes longer than covert
responding. "This finding seems clear, unequivocal and
most reasonable" (Holland, 1965). It requires a finite
time to write an answer, and over a whole programme this
writing time accumulates to an easily measured amount.
Unfortunately, most programmers have given only secondary
considerations to time factor as compared with comprehen-
sion. Since thousands of pupils use successful programmes,
it is worthwhile to have relatively small savings in time
when such savings are possible. Holland (1965) suggests
that methods should be devised for overt responding which
take less time such as using special systems of abbrevia-
tions or shorthand.

In short, covert response mode has the advantage
of saving time, especially with longer programmes; and it
could also be tentatively accepted that covert responding
does not have any inhibiting effects on learning, provided
the programme is shorter. Thus, the advantage of covert
responding is equivocal and compensatory in the sense that
with longer programmes the advantage in terms of time
would be significant for covert mode; but we lack unequi-
vocal and valid findings in favour of covert responding in
terms of comprehension and retention, though studies in
favour of overt responding exist. There is support

elsewhere in the literature (Angell and Lumsdaine, 1961)
for the view that it is important for the student to
actively make a correct response, before going to the
next step.

## Familiarity of Subject Matter and Overt Response

There have been discrepant findings regarding the
effects of response modes on achievement. Constructing
responses and then checking their accuracy has not con-
sistently led to higher achievement compared to reading
the programme with the responses filled in, or thinking
the answer without actually constructing (covert response)
it.

Previous research suggested that constructing res-
ponses does not lead to superior achievement on materials
with which subjects have had prior experience, while
achievement on technical, unfamiliar material was superior
when subjects constructed their responses. (Tobias,
1969 a, 1969 b). It is quite reasonable to assume that
topics with which subjects are unfamiliar may require a
more overt response for optimal learning than does familiar
content. Lack of familiarity implies that the responses
required by the task may not be in the pupils' repertory,
and therefore, responding overtly may be the surest way
of learning whereas for familiar subject matter, the
required responses may exist in the pupils' repertory,

and therefore, overt responding may not be a 'must'.
On such tasks the pupil does not have to start from the
rudiments, does not have to learn how to make the
responses, but rather how to connect or modify existing
responses to new, or different, situations. Overtly
making a response which is already in the repertory may
not strengthen its association to new situations to any
significant extent more than covertly thinking or reading
the material with correct responses already inserted.
Thus, for content in which the required responses have
been previously learned, little achievement difference
is to be expected between overt or covert responding,
choosing from one of several alternatives, or reading
the material. When the responses required by a programme
are new actually making an overt response and receiving
knowledge of results concerning it, is more likely to
lead to better achievement. This familiarity inter-
pretation is in line with what Daniel and Murdoch (1968)
found. They found overall achievement differences
favouring a group studying the content of operant psycho-
logy with a constructed response mode compared to those
studying the same content in a non-programmed style.
The important observation was that when differences
between the groups on the most technical, and presumably
least familiar items were eliminated from the dependent
measures by covariance adjustment, the other group
differences were no longer significant.

In the study by Tobias and Abramson (1971), the
main finding was that constructing responses could lead
to higher achievement only on technical unfamiliar
content, thus strengthening the response learning inter-
pretation mentioned earlier. Also, in accord with the
findings of other investigators, both the constructed
response group and no reinforcement group took signifi-
cantly longer than the reading group. Overt responding
took $2\frac{1}{2}$ times longer than reading the material. As
suggested by the authors, a comparison of time required
to achieve mastery is meaningful in those instances when
the time required to learn a subject is of equal, or
greater importance than the mastery attained. On the
other hand, asking subjects to skim through material
they have read once may improve their mastery of the
subject matter to the same level as working on instruc-
tional programme, and conceivably at less time.

Thus, the familiarity interpretation and the
response learning interpretation of these studies seem
to support the view that unfamiliar and technical content
are better learned by overtly constructing the response.
It is interesting to compare this point of view with the
findings of studies on prompting, wherein the response
blanks are already filled and so the student has just to
read, given in the following pages.

## (ii) STUDIES ON PROMPTING AND CONFIRMATION

As Holland (1965) points out, except for one or two, all
basic research on classical paired - associate learning would
have been excluded from the realm of programmed learning if a
few investigators had not viewed "prompting" and "confirmation"
as opposing programme characteristics. In paired associates,
prompting means that the response term is shown before there
is an opportunity for an overt response; whereas in the
confirmation method, the response term is shown after the
chance to respond. Discussion of "prompting" to assure
correct answers and low error rate has led to prompts that
often render important content irrelevant for attaining the
correct answer. As it is generally expected, only that
behaviour which must occur in order to reach an answer is
considerably more likely to be learned than behaviour not so
well controlled. Thus, the programe forms of "prompting"
nature have any significance only when the key concepts are
not thrown to the background, and 'reading' that material
does not decrease the probability of a correct answer on the
criterion test. Thus, although the 'prompting' forms do not
require an answer, care should be taken that the material
included in the frame does not become extraneous to the
concept involved therein. This needs a knowledge of certain
psychological and perceptual principles (e.g. underlining,
colouring, capitalization, etc.) by which the key word
attracts the attention of the pupil, though he does not get
it as an answer or response.

(iii) STUDIES ON READING FORMS

The studies comparing the active response versus mere reading of items containing correct responses are somewhat equivocal. Holland (1960), for example, found that a group which just read the complete statements (i.e. the answers already inserted in the blanks) made more errors than either active or covert responders on a final test, but took less time to complete the programme.

Campbell (1961) studied the effectiveness of the following four conditions:

1.  Subjects wrote the response only when sure of its correctness.

2.  Subjects wrote answers in every blank.

3.  Subjects did not write answers but mentally composed them.

4.  Subjects read the same frames with no words omitted - no blanks to fill.

On an immediate posttest there was no significant differ-ence among the means of the four groups. Ten weeks later, condition (4) was better than others at 0.05 level of signifi-cance. The expectation that condition (1) would make for more learning in the same time was not supported. Condition (1) resulted in fewer errors, but these did not show up in learning effect.

The earlier investigations like the one by Gropper and Lumsdaine (1962), found non-significant differences between

the reading and responding groups.

Pressey (1963) tested the first unit of the Holland-Skinner Psychology programme against the same material rewritten into good prose-paragraph. He found no significant differences in learning, although reading the prose took less time than working through the programme. When he added some of his typical review questions to his prose material, the amount of learning was higher, but still non-significantly so than the learning from the programme.

Leith and Gühman (1966) comparing the overt and covert responding with and without answers given in the blanks, found the covert construct response group to be consistently better than others.

The study carried out by Reid and Taylor (1965) had showed that the Reading Group (reading without responding and checking) learned as much as the Response Group from samples and panels, as well as from the purely textual programme items. The fact the Response Group answered test questions more rapidly than the Reading Group is of significance because it points to a temporary 'warm-up' effect produced by responding during learning. When unrecognized, this could become a source of confusion in experiments using timed tests.

As early as 1960, Holland did some interesting work regarding the cruciality of the required response. He prepared 3 new versions - one with blanks for responses

of a trivial and easy nature, a second one with blanks
which actually made the items ambiguous and difficult,
and the third one with blanks filled with responses. The
group using the normal version of the programme (in which
the blanks required the student to notice the critical
material) did better than the others. This demonstrates
that a overt response is meaningful  only when it facil-
itates the student in noticing the critical information
of the material, otherwise, trivial items, whether overt
or covert do not yield any fruitful or guiding sugges-
tions. In a later study, discussed and summarized by
Holland (1965), the normal programme, written to insure
that correct responses could be made only after careful
reading of the items, and in which the response was
determined, resulted in posttest performance that was
superior to posttest performance following the simple
reading of completed statements. The results for the normal
version of the same programme were conformed (Williams,
1963) by using a shorter (192-item) segment as review for
subjects who had already completed a psychology course.
Williams (1963) found that either an overt constructed
response or an overt choice between two alternatives
yielded better posttest scores than reading the completed
statements with or without critical material underlined.
However, as discussed by Holland (1965), in his study, the
distorted versions of the programmes, in which blanks were
either not related to the critical material in the items

or in which the responses were undetermined, showed a high

error rate*  The posttest scores following completion of

these programmes were not different from those whieh

followed reading of the completed items; thus, as Holland

suggests, when the answers are not contingent on the

important content or when correct answers are rare, overt

responding may not be effective.  When these two prime

rules of programming are met, these studies indicate a

posttest advantage for overt responding.  This aspect is

of prime importance because, in the light of these findings,

any valid generalization can be drawn only from those

studies which satisfy the abovesaid requirements.


(iv) STUDIES ON CONSTRUCTED RESPONSE
     AND MULTIPLE CHOICE

The control of response necessitates the programmer

to decide about the relative use of recall and recognition

type of items.  Some investigators are of the view that

multiple choice programmes are effective to teach recogni-

tion; and constructed responses to teach reeall.  Others

hold the view that unfamiliar material for which the student

has no conceptual structure needs a linear constructed

response programme, while material which can be assimilated

to already existing schemata may be taught by branching

programmes of multiple choice items.

Burton

grades who learned about animals did not support Skinner's idea that constructed response was superior to multiple-choice response. However, they did find a significant interaction among leading methods, student aptitude, and the strength of the desired response in the student's repertoire. When easy multiple-choice alternatives were used, they produced better learning of common responses by students who had high verbal reasoning aptitude. These data suggest that the difficulty of the material may be a determiner of the particular aptitude that come into play. If this is correct, then by changing the difficulty level (e.g., providing steps with more or less prompting), one should be able to adjust for the contributing aptitudes.

Quite a few studies like the one by Hough (1962) have directly compared constructed response and multiple-choice response in standard verbal programmes and failed to find any significant difference on the posttest. However, many studies are inconclusive and suffer from fundamental defects in the design of items and in experimental procedures. For example, the one by Roe and others (1960) used a 192-item sequence teaching elementary probability in which the answer is largely unrelated to the content of the item. There is little reason to expect any effect of response mode in such a programme. As a matter of designing the frame, the relationship between the response and the critical content in the item is as important here as in overt-covert response question.

Williams' (1963) finding of no difference between
constructed response and multiple choice, of course
deserves greater credence than the other "no difference"
studies. Because she did find both constructed response
and multiple-choice to be significantly better than covert
responding, her programme test and experimental procedures
were demonstrated to be capable of detecting effects.
A slight, although not significant, difference favoured
the constructed response condition, but the important
finding was that the test items requiring a technical term
were analysed separately, the constructed response mode
proved significantly better than the multiple-choice, and
on these items, the multiple-choice form was not better
than reading completed statements.

Similarly, Coulson and Silberman (1960) with a
different segments of the same programme as Williams,
also found no overall posttest difference, but did find
that on the constructed response portion of the post-test
the constructed response programme provided better perform-
ance. Both studies, in short, suggest that the constructed
response might have certain special advantages for certain
types of learning tasks as having to recall a new technical
term rather than recognizing it. This interpretation has
support elsewhere in a study by Fry (1960), comparing
constructed response and multiple choice in learning

Spanish equivalents of English words. When the posttest
required writing the Spanish word, then the constructed
response was better, but when the posttest required choos-
ing the Spanish equivalent from among several alternatives,
no differences were apparent between the conditions.
Writing the new Spanish word (construct response) helped
the person to reproduce it later (recall), but it was
unnecessary for choosing it later from among alternatives
(recognition).

The conclusion that emerges is that the nature of
the learning task determines the preferred response form.
As suggested by Cummings and Goldstein (1962), when the
criterion performance includes a precise response topo-
graphy (even a simple one such as writing a new Spanish
word as in the study of Fry), constructed response seems
to be the better form, whereas if mere recognition is desired,
the response form in the programme is probably unimportant.
In certain conditions like the one requiring a fine stimulus
discrimination, alternative responses may be preferable.
Most verbal knowledge programmes, which are the most common
forms used, though do not shape precise topographies, they
do  tend more often toward averbal repertoire than toward
simple recognition. Again, the Kaess and Zeaman (1960)
study of number of alternatives indicated that one alter-
native was superior to either two or three alternatives.
Had more alternatives or more difficult alternatives been

used, the data suggest that the "overt" multiple alternative
response group might have been substantially worse than the
"covert" single alternate response group not because of
response mode differences, but because of differences in
number of alternatives. In short this Kaess and Zeaman
study sufficiently indicates that difficult multiple-choice
alternatives have clear dangers, thus rendering to partial
or faulty conclusions.

(v) STUDIES ON LINEAR AND
    BRANCHING FORMS

It is often proclaimed that differences in individuals'
abilities and needs are best accommodated by programmes
which adjust to the performance of the individual. There-
fore, different branching methods have been suggested in
which responses on items determine what material will be
presented next, either by moving well ahead in the programme,
looping back for review, or presenting special remedial
frames.

Some programmers make branching their principal
technique whereas others feel that branching is rarely
necessary, and, if and when necessary, large branches
within the whole segments of courses. The issue concerning
the relative merits of branching and linear becomes the
debate of the day, and many times ignoring the fundamental
need for analysis of difference among tasks and the need

of diagnosing differences among subjects.

These are certain incidental outcomes in the above studies which warrant the researcher regarding the possible dangers of misinterpretations and other unexpected outcomes. Beane's study (1962), for example, used a control group for comparison purposes with all-branching, all-linear, half branching-half linear, and half linear-half branching groups. The instructor who normally taught the two experimental classes taught the control class. The control group had a higher mean score on posttest achievement than any of the four experimental groups, but the difference failed to reach statistical significance. Beane reports significant differences between control groups and the four experimental groups on time spent on the programme. He attributes the greater amount of time spent by the control group to homework assignments given only to that group.

There are two significant things in Beane's above mentioned study. Using the Henmon-Nelson Tests of Mental Ability to divide students into high and low ability subjects in each experimental group, Beane found high ability students in both achievement and retention. Of course, this finding is clear, and most reasonable. However, there were no significant differences on programme error-rate between high and low ability groups.

Although the low ability groups had a relatively low error-rate on the programme (8 per cent), their ability to grasp logical sequences was not equal to that of high-ability classmates. Such a finding as observed by Evans (1965), is a count against the use of programme error-rate as the chief dependent variable in programme experimentation.

The second important aspect of Beane's study is also worth noting. Beane, in the above mentioned study, found the branching programme more efficient (that) the linear programme timewise. It was also found that students preferred his linear programme to his branching version, even though the latter was more efficient for them. If this is repeatedly found, then it suggests that it may be necessary to trade off some efficiency for some amount of positive attitude toward the learning experience. On the other hand, it also may be possible to change attitudes toward the two so that the more efficient procedure also is preferred. (Stolurow and Davis, 1965).

Coming back to the studies comparing linear and branching forms, Campbell (1961, 62) in 11 different experiments, compared a short form of a programme and a form with forward loops through remedial material, but found a significant difference in comprehension favouring branching in only one of the 11 studies, and it proved unreplicable. In all cases the condition resulting in fewer items required

less time. Similarly, Glaser, Reynolds, and Harakas (1962)
created a branching programme from a small-step non-branch-
ing form by combining items and requiring a single answer
which when incorrect required use of the small step compon-
ent items from which the larger one was constructed. They
found no posttest difference between a group using the
branching form and one using the small-step linear form.

There are two studies, however, which indicate at least
a little advantage for adjusting the sequence to individual
differences. Skinner's (1958) original write-in machine
branched in a small way by automatically repeating incorrectly
answered items at the end of each 29-item set. Even in a
low error-rate programme, as was the case with the Holland
and Porter (1961) study, this repetition of missed items
improved posttest performance as compared with use of the
machine without repeating missed items. Here, the tests
consisted of completion items from the programme. At
every level of difficulty of item, the non-review group
made more errors than the review group (significant at .01
level). The significant thing was that those differences
were maintained on a 6-month retention test. The differ-
ences in performance between the two groups were almost
identical on both the first and second testings.

A post-test advantage of an adjusting sequence
over a fixed sequence was found in a more extensive use

of branching by Coulson and others (1962). In the branch-ing group, the sequence was determined by performance on diagnostic items, error in the instructional items, and the subject's own evaluation of his readiness to advance to a new topic, or need of further review. Out of a population of 345 items the branched group used an average of 213.5 items while the fixed sequence group used a 233 item programme (prepared from among the original 345-items programme). Posttest scores were significantly higher for the branching group than for the fixed-sequence group. Surprisingly, training times for the two groups were not significantly different. As observed by Holland (1965), unfortunately, there is no way to know whether useful items had been excluded or unnecessary items included in the fixed-sequence version. Holland further suggests that an additional "yoked" control group is necessary before concluding that the difference results from adjusting to individual differences or simply use of different sequences.

Though, studies with adults as subjects, for example the one by Roe (1962), failed to show any significant differences in the effectiveness between linear and branch-ing programmes, there are certain peculiar observations made. For example, the studies by Coulson and Silberman (1960) or the one by Fry (1960) have found that constructed response programmes give higher scores on a test of recall, though there is no difference when recognition tests are used.

In a study by Larkin and Leith (1963), using junior
school children of below ten years, the constructed
response group fared better than the branching group on
both kinds of tests (i.e. recall and recognition). In
keeping with the view of 'conceptual structures' the
linear was more effective for the low ability levels,
though the brightest children performed equally well with
either programme. Secondly, the linear group was better
on a four months retention test also. When Larkin (1964)
repeated the experiment with fourteen year old secondary
school pupils there were no differences between linear
or branching methods of programming on an immediate test
or a retention test, after four months.

Householder's (1964) study with linear/branching
programmes is also of 'no significant difference' type.
Of course, groups receiving linear programme required
greatest amount of time.

Branching programmes contain remedial information
and so may be considered useful for a wider range of
ability. However, it has been found by investigators
like Knight (1963), Wallis and Wicks (1963), Larkin and
Leith (1963),etc., that the correlation between ability
and test scores after learning through branching programmes
is usually quite high, while in a high proportion of
cases, for example, Larkin and Leith (1963), Cresswell (1964)
and Middleton (1963) etc., where linear programmes have

been used, the correlation is lower. Thus, it appears
that many·programmes are not suitable for a wide range of
ability.

Leith (1966) points out a practical disadvantage
of branching forms -

> "Branching programmes have an unexpected
> difficulty. The learner is intended to
> read the 'information' provided, then
> the question, and finally select an
> answer. Many learners, however, (includ-
> ing young children) acquire a set to
> read the question first and choose an
> alternative without going through the
> instructional part of the frame. This
> may, of course, merely speed up the pace
> but a motive for it may be classroom
> competitors and the result lower perform-
> ance or retention".

This difficulty may be overcome by using machines which
expose the question only after the student reads the
information.

Quite a few studies are there which have implica-
tions for constructing programmes, Campbell (1962), for
example, found that 'by-passing' or branching was more
effective than a linear programme for students who
scored about the 50th percentile on the DAT numerical
test. He further suggests that 'by-passing' is most
useful when the subject matter has a hierarchical struc-
ture. This provides sufficient cues to the need of

knowing the student aptitudes before using a particular programme form and again it hints at the necessity of analysing the conceptual structure of the lesson and deciding the extent to which it is hierarchical in nature before starting with the construction of a particular programme form. From his study, Campbell (1962) concludes, "one should apparently be prepared to supply remedial loops of instruction which may take 20 or 30 times as long as the basic steps"; When a topic has a hierarchical structure, "the simplicity and economy of by-passing justify its use on even a small scale". (Campbell, 1962).

Despite the predominately negative results regarding adjustment of programmes to individual differences, such adjustment must be effective at least when wide differences in achievement or capacity are found in the target population. The practical question worth mentioning is "whether the degree of selection imposed by the normal processes which segregate students into grade levels, if supplemented by pre-requisite testing, leaves a useful role for sequences that adjust to individual differences" (Holland, 1965). The difficulty in finding effects of branching points toward a qualified negative answer. Stronger evidence is reported by Shay. y (1961) who tested the hypothesis that different programmes might be preferable for different ability levels. He

specially designed parallel programmes having 103, 150 and 199 steps in decreasing step size, using data from subjects of high, medium, or low intelligence respectively. After each of the three forms was perfected for subjects of a specific intelligence level, all three programmes were used by subjects in all three difficulty levels in a 3 x 3 factorial design. No significant interaction resulted between intelligence and programme, thereby lending credence to the claim that within broad limits persons of different abilities do not require different programme forms.

## GENERAL OBSERVATIONS

It is interesting to note that only a handful of experiments make use of the 'intrinsic' or branching forms of programming advocated by Crowder. Most of the studies on programmed instruction have been done with linear programmes or at the most linear forms fitted with branches or loops, for example, by-passing forms, skip-programme forms etc.

In short, the observations made in the present chapter can be summarized as follows:

a) Relatively few discontinuous studies use branching form.

b) The value of an overt response depends on the difficulty level of the frame and the familiarity of the content.

c) Branching programmes take less time to work
through than linear programmes.

d) Research work into programmes of hybrid
nature, that is, combining the character-
istics of both the linear and branching
forms are practically nil.

€) Retention tests are important while evaluat-
ing the efficiency of a programme form.

## Epilogue

A number of studies have compared different forms of
programmes, which vary in different aspects like the
overt-covert response modes, linear or branching forms,
prompting or confirmation aspects, and so on. Despite
their prevalence such studies lack validity and do  not
permit generalizations of the results beyond the particular
instances. No linear form or no branching form represent
their whole class; nor do the two differ in only one
dimension; they differ instead in an indefinite number of
ways. Further, the efficiency of one 'form' can be changed
significantly  by indirect method i.e. by manipulating other
subtle variables. Thus, most of the studies appear to be
pseudo-experiments and do not serve 'as a valid and justified
basis for practical decisions. Roe (1962) enumerates four
reasons why he feels little of either statistical or social
significance has emerged from programmed learning research
to date:  (a) weak criteria measures; (b) limited number of

variables which can be measured at one time;  (c) failure
either to satisfactorily separate or combine learning time
and test scores - the two major performance measures; and
(d) lack of an adequate rationale for specifying the effi-
ciency of the teaching-learning process. Holland (1965)
depreciates hypothesis - testing studies on the basis of
the defects in design of items, particularly those involving
short programmes with 100 or 200 items. And Gilbert (1960)
admonishes the researcher to resist the temptation to design
formal experiments. "You don't want to know whether one
method teaches better than another, you want to know what
method teaches best". Problems of test sensitivity, prog-
ramme adequacy and other experimental and technical limita-
tions prevail in several programmes, and the associated
criterion tests which have been used repeatedly (unfortunately
confidently) in a variety of experiments without ever reveal-
ing a significant effect.

The frequent use of 'versus' in the titles of studies
is symptomatic of the inability to measure variables even
approximately. How much 'branching' is really  there in a
programme form used in a study comparing 'linear vs. branching'
forms of item? No clear theme emerges from the studies of
linear vs. branching type. In fact, linear and branching
forms serve different functions. When these functions have
been identified and controlled, both forms will be employed
as and when needed. The 'linear vs. branching' or the

'overt vs. covert' dichotomy will then disappear as the pseudoproblem which it actually is.

Similarly, present data are inconclusive in establishing any clear-cut advantage associated with a particular response mode. Covert response conditions typically result in significantly less learning time, but its effects on the retention is not consistently established. Similarly, in situations in which correct responses have low probability, factors such as overt responding and immediate feedback are more critical than in situations in which probabilities of correct responding are high (Evans, 1962). The results of studies reveal a larger proportion of differences in time than of differences in level of achievement. This suggests that the outcome to be considered in evaluating a programme form should involve time required to achieve a particular level of performance. But practical suggestions to evolve such dependent variables are still meagre.

The figure given in the following page shows a summary of outcomes of comparative studies mentioned in the present chapter. In the figure are incorporated the limitations of certain studies as observed by investigators like Holland (1965), Roe (1962), etc.

TABLE NO.2.1

## ANALYSIS OF THE OUTCOMES OF COMPARATIVE STUDIES

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                    ┌─────────────────────┐
                    │ COMPARATIVE STUDIES │
                    └─────────────────────┘
                              │
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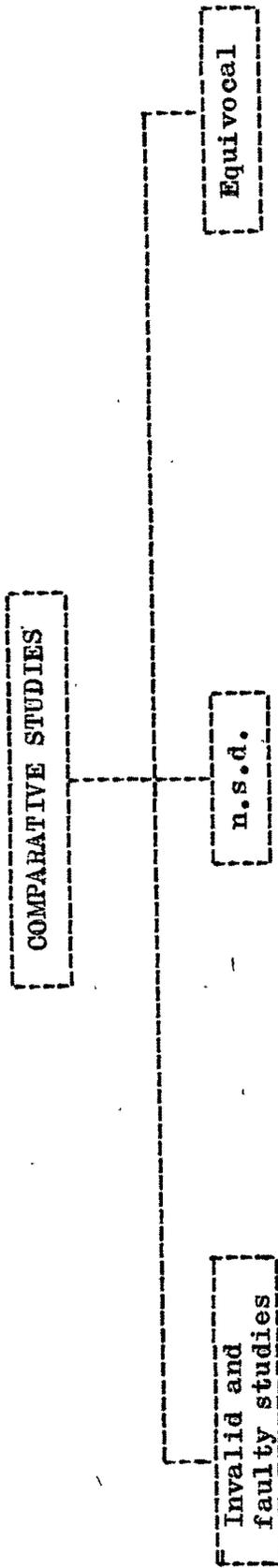
Reasons:

1. Errors due to "confounding" and masking

2. deficiencies in the design of items

3. methodological problems

4. very short programmes

5. problems of test sensitivity and weak criteria measures

Tentative generalization

1. for short programs, covert response is in no way disadvantageous

2. for long programs, a public, overt response is necessary

3. larger proportions of differences in time than of differences in level of achievement

Presently,efforts are made to study the relative roles of programme variables, with better statistical control and with an awareness of limitations as well. Since experimentation has become an aspect of programme preparation and refinement, the programmer is open-minded to accept and benefit from any experience, whether good or bad, that he encounters in his attempt. Finally, there is more and more recognition on the part of the programmer that the need is for constructive research which clarifies, defines and quantifies the parameters of programme characteristics. When one can, at least roughly, identify in a programme form the magnitude and nature of each of several dimensions, the technology of programming will help better, and the controversial issues of 'versus' type will be things of the bygone past.

The findings reported in the chapter prompted the investigator to devise an experiment in which various forms of programmed learning material could be tried out with a reasonable degree of precision. The next chapter proposes to describe the plan and procedure of the investigation with a mention of the experimental design used.

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