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ABSTRACT
        An experiment tested the efficacy of "discovery
learning" in a school setting. Fifty-two bright children ages one to
seven were randomly divided into two groups: a discovery learning,
non-directed group and a guided learning, teacher-directed group.
After both groups had spent eight months using an individualized
"talking typewriter" program designed to teach spelling and reading
skills, the children were tested on the WRAT (Wide Range Achievement
Test) reading and spelling achievement tests. The two groups showed
no significant differences. Objective and subjective measures of
motivation likewise yielded no strong difference between the two
groups. It thus appears that any differences between the two teaching
approaches either do not exist or are so small as to be mitigated in
long-term school use. (RB)

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Final Report

Project No. 1F041
Contract No. OEC-6-71-0484-(509)

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COMPARING TWO METHODS OF TEACHING PRE-SCHOOL
CHILDREN TO READ AND SPELL AT AN ELECTRIC
TYPEWRITER, THEIR REACTION TO THE EXPERIENCE,
AND THE SIGNIFICANCE TO EARLY CHILDHOOD
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SUMMARY

By testing the efficacy of "discovery learning" in a school setting it may be possible to avoid some of the irrelevancy, lack of comparability, and other such pitfalls present in many of the studies in the literature. In addition, such an in-school experiment allows investigation of other aspects of discovery learning versus other methods of instruction -- especially the effects of the various methods on the motivation of the children.

Fifty-two bright children ages one to seven, of various racial and social-economic backgrounds, were pre-tested on the WRAT reading and spelling achievement subtests. They were then randomly divided into two groups: a discovery learning, non-directed group and a guided learning teacher-directed group. After eight months of an individualized "talking typewriter" program designed to help the children acquire spelling and reading skills, the children were post-tested on the WRAT and questioned to determine their subjective reactions to the program.

When compared for gains in achievement the two groups showed no significant differences. Objective and subjective measures of motivation likewise yielded no strong differences between the two groups. It is suggested that advantages claimed for one or the other teaching methods are mitigated in long-term school use.

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INTRODUCTION

Several factors account for the recently
renewed interest in the "discovery learning"
variable. The public schools have come under
increased scrutiny by many social groups, and
changes in curriculum have resulted. There has
been a spread of the "open classroom" and growing
interest in the "free school" movement. An
increased interest in Montessori principles --
especially regarding her emphasis on greater
freedom on the part of the child -- has come
about. Montessori was convinced that a teacher
must "never substitute his own intelligence for
that of the child, but rather make the child
himself think, and induce him to exercise his
own activity." (8:44) In addition, educational
theorists -- especially Bruner -- have brought the
issue to public attention again, after a lapse of
many years.

Early educational theoreticians -- Rousseau,
Montessori, and Dewey -- emphasized the efficacy
of discovery learning as a method preferable to
the highly structured urban classroom settings.
In fact, several early articles in this field
tended to contrast "discovery" learning with
"rote" learning; as has been noted by Wittrock
(15:44) few people would be likely to vote against
the superiority of the former method, given those
labels.

Unfortunately, for many years the literature
on discovery learning has been crowded with biased
labels and ostensibly plausible hypotheses based
on anecdotal, analogic, or hypothetical concepts.
Many of them apparently make good sense, but lack
easy testability. An example, from a non-educational
context:

> For reasons never clearly spec-
> ified, it is argued by some ... that
> whatever is discovered (by a person)
> is intrinsically more valuable than
> whatever (is learned) due to ...
> attempts to teach him .... An analogy
> of approach is that of a man who
> pushes his stalled car to a gas station
> and is greeted by a mechanic who,
> believing in self-discovery, insists

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that his client deduce the cause
and remedy for his car's difficulty.
Under the guidance of a good mechanic,
the man will probably arrive at a
correct diagnosis, and even be able
to repair the car, but the joy of
self-discovery will hardly compensate
him for the expenditure in time and
fees that this approach implies. (13:102)

Similar analogies, hyperbole, etc. are used
also to bolster the case for discovery learning, both
in and out of the education context. Clearly, what
is needed in such areas of dispute is research to
test the principles involved. There is hope that the
concepts can be accurately defined, that specific
independent and dependent variables can be formulated
and results compared, and that the results can be
stated precisely and be checked with appropriate
statistical procedures. In that way, the argument
might be satisfactorily decided on the basis of fact.
Indeed, many studies have been undertaken in
an attempt to isolate the "discovery" mode of
learning, so that comparisons between it and other
methods of learning might be made.* Hermann (3) has
tried to summarize the results; it is a noble attempt,
but the data being compared are often based on a wide
range of concepts that were tested under varying
experimental conditions with subjects varying widely
in ages, abilities, etc. As a result, even a careful
reading of the Hermann article leaves one puzzled as
to whether the benefits or disadvantages of the
various learning methods have actually been shown
with any certainty. The article is, in fact, a

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*Together, the Hermann (3) and Wittrock (15)
articles summarize the majority of the work that
has been done on the "discovery learning" method.
Hermann's paper pulls together the major experimental
findings, and investigates several subsidiary
variables. Wittrock's paper analyzes the experiments,
explains underlying issues, and discusses various
research approaches. The book in which the Wittrock
article appears -- Shulman and Keislar (12) -- has a
comprehensive bibliography of the discovery learning
literature and also contains other pertinent articles.

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valiant effort to make sense out of a mass of
data that are not really unified, but are a series
of varied approaches to different subparts of the
whole problem.

Wittrock, the man who has done the most work
in attempting to synthesize the data -- Kersh and
Wittrock (6), Wittrock (14), Wittrock (15) -- has
pointed out that there are simply too many unsolved
problems in this area of research. He notes the
large variety of dependent variables used, the
basic flaws in the research techniques, and
comments:

> The reader is forewarned that
> the current state of research on
> discovery is very disappointing and
> precludes any important conclusions
> about teaching or learning.... The
> literature on learning by discovery
> does not lend itself to terse summar-
> ies. The studies are seldom closely
> interrelated to one another. The
> procedures are sometimes naive and
> crude and evidence only the research-
> er's preference for a type of
> treatment. Only by summarizing a
> few studies in detail can one
> appreciate the several meanings of
> the learning by discovery hypothesis,
> the severe shortcomings of the
> research, the futility of an attempt
> to gloss over the particulars of a
> study, and the meaninglessness of
> generalizations based on these
> studies. (15:45)

There is, however, another route to the
collection of data about discovery learning.
Bruner has stated at the conclusion of his out-
line of the discovery learning hypothesis that the
hypothesis is "of such important human implications
that we cannot afford not to test it -- and testing
will have to be in the schools." (1:26) This
opinion is echoed by Keislar and Shulman: "General-
izing from a two-month experiment to a two year
curriculum may involve overextrapolation, but at

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least it seems more reasonable than to base one's
judgment on data collected from a fifty minute
laboratory session on the same problem." (4:196)
     Basically, these men are suggesting that
a naturalistic -- in school -- study may be more
likely to produce answers to problems about how
children learn, than will a more narrowly-defined
but less relevant experimental study. In addition
to being able to investigate the discovery learning
hypothesis in a natural setting, a study done
in a school can also investigate several other
related questions that cannot be investigated
in the laboratory. Specifically: Friedlander
(2) believes that children given the correct
answer will probably tend, after a number of
such experiences, to have self-motivation
eliminated. Similarly, Kersh (5) claimed to have
found, from observational reports, that the "no
help" group of children were more motivated to
learn on their own; he suggested that a choice
existed between getting maximum understanding
or getting maximum motivation. Furthermore,
Kornreich (7) has pointed out the need to study
differing teaching methods to determine: specif-
ication of just what the differences in methods
really amount to, analysis of changes in student
behavior as a function of the differences in
teaching methods, and differences in criterion
performances (learning) among students in the
various teaching situations.
     In sum, there clearly exists a need for "in
school" investigations of the discovery learning
hypothesis for at least two reasons. First of all,
such investigations can provide data to support or
reject the use of discovery learning methods;
minimally, such research projects are likely to
provide data that will suggest new areas of the
problem that ought to be considered further.
Secondly, such investigations can provide
information relevant to several side issues --
specifically those hypotheses that have been set
forth concerning the likely side effects of discov-
ery learning versus other types of learning.

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METHODOLOGY

Setting and subjects:
        The Creative Learning Center in Dallas,
Texas is a year-round Montessori day school
for bright children aged one to seven; seventy
percent of the students are from poverty-area
homes, and the children come from Black, White,
Mexican-American, and American Indian families.
Students are pre-selected for admission to the
school by various social agencies, are then
tested on standard tests, and are admitted if
they are found to be above average in intelligence.
        During the course of the study, fifty-five
children were registered as students at the
school. Two children did not attend long enough
to be given complete testing, and one child would
not come to the research room. The data from the
remaining fifty-two children were used in the
study.

The learning situation:
        It was necessary to set up a learning
situation where the effects of discovery learning
could be compared to the effects of another
teaching method. Given the ages of the children
involved, and the availability of standardized
tests, it was decided to teach reading and spelling
skills using a "talking typewriter" program
similar to that originally designed by Moore (9),
and incorporating some of the non-computerized
variations suggested by Nimnicht (10). Basically,
the system consisted of one child and a teacher
working together, with the child doing the typing
and the teacher aiding the child in various ways.
The teacher and child were seated next to each
other, the child in front of an electric type-
writer modified for school use by the addition of
lower-case letters on the keyboard and the choice
of a very large, easy-to-read type size. Other
materials included masonite letters, cards with
pictured objects and the object names printed
beneath, a typed list of the names of the children
in the school, some early reading books, and a
typed alphabet. Additional supplies were brought
in as dictated by the progress of the children.

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Pre-typed lesson plans were created that called
for a wide range of typing activities such as
letter and word copying, word completion,
sentence completion, etc.

Besides allowing great control over the
teaching method due to only one child being
present at a time, this system made videotaping
for research purposes easy. Also, with the use
of a carbon paper system, copies of all the typing
done by the children could be kept, available
for later analyses. The researcher was new to the
field of education and had no particular prefer-
ence for any one teaching method; this was espec-
ially important in that the researcher also
filled the role of teacher in the study.

Independent variable:
The children were randomly divided into a
non-directed (ND) group and a teacher-directed (TD)
group; each group contained 26 children. Except
for the amount of teacher direction given, all
other aspects of the learning situation were
kept as similar as possible for the two groups.
Specifically, the children were asked about
coming to the typing room in a random order, and
all were approached with the same question:
"Would you like to come to the typing room?" (If
they refused, they were asked again the next day.
If they refused again, they missed that turn. The
children averaged slightly more than one turn per
week.) All were given the same maximum amount of
time in the room (10 minutes), were allowed to
leave whenever they desired, and were given a choice
of typing on a pre-planned lesson or on a blank
piece of paper. No matter which paper was chosen,
the teacher inserted it in the machine, due to the
difficulty the children had manipulating two sheets
of paper and the carbon. For both groups, if a
child hit more than one key at a time the machine
was shut off for ten seconds, the jammed keys were
released, and the teacher said, "Just hit one
key at a time." Throughout the typing session,
the teacher tried to maintain good rapport
with the child, and at the end of the time the
teacher quickly summarized what had been done
during that lesson.

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The two groups differed in the following
ways: For the NDs, no explanation was given
about the materials on the pre-planned lesson
sheet unless the children indicated, verbally
or otherwise, that they wanted an explanation.
The teacher did not urge NDs to do any particular
kind of work, nor did the teacher mention or
attempt to correct any mistakes made by the ND
children unless the children asked for the
information. No attempt was made to keep the
NDs at the typewriter; several of them spent
time looking at pictures, playing with the
videotape camera, etc. Basically, every effort
was made to put the NDs in a discovery learning
situation, where the initiation and direction
of learning tasks were left up to the children.
    Children in the TD group were told the pur-
pose of the pre-planned lesson sheets (for
example, "... and on this paper, the idea is for
you to make another letter just like the one you
see here.") before they chose between it and the
blank sheet of paper. If TDs chose the pre-planned
lesson sheet, it would be put in the typewriter,
and they would then be reminded of the purpose
of the particular lesson and would be urged gently
to work at it in that way. If TDs chose to work
independently or to look at other things in the
room, they were encouraged at least three times
to work at the lesson. Strong pressure by the
teacher was avoided. For this group, errors in
copying or writing words and letters were
mentioned, and the children in this group were
encouraged to correct their mistakes. For the
TDs, the goal was to set up a learning situation
in which the teacher lead each child through
progressive stages of reading and spelling
achievement.

Test instruments:
    The Wide Range Achievement Test was given
to the children at the beginning and end of the
study, the average time between pre-testing and
post-testing being 7 months and 26 days. All
tests were scored double-blind. The major
dependent variables, hereafter called "gain
scores," equalled the differences between the

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child's post-test and pre-test scores in reading
and spelling. At the end of the study, the
children were given an oral questionnaire
(Appendix A) in order to ascertain their
subjective opinions of the typing program.

Hypotheses:
1. Gain scores for the NDs will differ
   significantly from gain scores for the
   TDs -- a two-tailed hypothesis. The size
   of the difference may relate to the child-
   ren's ages, sexes, social-economic statuses
   (poverty versus non-poverty), or races.

To test the Friedlander contention that
children in the TD mode will have lessened self-
motivation and the Kersh contention that NDs will
learn more on their own, and to explore the
ramifications of Kornreich's suggestion that
children in different teaching systems will
behave differently, these one-tailed hypotheses
were formulated:
2A. The TDs will be less willing than the
    NDs to come to the typing room;
2B. The TDs will do less work than the NDs;
2C. The TDs will choose to do pre-planned
    lessons (versus blank paper) a smaller
    percentage of the time than will the NDs;
2D. The TDs will leave the typing room early
    more often than will the NDs; and
2E. The TDs will indicate on their answers
    to the questionnaire less pleasure in
    typing, less desire to come to the typing
    room, and less desire to work at the
    typewriter (versus working on other things
    in the typing room) than will the NDs.

A supplementary evaluation of the value of
the "talking typewriter" program can be made by
checking Nimnicht's contention that there was
"a positive correlation of .76 between the
number of times a child went to the booth and
the (learning) phase the child reached." (10:37)
The third hypothesis is, therefore, that:
3. There will be a positive correlation
   between the number of lessons given
   and the size of the gain scores.

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RESULTS

Validity of independent variable:
    In attempting to prove the validity of the
experimental manipulation -- that is, to prove
that the ND and TD groups actually were taught
under differing conditions -- a videotape was made
of the opening minute of typing sessions with
each of 42 randomly chosen children. This tape,
rating instructions, and semantic differential
rating sheets (Appendix B) were given to each of
three raters -- all familiar with the field of
education and professionally involved in it.
The raters were not told the purpose of the
study, nor were they told which children were in
each of the groups.
    The fifteen pairs of adjectives on the
semantic differential were chosen so that three
pairs reflected the manipulations present in the
independent variable (teacher-led:child-led,
directive:non-directive, and leading:following).
In choosing other pairs of adjectives, emphasis
was placed on finding those pairs that might be
likely to eliminate alternate hypotheses if
learning differences were found between the NDs
and TDs. For example, it could easily be argued
that different levels of attention by the teacher
might be present in teaching one group with a
directive method, and the other group with a
non-directive method; therefore, one pair of
adjectives included was "attentive:negligent."
For the most part, the remaining pairs of adjec-
tives were chosen from the major factors found
by Osgood, Suci, and Tannenbaum (11:53-61).
    Of the fifteen scales, it was predicted
that only the three scales reflecting the independ-
ent variable manipulation would show significant
differences between the two groups of children.
It was expected that: the teacher would be rated
as more "leading" for the TD group; the teacher
would be rated as more "directive" for the TD
group; the lesson would be rated as more "teacher-
led" for the TD group. All other scales were
predicted not to differ significantly for the two
groups. Reliability of the semantic differential
has been previously demonstrated (11).
    Rating results may be seen in Figure 1. The

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Figure 1
T-test Differences in Semantic Differential

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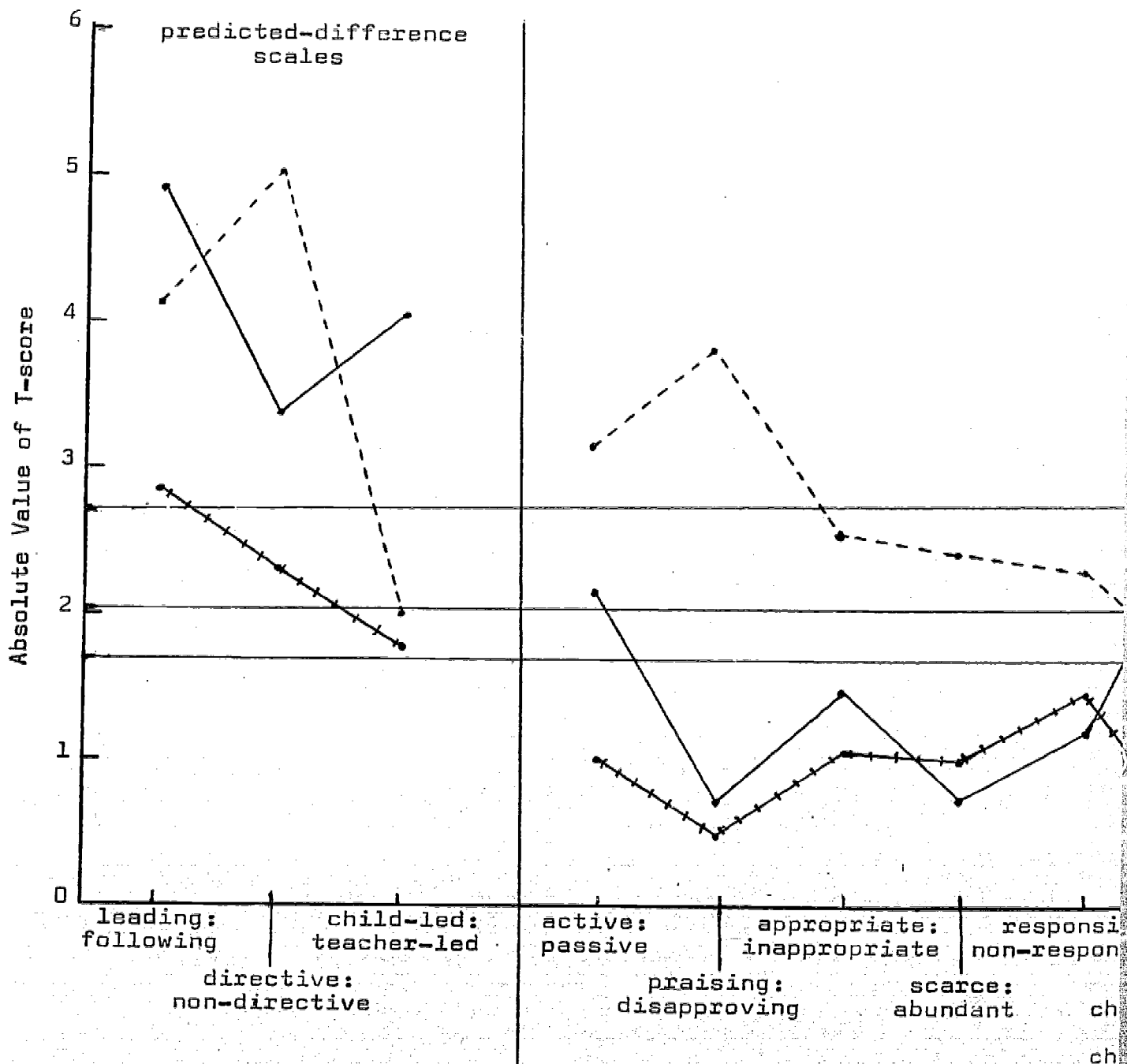
atings for the ND Versus TD Groups

no-predicted-difference
          scales

Rater 1 ————————
Rater 2 +++++++++
Rater 3 — — — — — —

p<.01

p<.05

p<.10

ve: attentive: orderly: helping:
sive   negligent   disorderly   hindering

   above   neat: distressed: pleasant:
ild's level: messy   comfortable   unpleasant
      below
ild's level
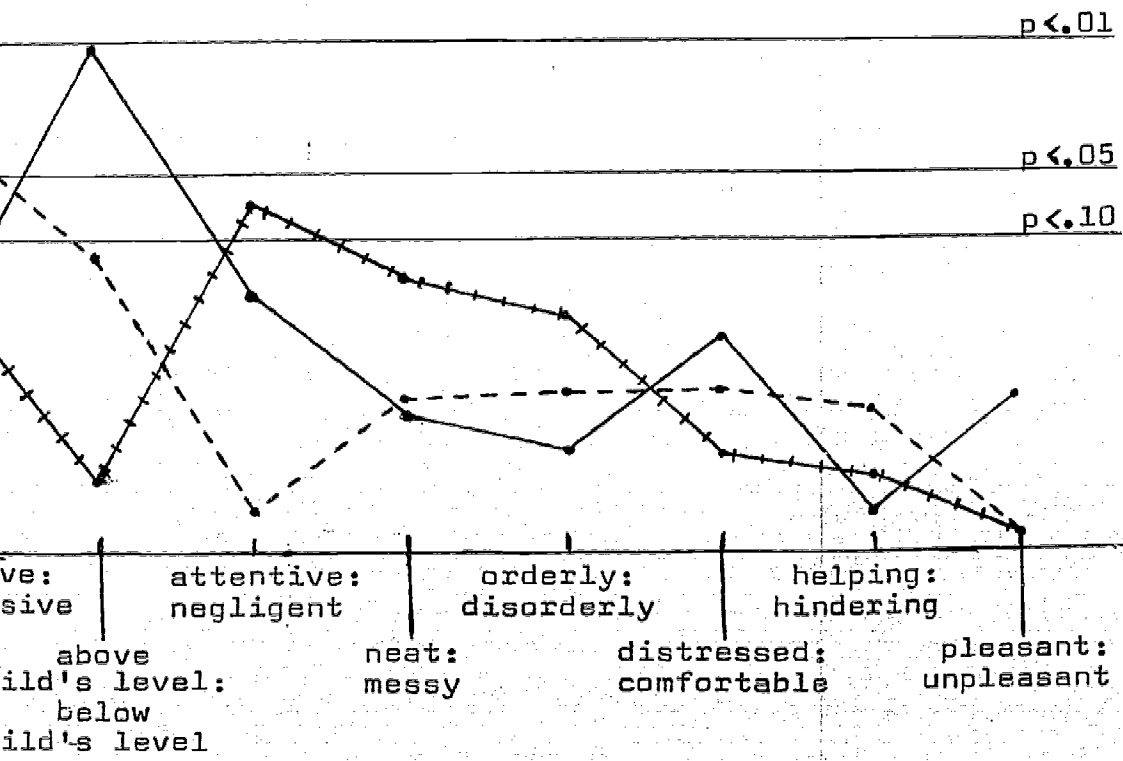
Rating Scales

three raters agreed -- all at the p<.01 level
for two of the three predicted-difference scales,
and with one rater at the p<.01 level and two
raters at the p<.10 level for the third scale --
that the two groups of children differed in the
expected directions. On only one of the twelve
no-predicted-difference scales did as many as
two of the raters agree that there were signif-
icant differences between the two groups of
children; on 6 no-predicted-difference scales
only one rater found significant differences; on
5 no-predicted-difference scales, no rater found
significant differences. The only no-predicted-
difference scale on which as many as two raters
found significant differences (one at the p<.05
and one at the p<.10 level) was the "active:passive"
scale. Both raters rated the teacher as more
active with the TD group. This finding offers
little reproach to the method, simply indicating
that directiveness on the part of a teacher
requires more activity than does non-directiveness.
        The results would be "cleaner" if all of
the no-predicted-difference scales had shown no
significant differences for any rater, but in
light of the few raters used and the relatively
broad ratings that were called for, it is clear
that the experimental manipulations have been
shown to be valid. It is possible for a single
teacher to structure two methods of teaching --
one directive and the other non-directive -- so
that valid and predictable differences can be
found between them; furthermore, this can be done
without producing strong differences in areas
other than the one being manipulated.

Data for the hypotheses:
        The validity of the experimental manipulation
having been proven, consider the data for the
major hypotheses of the study. For the first
hypothesis, no significant differences in gain
score existed between the TDs and NDs, either
when the scores were compared alone, or when
they were controlled for age, sex, social-
economic status, or race of the children.
        For hypothesis 2A, that the TDs will be
less willing than the NDs to come to the typing
room; the data in Table 1 indicate that no such

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difference existed at a significant level.

Table 1
Chi-square Data Relating to Hypothesis 2A

	TD	ND
No refusals to come typing	17	13
At least one refusal to come typing	9	13

$$X^2 = 1.26 \text{ (one-tailed)}$$
p>.10, non-significant

For hypothesis 2B, that the TDs will do less
work than will the NDs, it must be noted that the
amount of work done by the children could be
measured in many ways. Due to the time-consuming
nature of attempting to count "number of words
typed" or "number of letters typed" and due to
the questionable validity of such measures --
because many children practiced typing numbers,
practiced reading, and practiced various mechanical
operations on the typewriter -- it was decided that
a comparison of amount of work done between the TDs
and NDs would be based on the number of pages
typed per lesson. Table 2 shows the pertinent data.

Table 2
T-test Data Relating to Hypothesis 2B

Average number of pages per lesson:

TD	ND
1.14	1.25

t=1.59 (one-tailed)
p<.10, trend

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For hypothesis 2C, that the TDs will choose
to do pre-planned lessons (versus blank paper) a
smaller percentage of the time than will the
NDs; Table 3 shows that no such difference existed
at a significant level.

Table 3
T-test Data Relating to Hypothesis 2C

Percentage of lessons chosen,
(versus blank paper)

TD	ND
.27	.34

$t=1.18$ (one-tailed)
$p>.10$, non-significant

For hypothesis 2D, that the TDs will leave
the typing room early more often than will the NDs,
Table 4 shows that the difference between the
groups was non-significant.

Table 4
Chi-square Data Relating to Hypothesis 2D

	TD	ND
Child never left room before time was up	13	8
Child left at least once before time was up	13	18

$X^2=2.00$ (one-tailed)
$p>.10$, non-significant

For hypothesis 2E, the children's answers
to seven of the eight questionnaire items showed
acquiescence or reticence to great to make the
items reliable. The answers to question 3 --
"What do you like to do best in the typing room?"
-- were divided so that all replies indicating

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preference for spelling, reading, or typing
activities were included under the "typing"
category, and all other responses were counted
in the "non-typing" category. These categories
were decided upon before detailed data analyses
were done; note also that because some of the
subjects gave more than one preference, the
total number of preferences is greater that
than the number of children in the study.
Table 5 supplies the relevant data.

Table 5
Chi-square Data Relating to Hypothesis 2E

	TD	ND
Typing	14	19
Non-typing	12	11

$$X^2 = .56 \text{ (one-tailed)}$$
$$p > .10, \text{ non-significant}$$

In checking Nimnicht's finding of a .76
correlation between the number of visits to the
typing room and the learning phase reached, a
Pearson product-moment correlation was run between
the number of visits made by the children and the
size of the combined -- reading and spelling --
gain scores. An r of +.40 resulted, $p < .01$; this
strongly supports Nimnicht's findings.

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CONCLUSIONS

Despite ample evidence that the TD and ND groups of children were taught under two distinctly different teaching methods, differences between the groups in reading and spelling achievement were wholly non-significant. While it is unfortunate to find support only for the null hypothesis, such a finding suggests that the advantages often claimed for one or the other method are rather overstated. Even if it is the case in short-term research studies that TD groups do differ from ND groups in amount of achievement, the results from the present study indicate that such differences are unlikely to carry over to long-term, school-like situations.

As far as subsidiary hypotheses are concerned; while a single measure of motivation did show the TDs to differ from the NDs at the $p < .10$ level, this trend is almost completely lost among the four other measures of motivation which yielded no significant differences between the two groups. Clearly, the thrust of the data does not support either Friedlander or Kersh in their expectations of motivational differences between the teacher-directed and the non-directed groups of children.

Finally, as a subsidiary point, further evidence of the efficacy of a "talking typewriter" program with young children was found.

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Appendix A

Post-test questionnaire (administered orally)

1. Do you like to come to the typing room?

2. If you could change anything about the way we play with the typewriter, what would you change?

3. What do you like to do best in the typing room?

4. Do you have a typewriter at home?   Do you ever use it?   How often?
Who else uses it?

5. Would you like to come to the typing room more often?

6. What do you not like about the typewriter?

7. Do you like to type?

8. What do you like best about the typewriter?

Appendix B

Semantic differential rating sheet (form 1)*

Typewriter Project, Page __

Subject Number __

A. The instructor was:

FOLLOWING / / / / / / / / LEADING
DIRECTIVE / / / / / / / / NON-DIRECTIVE
COMFORTABLE / / / / / / / / DISTRESSED
HINDERING / / / / / / / / HELPING
DISAPPROVING / / / / / / / / PRAISING
ATTENTIVE / / / / / / / / NEGLIGENT
RESPONSIVE / / / / / / / / NON-RESPONSIVE
ACTIVE / / / / / / / / PASSIVE
UNPLEASANT / / / / / / / / PLEASANT

B. The materials were:

NEAT / / / / / / / / MESSY
ABUNDANT / / / / / / / / SCARCE
APPROPRIATE / / / / / / / / INAPPROPRIATE

C. The lesson was:

ABOVE   BELOW
CHILD'S LEVEL / / / / / / / / CHILD'S LEVEL
DISORDERLY / / / / / / / / ORDERLY
TEACHER-LED / / / / / / / / CHILD-LED

*Form 2, the same as form 1 but with the scales
in another order, was alternated with form 1 in
the stack of 42 rating sheets given to each rater.
This was done to lessen any error due to scale
position.

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