DOCUMENT RESUME

ED 220 276 SE 038 801

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TITLE Wait Time and Questioning Skills of Middle School Science Teachers. Final Technical Report.
INSTITUTION New York State Univ. System, Albany.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE Jun 82
GRANT NSF/SED-82006; SED-80-15819
NOTE 37p.

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Classroom Communication; Discussion; Electronic Equipment; Elementary Secondary Education; *Feedback; Middle Schools; *Questioning Techniques; Science Education; *Science Teachers
IDENTIFIERS *Science Education Research; *Wait Time

ABSTRACT

This investigation focused on teachers' questioning skills and the use of wait time (length of pauses after questions). A sample of 40 experienced middle school science teachers from 5 suburban school districts in 1 central New York State county was divided into 4 treatment groups of 10 teachers each. One group received instruction in wait time using a newly-developed electronic feedback device that monitors the duration of teacher and student pauses. (A green light glows when the criterion of a 3 second pause is met.) A second group received instruction in general questioning skills. A third group received both instruction and the use of the feedback device, while the fourth group served as a comparison and received neither instruction nor the electronic device. Tape recordings of class discussions were coded and analyzed for classroom interaction data. Comparisons were made using discriminant analysis, analyses of variance, and correlational relationships. The two groups using the electronic feedback device increased their wait time (although not to the 3 second criterion), used greater numbers of high level questions, and received more contributions from students as measured by length of answers, frequency of volunteered contributions, numbers of relevant student words, and percentages of student talk. (Author/PEB)

NSF/SED-82006

FINAL TECHNICAL REPORT

"Wait Time and Questioning Skills of Middle School Science Teachers."

SED No. 8015819

SUNY - Oswego
Oswego, New York 13126

J. Nathan Swift, Director
Department of Secondary Education

June, 1982

CONTENTS

This technical report contains the following:

NATIONAL SCIENCE FOUNDATION Washington, D.C. 20550	FINAL PROJECT REPORT NSF FORM 98A	
PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING		
PART I—PROJECT IDENTIFICATION INFORMATION		
1. Institution and Address SUNY - Oswego Oswego, N. Y. 13126	2. NSF Program RISE 4. Award Period From 10/1/80 To 3/31/82	3. NSF Award Number SED 8015819 5. Cumulative Award Amount 72,257
6. Project Title Wait Time and Questioning Skills of Middle School Science Teachers		

PART II—SUMMARY OF COMPLETED PROJECT (FOR PUBLIC USE)

Wait time is the term used to define the length of pauses between teachers and students engaged in discussions. Usually wait times are short, interfering with learning. For middle school science teachers at the start of this project, the pauses between students' responses and teachers' responses averaged 1.25 seconds; the pauses between students' responses and teachers' replies averaged .55 seconds. In this study, one group of ten experienced teachers were provided with written materials designed to improve their questioning skills, including suggestions for techniques for lengthening wait times. These materials were ineffective. The second group of ten teachers were provided with electronic devices that gave immediate feedback on wait time durations. These teachers made significant changes in their wait times, with increases of 100%, improved the thinking levels in their classrooms, and had greater student participation. The third group used both the feedback devices and the written materials. They too improved significantly, with wait time increases averaging 50%. Changes similar to the second group were found, but they were not as dramatic. A fourth group was observed for comparison purposes. Elevation of cognitive levels and increases in wait times are important. Others have found that both factors are strongly related to gains in science achievement. The use of electronic feedback devices promises to offer an effective method of improving school instruction.

PART III—TECHNICAL INFORMATION (FOR PROGRAM MANAGEMENT USES)

1. ITEM (Check appropriate blocks)	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM Check (✓)	Approx. Date
a. Abstracts of Theses	X				
b. Publication Citations		X			
c. Data on Scientific Collaborators		X			
d. Information on Inventions	X				
e. Technical Description of Project and Results		X			
f. Other (specify)					

2. Principal Investigator/Project Director Name (Typed)	3. Principal Investigator/Project Director Signature	4. Date
J. Nathan Swift	J. Nathan Swift	6/14/82

NSF Form 98A (5-78) Supersedes All Previous Editions

Form Approved OMB No. 99R0013

Technical Abstract

Wait time, the duration of teacher pauses after questions, is an important variable in research on science teaching. This project investigated the effects of increasing teachers' wait times on general questioning skills in science teaching. In previous research, the influence of wait time training has been confounded with instruction in general questioning skills, making it difficult to test the hypothesis that increasing the wait time will by itself improve classroom discussions. In this project, these variables were separated through the use of four treatment groups made up of science teachers. One group received instruction in wait time using a newly developed electronic feedback device that monitors the duration of teacher and student pauses; a second group received instruction in general questioning skills; a third group received both types of instruction; a comparison group received no instruction of either type. The tape recordings were coded and analyzed for classroom interaction data. Comparisons were made using discriminant analysis, analyses of variance, and correlational relationships. The wait time feedback devices facilitated the production of wait time means consistently superior to base-line performance, albeit slightly below the three second criterion sought. Regardless, the feedback groups did produce a large number of the hypothesized changes. Significant effects were found from a comparison of the discriminant function scores. Effects consistently favored the groups with the feedback devices. The presence of the guides seemed to make little difference. The groups with the devices used greater numbers of high level questions, especially those of the evaluative level. There were more contributions from students, as measured by length of answers, frequency of volunteered contributions, numbers of relevant student words, and percentages of student talk.

Publication Citations.

Journals:

1. Gooding, S. T., Gooding, C. T., and Swift, J. N. A microcomputer based pause analysis apparatus. Behavior Research Methods and Instrumentation, (in press).

2. Swift, J. N. & Gooding, C. T. Interaction of wait time feedback and questioning instruction in middle school science teaching. Journal of Research in Science Teaching, (in press).

Presentations:

1. Swift, J. N. & Gooding, C. T. Teaching about wait time. Paper presented at the meeting of the Association of Educators for the Teaching of Science, Rochester, N. Y., May, 1981.

2. Swift, J. N. & Gooding, C. T. Importance of wait time in science teaching. Report presented to science teachers, Conference Day, Liverpool, N. Y., October, 1981.

3. Gooding, S. T., Gooding, C. T., & Swift, J. N. A microcomputer based pause analysis apparatus. Paper presented at the National Conference on the Use of On-Line Computers in Psychology, Philadelphia, Pa., November, 1981.

4. Gooding, C. T. & Swift, J. N. Modifying teacher questioning behavior in classroom interaction. Paper presented at the meeting of the Eastern Educational Research Association, West Palm Beach, Fla., February, 1982.

5. Swift, J. N. & Gooding, C. T. The effect of wait time feedback on teacher-student interaction in classroom discussion. Paper presented at the meeting of the National Association for Research in Science Teaching, Chicago, Ill., April, 1982.

6. Swift, J. N., Gooding, C. T. & Swift, P. R. Importance of wait time in teaching. Report presented to school administrators, Jamesville-Dewitt Public Schools, Dewitt, N. Y., May 1982.

7. Swift, J. N., Swift, P. R. & Gooding, C. T. Improving wait time skills. To be presented at the meeting of the National Science Teachers Association, Baltimore, Md., November, 1982.

Interaction of Wait Time Feedback and Questioning Instruction on Middle School Science Teaching

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Running Head: Wait Time Feedback

Interaction of Wait Time Feedback and Questioning Instruction on Middle School Science Teaching

Investigations pioneered by Rowe (1974a, 1974b, 1978) identified two pauses in the dialogue between elementary school teachers and their students that appear to be critical variables in the determination of the cognitive level and the affective climate of classrooms. The first pause occurs after teachers ask questions (and before students respond). The second occurs after students pause momentarily in their replies without teachers ascertaining that the students have completed their replies. Rowe has labeled the pauses wait time 1 and wait time 2 respectively. She found the first to be about one second long, the second to be about .9 seconds. She also found that significant improvement in the intellectual and interpersonal climate of the science classrooms could be produced by training teachers to increase the length of these pauses to three seconds or longer. Others (Chewprecha, 1977; DeTure, 1979; Fagan, Hassler, & Szabo, 1981; Marsh, 1978; Tobin, 1979; Winterton, 1976) have extended these findings to high school and college classes in many subject-matter disciplines. The relationship of wait time to achievement has been summarized by Tobin and Capie (1981).

Objectives

Efforts to train teachers to increase their pauses following questions have been only partially successful. Difficulties in training teachers to use wait times of three seconds prompted the development of an electronic device that provides immediate feedback concerning the duration of wait time pauses. This monitor permitted feedback to be given to teachers and students free of other information regarding teaching skills. In previous research, the influence of wait time training has been confounded with instruction in general questioning skills, making it difficult to test the hypothesis that increasing wait time by itself would improve questioning skill. This study allowed the examination of these variables in isolation and together.

Method

A factorial design, illustrated in Figure 1, was utilized, thus permitting the examination of interaction effects. The independent variables studied were:

1. Training. The use of printed materials on questioning techniques in classroom discussion.

2. Feedback. The use of the wait time devices to provide immediate feedback on pauses following questions and responses.

Insert Figure 1 about here

In the training conditions teachers were provided with a series of eight instructional booklets called Discussion Guides. Each guide described one or more principles of effective questioning. They included: wait time instruction, general questioning techniques, use of divergent questions, development of questioning strategies, and methods for increasing student participation. The booklets provided examples of the principles and gave suggestions for their use in class.

In the feedback conditions teachers used the electronic apparatus during their class discussions, which gave visual indication of wait times. Through the operation of a voice activated relay system, the teacher was provided with a green light signal when the appropriate criterion of a three second pause was met. A red light indicator on the classroom apparatus showed that someone was talking or that the three second pause criterion had not yet been met. Both teachers and students monitored their wait times in this manner.

Description of the Four Groups

The participants assigned to group I served as a comparison group with class discussions being taped for analysis. The teachers assigned to experimental group II were provided with instruction in effective questioning techniques. Recording devices were installed in their classes for monitoring discussions, but wait time feedback devices were not used. Experimental group III consisted of teachers whose classrooms had wait time feedback monitoring devices provided for their use. These teachers were not given instructional protocols on effective questioning techniques, but were instructed only in the use and purpose of the feedback devices. Members of group IV were given wait time feedback monitors, and each teacher received printed instructional protocols describing effective questioning techniques.

Hypotheses

It was hypothesized that the experimental groups of teachers would exhibit: (A) a more conversational tone in their classrooms as shown by 1) longer wait time durations, 2) decreased questioning rates, 3) greater length of responses, 4) more frequent questions from students, and 5) less teacher domination; (B) improved affective climate as shown by 1) fewer failures to respond, 2) decreased numbers of disciplinary acts, 3) fewer inflected responses, 4) fewer interruptions of each other, and 5) fewer derogatory comments; and (C) improved cognitive levels as shown by 1) greater uses of high level questions by teachers, 2) fewer memory level questions, and 3) more student responses that contain statements of evidence or suggested experiments.

Dependent Variables

Variables reflecting teacher behavior which were analyzed in this study included: 1) frequency of questions, 2) classification by question level (e.g., memory, convergent, divergent, or evaluative), 3) number and percentage of higher level questions, 4) rhetorical, management, leading, and chain (repetitive or sequential) questions, and 5) disciplinary remarks. Measures of student behavior included: 1) frequency and length of a) responses, b) volunteered contributions relevant to the discussion, and c) student generated questions, 2) failures to respond, and 3) inflected responses. Those reflecting both teacher and student behavior included: 1) length of wait times, 2) frequency of interruptions and insults, and 3) the percentage of teacher and student talk.

Subjects

A sample of 40 middle school science teachers were drawn from experienced faculty members in five suburban school districts. The sample of schools was obtained by subsampling the middle schools in one Central New York State county. The teachers in the study were assigned to four groups of ten teachers with each group consisting of one to seven teachers from three or more schools as illustrated in Figure 1. The sample of teachers was drawn randomly from middle school teachers within schools. The schools were randomly assigned to the four treatment conditions. Clusters were necessary to minimize the transfer of ideas or apparatus from one experimental group to another. One class from the total number of sections of science instruction offered by each teacher participant was utilized in this project.

A condition for acceptance into the project was the completion of at least one year of teaching experience. Of the 40 participants, 38 were tenured. The experience levels ranged from one to 23 years, with a mean of 12 and a standard deviation of 6 years.

Procedure

As a condition of volunteering to participate in the study, each teacher was asked to conduct one discussion period per week which was tape recorded. After an initial period of three weeks to accustom the teachers and students to preparing tape recordings and for the gathering of base-line data, the experimental variables were introduced. Those using feedback devices were instructed in proper usage of the instruments. Those receiving the printed instructional materials received one Discussion Guide each week for eight weeks. The comparison teachers received encouragement through placebos.

Personal contacts with the participants were kept to a minimum for the duration of the study. All communications were by letter. When contacts were made with the teachers in the experimental groups, parallel letters (placebos) were sent to the members of the comparison group.

Toward the end of the study several notable events transpired. There was a delay of one week in the project between weeks 10 and 11 due to a spring holiday. Wait time devices were withdrawn from groups III and IV at the close of week 14. A final discussion tape was prepared during week 15 in the absence of wait time feedback. This was done to evaluate the stability of the treatment.

An impartial observer coded the tape recordings so that the name of the teacher, treatment number, and date of the tape were not revealed to the analysis team. After transcriptions of the tape recordings, data gathered from teacher pa[illegible]icipants was recorded on logging sheets. Wait times were measured using special computer-driven equipment designed to monitor pauses in human speech (Gooding, Gooding, & Swift, 1982). Pre-data, intermediate-data, and post-data were tabulated for all 40 participants.

Questions were classified using the system developed by Blosser (1973). Two modifications in her procedure were deemed necessary (see Table 1). Convergent questions were divided into two categories. The first was used to denote simple transformations (classification B-1). The second was used to identify more complex operations encompassing application and higher cognitive levels (B-2).

Insert Table 1 about here

The other modification involved classroom management questions. Ordinary management questions, such as "Will you please open your books to page 312?"

were categorized in the "Management" (M) category. The label "Management Plus" (M+) was given to questions that relate to furthering the objectives of the lesson. Questions such as "Do you understand?" and "Jim, do you have anything to add?" were included in this category.

Results

Prior to the introduction of the experimental variables, there were no significant differences between the wait time means of the four groups. The wait time 1 mean of 1.18 seconds was slightly longer than the one second that is frequently cited. Wait time 2 means were surprisingly short, only .55 seconds. Wait time 1 means differed by only .20 seconds among the four groups; the difference was only .02 for wait time 2.

After the introduction of the experimental variables, clear differences developed among the four groups. Table 2 shows the analysis of variance summary for wait time 1 and 2. Discussion guides produced only a slight increase in the teachers' wait times. The use of the feedback devices caused the teachers to increase their wait times significantly. Interaction effects were also significant, favoring those who had access to the devices without the additional complication of reading the written materials. Although the wait times were much longer than on the base-line data, the pause means did not achieve the desired three second criterion.

Insert Table 2 here

Discriminant analysis (SPSS, 1975) was chosen as a means for summarizing the wealth of information concerning the dynamics of the classrooms. The discriminant function was used primarily in its descriptive form to provide a set of scores which had the properties of maximizing classroom differences and independence. In the present study the discriminant scores may be regarded as analogous to the scores generated in factor or principal component analysis (Cooley & Lohnes, 1976).

Between group differences were summarized by using the discriminant functions as dependent variables. Discriminant function score means, reported in Table 3, were similar across the four groups initially. Analysis of variance of the intermediate data set (weeks 4 through 13) revealed that the experimental treatment produced distinct differences, describe in Table 4. Greatest changes occurred when teachers and students used the feedback devices, with the differences significant beyond the .0001 level. The effect of the guides, significant at the .04 level, was such that teachers who did not have guides obtained higher means than those with guides.

Insert Table 3 and Table 4 here

Treatment effects were at a maximum by the time of the fifth week of the project, as indicated in Figure 2. Subsequently, the differences among the four groups diminished as the semester evolved toward the termination of the school year. The two groups with feedback devices consistently obtained higher mean scores so long as the devices were in place. Removal of the devices, and perhaps the pressure of coming final examinations, resulted in the performance of the groups with feedback being reduced to that of the groups without immediate feedback.

Insert Figure 2 here

Specific treatment effects were evaluated using an ANOVA for each variable of interest. Of greatest importance is the use of higher level questions. This category consists of convergent questions of the application level and higher as well as divergent and evaluative questions. Regardless of whether one scrutinizes the number of higher level questions ($p = .035$), the percentage of these questions ($p = .050$), or the number of higher level questions with the total number of questions as covariate ($p = .033$), the use of the feedback devices appeared to increase the use of these questions. For example, groups I and II (guides) used 14.11 and 14.20 percent higher level questions; groups III and IV (feedback) percentages were 22.04 and 19.15 percent respectively. Although the guides emphasized the value of higher levels of questioning, their use produced no change in the higher-level question variables.

Other significant treatment effects that appeared in the two groups which received immediate feedback on the length of wait times were:

1. more frequent use of evaluative questions ($p = .050$),
2. less frequent use of chain questions ($p = .040$),
3. more frequent contributions of volunteered information relevant to the discussion ($p = .006$),
4. longer answers to questions ($p = .003$),

5. a lower percentage of teacher talk (p = .000), and

6. more student words relevant to the discussion uttered by students (p = .001).

Guides produced fewer changes in the teachers' classes. Those noted were:

1. more frequent use of leading questions (not a desired change) (p = .005),

2. a lower percentage of teacher talk (p = .002), and

3. more student words relevant to the discussion uttered by students (p = .040).

No interaction effects between the main variables were significant.

Summary Conclusions, and Implications

Four groups of ten teachers each made tape recordings of middle school science classes once each week for 15 weeks. Base-line data were collected during the first 3 weeks. Group I was a comparison group. Group II received instructional material on discussion and questioning skills weekly for 8 weeks. Group III was instructed to use an electronic device that provided immediate feedback on wait time during that period. No additional information was provided to this group. Group IV received both the feedback device and the weekly discussion guides. The tape recordings were coded and analyzed for classroom interaction data. Comparisons were made using discriminant analysis and analyses of variance.

Significant effects were found from a comparison of the discriminant function scores. Effects consistently favored the groups with the feedback devices. The presence of the guides seemed to make little difference. The groups with the devices used greater numbers of high level questions, especially those at the evaluative level. There were more contributions from students, as measured by length of answers, frequency of volunteered contributions, numbers of relevant student words, and percentages of student talk. Additionally, feedback group teachers did not ask as many multiple (chain) questions.

The wait time feedback devices facilitated the production of wait time means consistently superior to base-line performance, albeit slightly below the three second criterion sought. Regardless, the feedback groups did produce a large number of the hypothesized changes. Thus, it appeared that any real change in wait time is sufficient to change a large number of measureable classroom variables. The result of these changes was a higher cognitive level and a greater contribution by students to classroom discussions.

The guides were constructed with great care. All were based on research findings. None were very long and, distributed weekly, did not pose any imposition on the planning time of the teachers. A reaction sheet, collected weekly, provided evidence that they were read. In spite of these precautions, guides appeared to bring about minimal improvements in questioning skills. For example, the first guide concentrated on extending wait time, but only a slight change was effected.

It is also important to point out the fact that all four groups experienced a downward trend on the discriminant analysis data plots following week 13. Between weeks 13 and 14 the wait time devices were removed from the classrooms. Thus it may be that the teachers in all groups reverted to a drill type of discussion format in preparation for final examinations which were given immediately following the Memorial Day weekend (week 15). Group III, the group which experienced the greatest effects under the treatment, experienced the greatest decline. It may also be that those teachers felt a stronger impulse to review quickly now that examinations were imminent.

When the experiment was designed, it was anticipated that the wait times and other behavioral changes would be greater for group IV than for group III. The fact that the wait times were longer for group III is intriguing. The available data does not provide the means to offer an explanation for this outcome. One explanation is that the ten teachers in group IV were fundamentally different from those in group III. Another possibility, also intriguing, is that the teachers who had guides and wait time devices may have had difficulty managing multiple tasks. Subsequent discussions with the teachers suggest this as a possible explanation. More research will be required in order to arrive at a definitive answer to this interesting question.

In summary, it was concluded that instructional materials alone produce little change in teaching behavior. Feedback procedures, modifying the wait time behavior of both students and teachers, do produce a consistent pattern of increasing the cognitive levels and interaction in middle school science classrooms.

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Footnote

This research was supported in part by a grant from the National Science Foundation (Contract No. SED80-15819). The opinions expressed in this paper are those of the authors, and do not necessarily reflect the position, policy, or endorsement of the National Science Foundation.

		FEEDBACK: ABSENT	FEEDBACK: PRESENT
TRAINING	ABSENT	10 Teachers (Group I)	10 Teachers (Group III)
	PRESENT	10 Teachers (Group II)	10 Teachers (Group IV)

Group I = Comparison Groups

Group II = Printed Guides Only

Group III = Wait Time Feedback Only

Group IV = Both Guides and Feedback

Figure I. Research design.

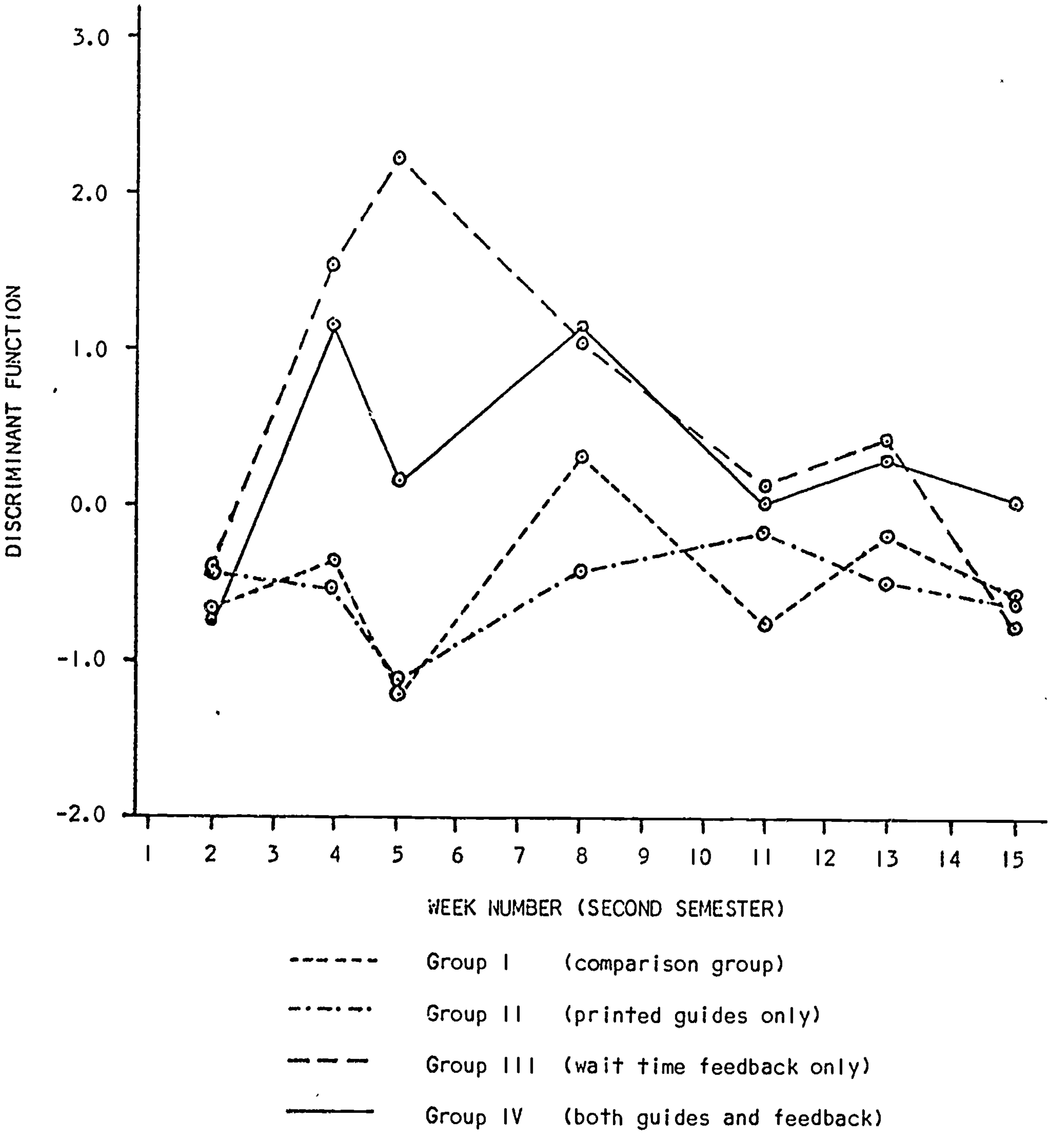

Figure 2. Canonical discriminant functions evaluated at group means.

Table I

The Question Category System for Science

Level I	Level II	Level III	This Study
I. Closed Questions	A. Cognitive-Memory	1. Recall 2. Identify, Name, or Observe	A
	B. Convergent Thinking	1. Associate, Discriminate, or Classify 2. Reformulate	B-1
		3. Apply 4. Synthesize 5. Closed Prediction 6. Make "Critical" Judgment	B-2
II. Open Questions	C. Divergent Thinking	1. Give Opinion 2. Open Prediction 3. Infer or Imply	C
	D. Evaluative Thinking	1. Justify 2. Design 3. Affective Judgment 4. Cognitive Judgment	D
III. Rhetorical Questions	(not subdivided)		R
IV. Managerial Questions	A. Management		M
	B. Management Plus		M+

Table 2

Analysis of Variance Results for Mean Wait Times in Seconds

	Comparison Group	Experimental Groups					
	Group I Mean	Group II Mean	Group III Mean	Group IV Mean	Source of Variation	F	p
Wait Time I	1.19	1.35	2.62	1.80	Between Guides	3.44	.065
					Between Feedback	27.88	.000
					Interaction	1.63	.007
Wait Time II	.54	.68	1.36	.97	Between Guides	1.34	.248
					Between Feedback	26.61	.000
					Interaction	6.19	.014

Table 3

Discriminant Function Analysis Cell Means

Week	Groups			
	I	II	III	IV
2	-0.63	-0.41	-0.39	-0.67
Treatment Variables Introduced				
4	-0.38	-0.53	1.57	1.18
5	-1.21	-1.13	2.27	0.17
8	0.34	-0.34	1.08	1.19
Spring Vacation				
11	-0.77	-0.16	0.15	0.05
Last of 8 Discussion Guides Distributed				
13	-0.17	-0.48	0.45	0.33
Wait Time Feedback Devices Removed				
15	-0.52	-0.60	-0.73	0.07
Weeks 4 through 13	-0.42	-0.53	1.12	0.59

Table 4

Analysis of Variance Results for Discriminant Function Scores
Weeks 2 through 13

By Variable 2 (Guides)
Variable 3 (Feedback Device)
Variable 6 (Time)

Source of Variation	Sum of Squares	*df*	Mean Square	*F*	*p*
Main Effects	106.80	6	17.80	15.62	.000
Variable 2	4.90	1	4.90	4.30	.040
Variable 3	85.80	1	85.80	75.31	.000
Variable 6	15.64	4	3.91	3.43	.010
Two Way Interactions	33.90	9	3.76	3.30	.001
Variable 2 Variable 3	2.31	1	2.31	2.03	.156
Variable 2 Variable 6	8.40	4	2.10	1.84	.123
Variable 3 Variable 6	22.93	4	5.73	5.03	.001
Three Way Interactions	12.24	4	3.06	2.68	.033
Variable 2 Variable 3 Variable 6	12.24	4	3.06	2.68	.033
Explained	152.96	19	8.05	7.06	.000
Residual	199.39	175	1.13		
Total (193 Cases)	352.35	194	1.81		

A Microcomputer Based Pause Analysis Apparatus

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Behavior Research Methods in Instrumentation, (in press).

A microcomputer-based pause analysis apparatus

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The study of pauses in human speech is an important component of the psycholinguistic analysis of speech patterns. Since the inception of this type of research, problems in instrumentation have presented a number of concerns. These problems have been well documented in the literature in pausology. While accurate instrumentation has been developed by several research teams, cost of such equipment has been high, and hand recording of data has been required. This report describes a microcomputer-based pause analysis apparatus, which enables the measurement of pause times precise to better than .01 sec at less cost than previous technology. The apparatus consists of analog hardware and digital computer hardware and software. A printout provides a permanent record of pause times keyed on a line-by-line basis to transcripts. Flexibility is built in by means of a BASIC program enabling specifications for selections of pauses between words, phrases, or sentences based on pause duration.

The study of pauses in human speech is an important aspect of the psycholinguistic analysis of speech patterns. Some researchers are interested in the pauses that divide words and phrases; others are interested in wait time, the pauses that occur between questions and responses. Recent research on pauses in interactive speech in educational settings has made accurate measurement of pauses in dialogue imperative. However, instrumentation in the field of pausology has presented serious problems to researchers. As early as 1965, Goldman-Eisler called attention to the fact that rectifier devices available in those early stages of pausology research were inadequate for reliable monitoring of speech pauses. Shortly thereafter, improvements in instrumentation utilizing a decade counter (Hewlett-Packard AC-4A/B) and a digital recorder (Hewlett-Packard 560A) were reported (Goldman-Eisler, 1968). In subsequent years, pause measurement instrumentation has continued to improve.

PROBLEM

Because of instrumentation costs, pausology research has made widespread use of subjective judgment in monitoring the location and frequency of unfilled pauses, even in more recent studies (Braehler & Zenz, 1975; O'Connell & Kowal, 1981). These authors have noted that more reliable and valid measures, such as those produced by an audio-frequency spectrometer and level recorder, are imperative if progress is to be made. O'Connell and Kowal have found that such instrumentation as the Bruel and Kjaer audio-frequency spectrometer (Type 2112) and level recorder (Type 2305) provides a precise and objective measure of pauses. Problems remain, however, because even sophisticated apparatus requires laborious and time-consuming hand recording of data and equipment costs are high.

Au—Should this be Brüel?

The newly developed apparatus described in this report represents an advance in pause measurement instrumentation, since it provides an accurate measure of pause time in speech and does so at considerably less cost than earlier technology did. This apparatus was designed and constructed as part of a National Science Foundation funded research project in science education. The project, which deals with teacher pauses in questioning behavior and subsequent effects on student behavior, further extends and evaluates the pioneering work of Rowe (1974) on pause patterns of teachers. The study, consisting of audio-tape data from 40 science classes, produced 6,000 min of audio-taped transcriptions. Faced with such a large amount of data for pause-time analysis, it was imperative that an automated pause analysis system be developed.

INSTRUMENTATION

The complete pause measurement package incorporates analog hardware and digital computer hardware and software. The analog components are composed of

This research was supported in part by National Science Foundation Grant SED 8015819, J. Nathan Swift, principal investigator. Findings and opinions expressed in this paper are solely the responsibility of the authors. Information concerning software, including program listings, is available from the authors.

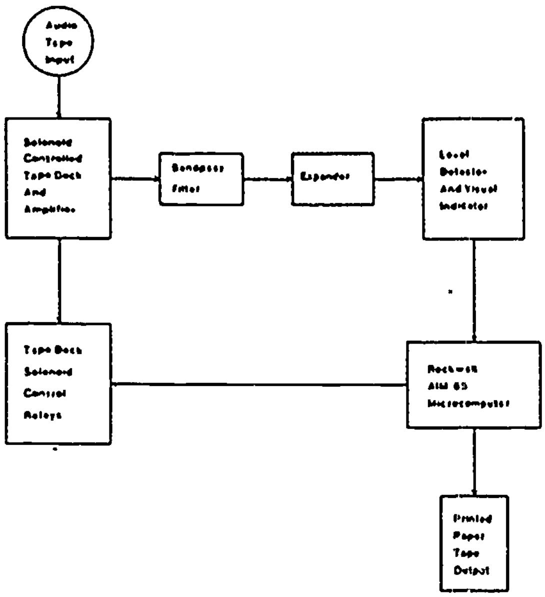

Figure 2. Pause analysis apparatus block diagram.

adjustment to permit tape hiss and background noise rejection.

The output of the level-crossing detector is conditioned by the custom digital interface. Visual indication of level-crossing detection is also provided by this circuit. The output of this interface circuit is fed directly into the AIM 65 microcomputer. The remainder of the custom interface circuit provides computer control of the cassette tape through a simple relay setup.

The assembly language subroutine continuously samples the digital signal from the interface circuit at high speed. Pauses are detected by determining when valid speech stops. Noise bursts during the pause are rejected. When valid speech is again detected, the value representing the total pause time is passed to the BASIC language program. Samples are taken at .001-sec intervals, and groups of 255 are evaluated. This results in a minimum pause detection time of .255 sec, with .001-sec detection accuracy after initial pause detection occurs. Thus, all pauses less than .255 sec are recorded by the assembly language subroutine as .255 sec.

The BASIC program accepts the pause duration values from the assembly language subroutine and converts the value to seconds accurate to three decimal places. The pause duration in seconds and other information is indexed to the speech patterns by operator interaction. This is accomplished through following the dialogue on a transcript as the computer measures the pauses. Valid pauses can then be separated from invalid pauses, noise, or other inappropriate input. Each pause is automatically indexed to the transcript by line number and pause type. Additionally, the cassette tape is started, stopped, and reversed by BASIC subroutines as required. This control is achieved through the simple relay setup in the custom digital interface. Other information and identification can easily be added to the program as required. The paper-tape printout provides a permanent record of the pause times on a line-by-line basis. It also prints the total and mean pause times for each audio tape and accompanying transcript. Thus, the circuit and software in combination perform tape hiss and noise-burst rejection respectively, thereby increasing reliability and validity of the output. Flexibility is built in by means of a parameter that exists in the BASIC program, enabling specifications for selections of pauses between words, phrases, or sentences based on the pause duration. Measurement of pauses is therefore automatic and precise to better than .01 sec. The importance of the .01-sec precision and other variables involved, such as bandpass, must not be under estimated. In order to compare and support results and findings, care must be taken to preserve these baselines and ensure that a similar metric is used. If this is not the case, then any comparison will be invalid.

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a solenoid-controlled audio-cassette tape deck (NAD Model 6140), a 10-band graphic frequency equalizer (Radio Shack Model 31-2000), an audio-signal restoration unit (Symmetric Sound Systems Model ASRU), and a level-crossing detection circuit as diagrammed in Figure 1. The digital hardware features a microcomputer that combines a 6502 microprocessor, an LED display, a thermal printer (Rockwell AIM 65 microcomputer), and a custom digital interface circuit described in Figure 1. The computer software is composed of a high-speed assembly language subroutine and a BASIC language program designed to search, measure, record, tabulate, sum, and average pauses in prerecorded speech. The block diagram in Figure 2 shows the relationship among the components of the instrumentation package.

The level-crossing detector performs the analog-to-digital interface function. It accepts input from the audio tape conditioned by the frequency equalizer and signal restoration unit. The equalizer is set up as a 250-Hz to 1,000-Hz bandpass filter, and the restoration unit provides 8.5 dB of signal expansion. The output of the level crossing detector is digital in nature (being 1s or 0s). The 1 to 0 transitions correspond directly to the audio transitions of the set detection level. This detection level is variable, thus providing

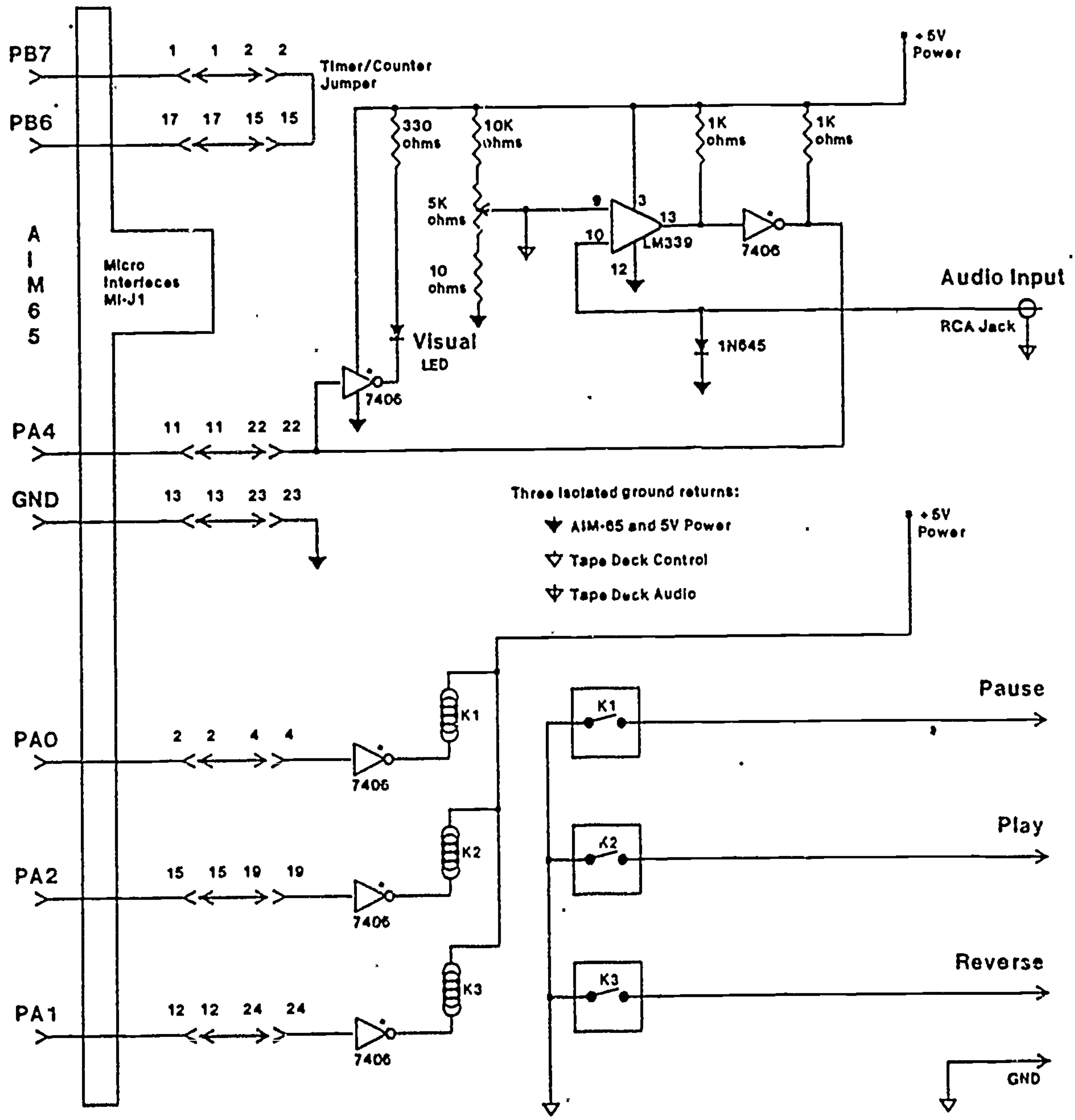

Figure 1. Pause analyzer circuit diagram.

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Note: Five additional graduate students have developed thesis proposals based on the research data collected in this study. These are currently in process.