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ABSTRACT

Students' macroprocessing of instruction was studied in a learning situation which used adjunct questions. The subjects were offered various macroprocessing options while reading a passage on data processing and computer programming. Each sentence appeared on a computer CRT screen one at a time. The options included: (1) review any sentence or sentences; (2) preview any sentence or sentences; (3) consult an alternative text written in an easier vocabulary; (4) review the alternate text; (5) preview the alternate text; (6) take notes; (7) review the notes; (8) view an outline of the 49-paragraph presentation; or (9) view and select from a menu of options. Tests of reading, worry, test anxiety, and study skills were administered. Three groups were assigned: only reading the text; reading and responding to adjunct questions after each screen; or reading, answering questions, and receiving feedback. The computer system monitored which options were selected, as well as the frequency and time requirements. The results suggested that students did not select options which optimized individual achievement; in fact, they may not have known which macroprocesses to use to improve learning. (GDC)

Macroprocesses, Individual Differences and Instructional Methods

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Abstract

This paper reviews the theory and research dealing with students cognitive processing of instruction, or macroprocessing. The results of a study tracking students macroprocessing of instruction in an adjunct question context are reviewed and implications for further research on macroprocesses discussed.

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An implicit assumption of all the papers in this symposium is that learning from instruction depends critically on the frequency and intensity of student cognitive processing of instruction. Doyle (1978) has called these cognitive activities mediating processes, Salomon (1982) talks about the amount of invested mental effort, abbreviated as AIME, and I have called them macroprocesses (Tobias, 1982, 1983). The concepts associated with my colleagues on this symposium, whether Wittrock's (1974) generative learning strategies, Peterson and her colleagues' (1983) student cognitions, or Rohrkemper and her colleagues' (1983) inner speech all fit easily under any of these labels.

Since I am most comfortable with the term macroprocesses, let me describe these, and attempt to distinguish them from other related labels. By macroprocesses I mean those relatively molar cognitive processes students use when they learn from meaningful instruction, such as reviewing, previewing, looking for clarification, and the like. These could, of course, also be called study skills or metacognitive strategies and it may be useful to differentiate between these constructs. Study skills, as used by Weinstein (1983), by Dansereau and his colleagues (1979), and by others, (Brown & Holtzman, 1970) imply both cognitive activities and affective states such as anxiety, motivation, attitudes and the like. Macroprocesses, on the other hand, denote only the cognitive processes used by students to learn from instruction. As indicated previously (Tobias, 1983) metacognitive strategies (Flavell, 1979; Brown, 1980) imply some degree of self-monitoring of one's knowledge; macroprocesses do not carry that implication.

Along with the other participants in this symposium I believe macroprocesses to be critical in enlarging our understanding of meaningful learning. Cognitive processing of instruction is important not only because it is a truism that the type of macroprocessing determines what and how much is learned; equally important is the fact that students are aware of the macroprocesses they use. It is hoped that awareness of these activities means that the processes can be controlled and, if necessary, altered.

As indicated elsewhere (Tobias, 1982, 1983) my interest in macroprocesses came from an attempt to understand conflicting findings dealing with the achievement treatment interaction (ATI) problem. ATI research, of course, investigates interactions between student individual difference characteristics, or aptitudes and different instructional treatments (Cronbach & Snow, 1977). I have preferred the term achievement treatment interaction (Tobias, 1976, 1982). Since that descriptor also gives rise to the ATI abbreviation, that makes life convenient for everyone.

One assumption of instructional research in general is that alternate methods induce different types of macroprocessing. Surprisingly, there is relatively little research substantiating this most basic assumption. My colleagues on this symposium and others around the country are hard at work in an attempt to develop evidence to substantiate this assumption. For an ATI researcher, however, evidence that alternate instructional methods engage different types of macroprocessing is only one third of the job. Another third is that different macroprocesses should be used by students with different affective or cognitive characteristics, or that similar macroprocesses should be used with different frequencies. The final third of the ATI researcher's task is to establish an interaction between the macroprocesses engaged by instructional methods, and those that are characteristic of students at varying points of individual difference dimensions. It should be obvious that in the absence of firm empirical support for either of the first two assumptions evidence for the third will be difficult to obtain. One can readily see why ATIs have been difficult to find, difficult to replicate, and sometimes impossible to understand.

Our task, then, is to conduct the kind of research which will ultimately allow us to infer that different instructional methods will, in fact, lead to alternative cognitive processing for specified students. The other presenters at this symposium have described the ways in which they have attacked this general problem. Peterson and Swing (1983) and Rohrkemper et al (1983), like Winne and Marx (1982), have previously investigated the macroprocessing problem by stimulating the recall of students regarding cognitive processes employed during a class lesson. In such research, lesson videotapes are typically viewed and students interviewed regarding their prior cognitive activities. In another study Winne (1982) used an adjunct question paradigm, and trained students in the strategies they were to use. Salomon (1982) studied macroprocesses by developing a questionnaire asking students to rate the mental effort invested during different types of instruction.

We have taken a somewhat different approach to this problem. Rather than relying on either self-report, or stimulated recall we hoped to track the processes used by offering students various macroprocessing options while learning from text. Students' use of options was monitored while they studied materials displayed by microcomputer and constituted our operational definition of macroprocesses. A 49 paragraph passage was developed introducing students to general concepts of data processing and computer programming, and illustrated by a few instructions in the BASIC language. Sentences were numbered, and appeared on a CRT screen one at a time. When students finished a sentence and pressed the space bar the sentence was erased, though the space it occupied and its number remained on the screen. This slight artificiality was required in order to exercise most of the options to be described below.

All students could choose any of these options: They could 1) review, or 2) preview any sentence, or group of sentences. 3) Students could consult an alternate text written with easier vocabulary (10th grade level on the Frye formula, compared to 14th grade for the original passage) at the end of every paragraph. The alternate passage was also more clearly organized than the main passage with respect to super-ordinate and subordinate paragraph structure. 4) The alternate text could be reviewed, or 5) previewed. 6) Students were able to take notes on the computer system, 7) and review their notes. 8) An organizational display could be requested containing all the headings in the main and alternate text, the sentence numbers covered by each heading, and the number of the sentence students were presently reading. 9) A menu of the options available, and how these could be invoked could also be requested.

In order to assure that students were aware of the available macroprocessing options and understood how to invoke them, a preliminary program was prepared. This program described each of the options, how it was invoked, and required students to use every option before proceeding. In this way, we could be sure that students knew how to use each option prior to starting the instructional passage. Both the preliminary and main programs enabled students to invoke the macroprocesses with minimal time delays, averaging about half a second each.

In addition to the options described above, student volunteers participating in this experiment were administered a multiple choice pre-test (Alpha reliability=.75); only those with raw scores of less than 60% were used in the study. In addition, the following measures were administered: The Nelson-Denny Reading Test, Sarason's (1980) Test Anxiety Scale, plus five scales from Weinstein's (1983) Learning and Study Skills Questionnaire. Morris, Davis & Hutching's (1981) Worry and Emotionality instrument was also administered several times during the study. Finally, after students completed reading the material a constructed response posttest was administered. The alpha reliabilities of the posttest were: incidental .85, relevant .86, and total .92.

In this experiment we examined whether instructional conditions implemented via different text presentation modes changed the frequency and type of macroprocesses used. Students were randomly assigned to three conditions: 1) Merely reading the text; 2) reading the text and responding to adjunct questions appearing after every screenful; 3) reading, adjunct questions and receiving feedback regarding the accuracy of responses. In accord with the procedures widely used in prose investigations we categorized the posttest and the text sentences as to whether they were relevant, or incidental to the adjunct question. The macroprocessing data were also categorized so that we could determine whether the options were invoked to select an incidental, or a relevant text segment. Finally, the program retained whether the options were selected from an incidental or relevant text segment, and noted the frequency as well as time required for option use.

In addition to having objective data regarding use of macroprocesses, another motivation for utilizing this computer based procedure was that we had hoped to avoid the mass of transcribed data Rorhrkemper et al (1983), Peterson and Swing (1983) and their colleagues had to wade through to conduct their data analyses. We were hoping for a neat and clean data set. Needless to say, once the research was completed we found ourselves with 55 rows of data, each containing up to 74 characters, and a total of 225 variables for each of 120 or so students. So much for neat and clean data sets.

Table 1 displays means and standard deviations for some of the major dependent and independent variables in this study, as well as descriptive data on the sample.

Insert Table 1 about here

Multivariate regression analysis of the post test results indicated that, as expected, pretest contributed significantly to the posttest scores. Also as expected, there were significant differences among groups in achievement on both the relevant and incidental part of the posttest. Both groups with adjunct questions had higher scores than those in the read-only group. There was also a main effect attributable to worry, a component of test anxiety (Morris, et al 1981), indicating that anxious students learned less than those lower in anxiety. None of the interactions among these variables were significant.

The means and standard deviations for the macroprocessing options, and percentage of people <u>not</u> employing any of the options are displayed in Table 2.

Insert Table 2 about here

The most striking aspect of these results was the incredible variability for most of the macroprocessing data. The percentage of students who did <u>not</u> use an option at all varied from 18 to 88%. At the other extreme, there were a number of students who used these options very frequently. The standard deviations for these variables attest to the large variability. In order to reduce the effects of outliers we set the data of students whose use of any of these options fell over three standard deviations above the mean at the three standard deviation value. Despite that, it is evident that the variability is still very large indeed. Table 2 also displays the correlations of each of the options with incidental, relevant and total posttest scores.

Multivariate regression analysis of the option data indicated an overall difference for the three groups, with significant univariate effects for use of alternate text and for notetaking. In general the group receiving feedback used the options least frequently, and the adjunct question group most frequently. Neither worry nor pretest score exerted any overall effect on the data, nor did the interaction among any of the variables.

It had been assumed that use of the options would be an index of the intensity of cognitive processing of the subject matter. There is support for this expectation in our data. As indicated above, the group receiving feedback used all of the options less frequently than the other groups. The significant achievement differences among the groups parallel the macroprocessing frequency data. That is, the adjunct question group used the greatest number of options and learned most and the feedback group used the fewest options and learned least. These data, then, support the assumption that the frequency of option use was related to the intensity of macroprocessing, which, in turn probably contributed to the amount learned. While option selection may not have been wise, as discussed below, the frequency of such use did seem related to intensity of processing.

The macroprocessing and achievement differences between the adjunct question and feedback groups confirms some expectations concerning the relationship between instructional support and achievement (Tobias, 1982). It was argued that when an instructional sequence does for students what they can do for themselves, the intensity of cognitive processing is reduced and consequently, that learning is lowered. In this study the feedback may have given students the type of instructional support that the adjunct question group had to provide for themselves. The greater utilization of instructional options by that group suggests that the processing of the material was more active and intense presumably accounting for the higher achievement.

The selection of instructional options by students presented something of a paradox in that two opposing student strategies seemed apparent in the data: 1) Invoke no options, 2) or invoke as many options as possible. Option data suggest that both of these tendencies may have been present. Summing over the totals for all groups indicates that options were <u>not</u> used by a mean of 60% of the students. On the other hand, some students invoked each of the options with incredible frequency. For example, one student used the preview option 168 times in a 173 sentence passage! Clearly, it is hard to justify student's use of options with such frequency as being in the service of improving comprehension.

One possible explanation for the variable option use may be that students do not know which strategies to employ when they encounter learning difficulties. The excessive option use by some students may indicate a relatively random, trial and error pattern of jumping from one type of macroprocessing to another in an attempt to seek help. Students may have been unaware of which strategies were most effective to help them master the material. There are some data to confirm this interpretation. For example, use of the options was uncorrelated with any of the scores on the Nelson-Denny Reading Test If options were selected to improve comprehension, some relationship with the reading indices would, of course, have been expected. Since, as indicated above, there is some reason to believe that option use was related to the intensity of macroprocessing, we suspect that student inability to choose options which were most likely to improve their achievement may well be the major reason for the variability in the selection of macroprocessing data. A final reason for the variability of option use may be that some students invoked few options so as to complete the task as quickly as possible.

I think that there is an important lesson to be learned from these data. Students apparently do not select instructional strategies or options which are ideally suited to them, or which optimize achievement. In fact they may not know which macroprocesses to use to improve learning. The research results dealing with students' preference for instructional methods (Tobias, 1972), and research on the issue of learner control of instruction have also indicated that students do not use instructional strategies wisely.

We are now planning a test of these interpretations. In this study we were interested merely in observing the type of options used by students voluntarily. We were strongly influenced in this strategy by significant findings emerging in the research relating teacher behavior to student achievement (Rosenshine & Stevens, 1981; Brophy, 1979). In that field research was begun with low inference observational schemes in order to determine relationships between student learning and teacher behavior. We have learned from our research that apparently students do <u>not</u> choose macroprocessing options wisely.

In our future research we intend to prescribe student option selection in terms of performance on adjunct questions. That is, we plan to use some groups for whom option use will be determined by the accuracy of responses to adjunct questions. For example, one condition in our next study will require students to review a preceding screenful of text if their answers to adjunct questions are wrong. We are also investigating the possibility of prescribing use of the easier text version for other students depending upon their scores on the reading test, and their response to comprehension questions. In addition, of course, we shall also employ groups with free choice of options to explore whether prescribing option use improves achievement. I hope that by the time next year's AERA convention rolls around that we will have some information on these questions, in addition to the variety of provocative questions aroused whenever student's performance in meaningful instructional situations is subjected to careful scrutiny.

Table 1. Mean and Standard Deviations for Various Variables in Macroprocessing Study, by Group.

Variables	Adjunct Questions plus Feedback	Adjunct Questions	Read Only
Posttest Incidental	13.14 5.40	14.84 5.86	11.99 5.05
Posttest Relevant	17.56 5.28	17.90 6.00	13.91 5.16
Posttest Total	30.70 10.13	32.74 11.48	25.89 9.47
Pretest Incidental	8.34 3.74	8.51 2.87	7.74 3.03
Pretest Relevant	11.10 4.43	12.26 3.82	11.37 3.38
Pretest Total	19.45 7.41	20.77 5.77	19.12 5.45
<u>Anxiety Variables</u>			
Test Anxiety	17.00 6.46	17.97 8.28	19.44 6.35
Worry-Pretest	8.16 3.67	8.62 4.28	8.67 3.84
Emotionality-Pretest	7.39 3.85	8.05 4.66	6.67 2.33
Worry-Program	9.24 3.91	9.62 4.66	9.33 4.04

Table 1 continued.

	Adjunct Questions plus Feedback	Adjunct Questions	Read Only
<u>Anxiety Variables Continued</u>			
Emotionality-Program	7.53 3.68	7.03 2.58	8.05 3.56
Worry-Posttest	8.59 3.26	9.76 4.61	11.86 5.57
Emotionality-Posttest	7.22 3.54	7.50 3.87	7.79 3.56
<u>Nelson-Denny Reading Raw Scores</u>			
Vocabulary	41.18 21.13	42.51 23.75	38.23 22.27
Comprehension	29.60 14.69	30.74 18.32	27.28 16.27
Total	71.58 31.48	72.18 18.32	65.44 36.65
<u>Study Skills</u>			
Motivation	28.08 7.29	31.13 8.89	30.77 8.75
Self-Testing	17.22 4.20	16.53 3.60	16.33 3.18
Self-Scheduling	17.14 3.64	14.40 4.42	15.13 4.63
Attitude	7.06 3.01	7.34 3.00	6.85 2.73
Information Processing	64.30 10.68	55.11 10.08	58.18 13.16

Table 2. Means and Standard Deviations of Option Use, Percentage Not Using Each Option, and Correlations with Posttests

		Adjunct Questions plus Feedback	Adjunct Questions	Read Only
<u>Macroprocessing Frequency Data</u>				
Preview Incidental[1]	M	.55	1.02	1.13
	SD	1.70	2.22	2.11
	<u>r</u> =	-.22	.14	.05
Preview Relevant[2]	M	.50	.72	.49
	SD	1.16	1.56	1.10
	<u>r</u> =	-.30*	.10	.03
Preview Total[3]		1.05	1.74	1.63
		2.51	3.54	3.04
	<u>r</u> =	-.35*	.14	.06
	% not using	69	59	58
Review Incidental[1]	M	5.77	9.53	6.19
	SD	12.17	12.83	11.01
	<u>r</u> =	-.05	.37*	.39**
Review Relevant[2]	M	3.78	6.70	3.74
	SD	8.18	9.82	7.44
	<u>r</u> =	-.02	.36*	.33*
Review Total[3]	M	9.55	16.23	9.93
	SD	20.06	22.24	18.19
	<u>r</u> =	-.03	.37*	.40**
	% not using	54	42	49
Alternate Text Incidental[1]	M	2.53	23.14	9.95
	SD	7.06	29.06	17.46
	<u>r</u> =	-.23	.15	.16

Table 2, part 2

Alternate Text Relevant[2]	M	2.21	14.35	5.44
	SD	6.14	18.60	10.55
	r =	-.20	.10	.09
Alternate Text Total[3]	M.	4.74	37.50	15.40
	SD	13.04	47.32	27.48
	r =	-.21	.14	.14
	% not using	69	52	41
Review-Alternate Incidental[1]	M	1.84	2.23	2.14
	SD	8.78	4.95	6.21
	r =	. 26	.13	-.23
Review-Alternate Relevant[2]	M	.42	2.06	1.32
	SD	1.62	5.29	3.64
	r =	.22	.11	-.24
Review-Alternate Total[3]	M	2.28	4.29	3.46
	SD	10.36	9.94	9.75
	r =	.24	.14	-.27
	% not using	88	88	71
Notes From Incidental[1]	M	2.92	3.79	6.19
	SD	4.72	5.28	7.27
	r =	.26	.22	.19
Notes From Relevant[2]	M	.87	1.74	2.92
	SD	1.56	2.64	4.22
	r =	.43**	.18	.10
Notes Total[3]	M	3.79	5.54	9.10
	SD	5.98	7.67	10.97
	r =	.33*	.21	.20
	% not using	47	32	18
Review-Notes from Incidental[1]	M	.21	.48	.62
	SD	.70	.84	1.24
	r =	.27	.16	.25

Table 2, part 3

Review-Notes from Relevant[2]	M	.08	.20	.30
	SD	.36	.52	.58
	_r_ =	.25	.23	.11
Review-Notes Total[3]	M	.29	.69	.92
	SD	.96	1.09	1.64
	_r_ =	.30	.22	.28
	% not using	86	67	74
Headings from Incidental[1]	M	.39	.64	.91
	SD	.86	1.21	1.28
	_r_ =	-.14	.31	-.07
Headings from Relevant[2]	M	.18	.27	.48
	SD	.56	.57	.78
	_r_ =	-.18	-.20	-.16
Headings Total[3]	M	.58	.92	1.38
	SD	1.11	1.53	1.93
	_r_ =	-.11	.13	-.11
	% not using	72	70	57

1=Correlated with Incidental Posttest
2=Correlated with Relevant Posttest
3=Correlated with Total Posttest

* = _p._ <.05
**= _p._ <.01

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