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ABSTRACT

The cognitive processing capacity (CPC) model of teaching and studying was used to determine whether tenth grade students could improve their performance in biology. The 27 students in the experimental class were taught to study information in quantities that matched their CPC and to chunk these quantities together under a heading in a study outline or diagram. In teaching, the same process was used by the teacher of the experimental class. The control group, another biology class of 27 students, continued to be taught as they had been in the past. After completion of two units of biology, the performances of the experimental group students were superior to those in the control class. Correlations between CPC scores and biology unit test scores tended to account for 46% to 82% of the variance in the control group's biology test scores. On a third biology unit, both classes were taught by the CPC model of teaching, with the experimental class continuing to achieve at a significantly higher level. When a comparison was made of the letter grades received by the two groups of students in their other content area classes, the experimental group had a significantly higher proportion of letter grades that increased versus letter grades that decreased. These findings appeared to add stronger support for the use of the CPC model of teaching and studying in the classroom. (RL)

A Cognitive Processing Capacity Model of Teaching and Studying Applied to Biology

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A Cognitive Processing Capacity Model of Teaching and Studying Applied to Biology[1]

The purpose of this study was to investigate the effects of a cognitive processing capacity (CPC) model of teaching and studying in the learning of biology at the high school level.

In a previous study, CPC and learning modes were found to affect prose learning (Furukawa, 1977). The first factor, CPC, was measured by the simultaneous presentation of a list of 20 adjective-noun pairs. One-half point was given for each correctly recalled word and the average of the sum of the scores on two sets became a subject's CPC score.

The CPC was said to be a measure of innate and acquired knowledge and probably levels of processing (Craik & Lockhart, 1972) as opposed to a measure of short-term memory (Furukawa, 1977). Further, the CPC restricts the quantity of information that a person can process at one time before rehearsals become necessary. On this point, a positive but curvilinear relationship was said to exist between CPC and performance scores on learning tasks (Furukawa, 1970). That is, either too much information or too little information to be processed led to depressed performances. Best performances were recorded when the quantity of information matched the CPC of the learners.

Of the prose learning variables studied earlier, a chunking programmed instruction mode was found to be superior by Furukawa (1977). This learning mode consisted of a programmed unit, an answer sheet, and a chunking study outline (CSO).

The programmed unit was composed of an article segmented into seven sections, with each section consisting of seven completion questions and seven answers. The accompanying directions required the subjects to read the text, answer the questions, and check their answers. The answer sheet had seven section headings and spaces below each one for writing the responses to the questions in the programmed unit. Additionally, the CSO had the same seven section headings, each with seven key words (nouns and adjective-noun pairs). Accompanying instructions explained the organization of the outline and directed the subjects to use the outline in studying by taking each section separately and organizing the key words into a meaningful whole (chunking) under the nexus of the section headings.

Furukawa's chunking programmed instruction mode was prepared for subjects with average (seven) CPC. As such, subjects were to learn information in selected quantities that matched their CPC and to chunk the information into a meaningful whole by using the CSO, with the end product to be recalled being no more than seven information-rich units.

The present study was an attempt to apply Furukawa's findings to a particular classroom situation but with one major difference: The programmed instruction was eliminated. This step was taken for two reasons. First, if the cost (time and money) of preparing the program could be reduced, the CPC model of teaching and studying might be more likely to receive wider acceptance and use. Second, the model would be more compatible for use in the average classroom where the lecture is probably the most prevalent method of teaching. The investigators recognize, nevertheless, that the programmed instructions mode has value in the individualization of instruction, particularly in certain presentation modes, such as computer-assisted instruction and television productions.

The following two questions were asked in the present investigation: (1) Could the achievement of "average" tenth graders in biology classes be improved by use of the CPC model of teaching and studying? and (2) Could the students successfully generalize the model of studying from biology to other subjects and improve their grades?

Method

Subjects

The participants were tenth grade students in two biology classes taught by the same teacher in successive classes. Each class consisted of 27 students who were designated by the school authorities as being "average" based on their grade and teacher ratings.

Materials

The CPC test of Furukawa (1977) was administered.

A programmed instruction book on the CPC model of studying was used to teach the students how to study (Furukawa, 1978). The book was programmed for average CPC students, with paragraphs of material followed by about seven questions and answers--answers that were nouns or adjective-noun pairs listed in an outline format. Three chapters of the programmed book were devoted to the study method and the fourth to testing.

Four other chapters dealing with causes of failure and similar topics were omitted from the student training program.

The CPC model of studying described in the programmed text consisted of three parts: CPC, pyramid of knowledge, and chunking. The CPC part required each individual to capitalize on his or her particular CPC by using it as a gauge of the quantity of information to be processed at one time. Once the capacity was "filled," the learner was to process this information in a prescribed way. The determination of an appropriate quantity of information and the processing of the information are described in the following two parts of the CPC model.

The pyramid of knowledge is embodied in a chunking study outline (CSO). Unlike the traditional outline, the CSO is drastically reduced in content. That is, the contents are limited to chapter and section headings and subjects of paragraphs and key sentences. Nevertheless, like a traditonal outline, the format is as follows: I, A, 1, a. (See Figure 1 for a sample of a CSO.)

Insert Figure 1 about here

According to Furukawa (1978), each line of information in the CSO is to be treated initially as a discrete unit of information. Consequently, a learner with a CPC of five would limit his or her learning at the first stage (see Figure 1) to "I. Respiration" and stop after "b. carbon dioxide." The actual number of units of information at this point is six instead of five because students should avoid separating information under a heading (p. 83, Furukawa, 1978). This CPC-filling set of six units is to be processed by chunking.

<u>Chunking</u> is described as "a process whereby quantities of information in a chunking study outline are grouped together and remembered as a single unit" (Furukawa, 1978) and follows Miller's (1956) definition. During the initial stage of learning the parts (e.g., the set of information identified in the CSO in the previous paragraph) are chunked into a meaningful whole. Thus, the recall of "Respiration" should lead to the recall of the subordinate units of information. These separate "wholes" are rechunked into a <u>single</u> meaningful whole. This successive chunking process is apparently unlimited.

The classes taught during the three-month field study required the attainment of certain instructional objectives that were primarily based upon information contained in three chapters of a biology textbook. For each of these chapters, a CSO was prepared. The CSO was composed of hierarchically structured headings and key words (normally nouns and adjective-noun pairs) that were subjects of the paragraphs and/or key sentences.

Diagrams and summary sheets were also provided. A sample summary sheet is shown in Figure 2. These learning aids were

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Insert Figure 2 about here

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designed to facilitate use of the CPC model of teaching and studying.

Quizzes were administered after each of the chapters of Furukawa's programmed unit and after each of the biology chapters. Four unit tests were also prepared: one for the programmed unit on study skills and three for the chapters of the biology text. The first two biology tests were 30-item multiple-choice tests, and the last one was a 20-item multiple-choice test.

Procedure

The investigators spent the first week teaching the CPC model of studying to the students. Thereafter, the classes were conducted by the regular classroom teacher using the CPC model of teaching. The CPC model differed in teaching and studying aspects only in terms of the user. For example, whereas the student attempts to learn the materials shown in Figure 1 as described in an earlier discussion of the pyramid of knowledge, the teacher, instead, begins by introducing the topic by placing the five Roman numeral headings on the board. Next, assuming that the students have a CPC of five, the items on the outline (Figure 1) from "I. Respiration" through "b. carbon dioxide" would be placed on the chalkboard and discussed. Finally, the information would be chunked by the teacher, perhaps by asking, "As for respiration, what can we say about 'living things'?" and reviewing the major points of the discussion. In short, the teacher models the behaviors that the students should manifest in order to learn.

At the end of each biology unit, the teacher administered a test. Quizzes were also given almost weekly as a section of a biology unit was completed.

Although the initial plan called for one class to be an experimental group and the other to be a control group, this plan was abandoned at the end of the second unit test on biology. The investigators felt that the results were conclusively in favor of the experimental group and, therefore, the control group should not have been deprived of the learning aids.

Results

The mean and standard deviation on the CPC test for the experimental group were 6.87 and 1.31, respectively. Those for the control group were 6.40 and 1.46.

The mean and standard deviation for the 30-item tests on the first two biology units were as shown in Table 1. A repeated measures (tests one and two) analysis of variance was completed on the two independent groups. The main effect for the experimental group versus the control group was significant, $\underline{F}$ (1, 38) = 14.58, $\underline{p} < .001$.

Insert Table 1 about here

The third biology test consisted of 20 questions instead of 30. The difference between the two groups was still significant, $\underline{t}$ (49) = 3.01, $p < .01$ although both groups were taught identically with the CPC model. The only difference being that the "control" group was never taught the CPC model of studying. The mean and standard deviation for the experimental group were 16.48 and 2.41, in that order, and 13.75 and 3.81, respectively, for the control group.

The correlations between CPC scores and biology test scores are shown in Table 2. When corrected for possible attenuation

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Insert Table 2 about here

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of range in both scores--these were students of average CPC and relatively restricted variability--the correlations for the control group tended to account for anywhere from 46% to 80% of the variance in biology test scores. On the other hand, the correlations between CPC and performances on tests one and three were low for the experimental group.

The students' ability to generalize the study skills from biology to other courses was investigated. Specifically, the two groups were compared with respect to the number of grades that went up and the number that went down from one report card period to the next. The students in the CPC model group averaged a 1.48 letter grade increase and a 1.04 decrease. In contrast, the control group students averaged a .83 increase and a 1.39 decrease in letter grades. The observed differences in the proportion of letter grades that increased to those that decreased for the two groups were significant, X^2 (1) = 7.34, $p < .01$.

Discussion

The tenth grade students in the experimental group were able to master the CPC model of studying and to use it successfully with the assistance of their biology teacher, who used the CPC model of teaching. The experimental group maintained its superiority on the third chapter of the biology textbook even though the control group was also taught with the CPC model. One reason for this continued difference was probably the advantage of having learned the CPC model of studying and the additional advantage of having practiced the use of the model. Since much of the learning process occurs outside of the classroom without the aid of the teacher, the studying part of the CPC model may be more important than the teaching part. The best results should be obtained when both are used together.

The correlation between CPC scores and biology test scores emphasizes the importance of the CPC model of teaching and studying. If the students and teachers do not use the model, the high-CPC students are more likely to surpass the performances of the low-CPC students. This finding is supported by other studies (e.g., Furukawa, 1970; 1977). Nevertheless, there appears to be a discrepancy in the substantial correlation found for the experimental group on test two when compared to those of the other two tests. This increase, from test one to test two, also appears for the control group. The increase was probably the result of a substantially more difficult biology unit which required the memorization of parts of the heart and the circulation of the blood. This increased correlation between CPC and test performances could be prevented or reduced by giving the students more time to study and/or by providing additional highly organized materials designed to make it easier to study.

The fact that the grades of the experimental group showed a significant increase in contrast to the decrease shown by the control group needs to be interpreted cautiously. In a field study of this type, stringent controls obviously could not be imposed. Consequently, it may be impossible to say that the

CPC model of studying was solely responsible for the increase in grades in other subjects. The results may be due to a motivational factor--having improved their grades in biology may have had a "halo effect." Nevertheless, if the increase in grades in the other subjects is tentatively attributed to the effects of the CPC model, barring viable alternative hypotheses, then the statement may be made that the generalizations might not have been as successful if the students had not been shown how to apply and practice the use of the CPC model in the biology class. It is also possible that the application of the model in studying in other content areas could have been more effective if the teachers in the other courses had also used the model.

In short, the findings seem to indicate that the CPC model of teaching and studying is effective in increasing student achievement and that it can also be used to learn different kinds of materials.

Footnote

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Table 1

Means and Standard Deviations on Biology Unit Tests

Groups	Test One	Test Two
Experimental		
Mean	19.56	21.00
Standard deviation	4.29	3.89
Control		
Mean	15.37	15.96
Standard deviation	3.36	4.68

Table 2

Correlations Between CPC and Biology Unit Test Scores

	Test One		Test Two		Test Three	
Groups	U[a]	C[b]	U	C	U	C
Experimental	.04	.006	.45*	.77**	.04	.008
Control	.41*	.68**	.63**	.90**	.58**	.80**

a = Uncorrected correlation

b = Corrected correlation

* $p < .05$

** $p < .01$

Figure 1

Sample Chunking Study Outline

Chapter 43. Respiration and Energy Exchange

I. Respiration

II. Parts of the Respiratory System

III. Mechanics of Breathing

IV. Gas Exchange

V. Environmental Affects

I. Respiration

A. Living things (p. 569)

1. all cells

2. definition

a. oxygen

b. carbon dioxide

B. Two phases (p. 569)

1. external

a. exchange

b. lungs

2. internal

a. exchange

b. cells

(The remainder of this outline has been omitted.)

Figure 2

Summary Sheet

Circulation of Blood Through the Heart

In (right)	Lungs (left & right)	Out (left)
1. vena cava: superior, inferior		
2. right atrium		8. left atrium
3. right A-V valve		9. left A-V valve
4. right ventricle		10. left ventricle
	5. semilunar valve	11. semilunar valves of the aorta
	6. pulmonary arteries: left and right	12. aorta
	7. pulmonary veins: left and right	