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AUTHOR	Allen, ~-ockenbrough S.
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ABSTRACT

The feasibility of guiding students of moderate aptitude to select appropriate learning strategies while they are learning an imaginary classification system was investigated in a study that contrasted the effect of system-assigned strategies for learning concepts with strategies selected by students. Subject-matter content was based on a set of imaginary particle systems similar to atoms or molecules. The classification system consisted of 10 major categories and encompassed approximately 200,000 unique instances. Subjects were 39 volunteers from a continuation high school, who used a computer program to explore the organization of the classification system by selecting and viewing paired examples of defined concepts and who received varied strategy recommendations. In the computer system-assigned strategy treatment, students were given strategies for selecting matched examples and non-examples of concepts, remembering concept attributes, and reviewing concept definitions. In the student-assigned strategy treatment, students received non-directive placebo instructions. A 30-item classification post-test, administered immediately after program use, measured concept acquisition. Results showed a borderline treatment effect favoring the system-assigned strategies. (Author/LMM)

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The Effect of System-assigned Exemplar-comparison Strategies on Acquisition of Coordinate Concepts

Brockenbrough S. Allen
Educational Technology Program
San Diego State University

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ABSTRACT

The Effect of System-assigned Exemplar-comparison Strategies on Acquisition of Coordinate Concepts*

Brockenbrough S. Allen
Educational Technology Program
San Diego State University

This study contrasted the effect of system-assigned strategies for learning concepts with strategies selected by students. Subject-matter content was based on a set of imaginary particle systems similar to atoms or molecules. The classification system consisted of 10 major categories and encompassed approximately 200,000 unique instances.

Treatments were implemented by a computer program that allowed students to explore the organization of the classification system by selecting and viewing paired examples of defined concepts. During this time period, students received the strategy recommendations which represent the treatment conditions.

In the system-assigned strategy treatment, students were provided with strategies for selecting matched examples and non-examples of concepts, for remembering concept attributes, and for reviewing concept definitions. In the student-assigned strategy treatment, students received non-directive placebo instructions. All strategy instructions were free of references to the subject-matter content.

Procedures. Students were screened from the student body of a continuation high school, using scores on the Wide-Range Achievement Test (WRAT). Those with a grade-level equivalent of at least 5.3 for math achievement and at least 6.8 for reading were asked if they wished to participate in the experiment. Volunteers were randomly assigned to treatment groups.

Each participant completed the conditions subtest of the Culture-Free Intelligence Test. Scores from this test were used for covariate control of prior aptitude for concept learning. Verbal instructions (based on written protocols) were used to orient students to the computer system and to introduce prerequisite content relating to the terminology of the imaginary particle systems. Students were also shown sample items from the posttest.

Students in each treatment group then used the computer system to explore the Xenograde concepts. System-assigned learning strategies and placebo strategies were provided to the respective treatment groups at at measured intervals during this period.

A thirty-item classification test administered immediately following the exploratory session served as a measure of concept acquisition.

Findings. Scores on the classification test were subjected to an analysis of covariance using scores on the Culture-Free Intelligence Test as a control for prior conceptual ability. Results indicate a borderline treatment effect ($F = 3.55$, $p = .07$) favoring the system-assigned strategies.

* Paper presented at the Annual Meeting of the Research and Theory Division of the Association for Educational Communication and Technology, January 17-22, 1985, Anaheim, CA. A copy of the complete paper will be included in the proceedings of the conference.

The Effect of System-assigned Learning Strategies on Acquisition of Coordinate Concepts

Brockenbrough S. Allen
Educational Technology Program
San Diego State University

Effective instructional presentations must, by definition, induce mental processes that result in desired performance. Conventional approaches to instructional design usually attempt to induce the necessary mental processing through cues and other stimuli that are built into the fabric of content presentations. The content is interlaced with elements that are intended to get the learner to think about the material in helpful ways. Common examples of this approach include repeating or paraphrasing key points, asking questions, supplying illustrative diagrams or pictures and providing examples or analogies.

Independent learners--those who are free of the need for instruction--must be able to induce the required internal processing on their own. Presumably, such learners can select and apply appropriate learning strategies without help. These learning strategies are often analogous to the explicit representations of external instruction: paraphrasing or repeating to oneself, asking and answering self-generated questions, forming images, generating analogies and examples, and so on. An expert learner knows <u>which</u> of these internal processes will be effective methods for mastering the required skills and knowledge.

<u>Degree of Instructional Support</u>. But what kind of support is required by learners who fall short of such expertise? Suppose, for example, that a learner already knows something

about how to paraphrase or generate an image, but is unclear about which technique would be effective for a given learning task. It is probably unnecessary (and perhaps even counter-productive) to supply learners with ready-made paraphrasings or images when they are already capable of generating these representations internally. A more appropriate method may be to assist the learner in selecting the best method for a particular learning task. On the other hand, a learner who does not possess strategies appropriate to a learning task is unlikely to profit from directions to use such unmastered skills.

Rigney's Embedded and Detached Strategies. Rigney (1978) has described a convenient framework for describing instructional treatments. He draws a distinction between embedded and detached processing strategies. Embedded processing strategies are reflected in the actual structure of an instructional presentation, in that they encourage or require the learner to process information in certain ways in order to work through the material. A student might, for example, be asked to write the answer to a specific question, to circle part of a diagram or to write a short paragraph applying new knowledge to a familiar personal problem. Detached processing strategies, on the other hand, are independent of the information to be processed. They represent decisions by the student on how to process given information. Detached strategies are based on the assumption that the student has some latitude in selecting task-relevant processing skills from a set of previously acquired skills. Thus, in reading a text book, a student might employ a number of

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learning strategies by, for example, paraphrasing a passage in his or her own words, by engaging in mental imagery, or by relating the new information to a previously encountered instance.

Embedded strategies minimize the demands on the student's internal processing ability by providing the processing in external form as part of the instructional presentation, while detached strategies presume previous acquisition of certain essential processing skills. Many instructional systems combine the two approaches--relying on the student's ability to self-select previously acquired processing skills for some phases of the instruction and providing (or requiring) specific processing strategies in other phases.

Rigney draws an additional distinction--crucial to this discussion--between <u>system-assigned</u> detached strategies and <u>student-assigned</u> detached strategies. System-assigned strategies involve recommendations to the student (by the instructional system) on when to apply one or more previously acquired learning skills. <u>Student-assigned</u> strategies are selected by the student without guidance from the instructional system.

Learning Strategies

A learning strategy can be thought of as a cognitive process that is specifically directed toward the acquisition of new information or skills. Learning strategies may be distinguished from instructional strategies in that they represent processes that are lodged <u>in the learner</u>, rather than those which are based in the instructional presentations.

Callahan and Merrill (1980) have listed some of the learning strategies for which there is empirical support. These include repetition, paraphrasing, creating memorable images, generating or recalling examples, asking self-generated questions, constructing analogies, and so on. It should be noted here that Rigney's (1978) embedded treatments cannot in themselves be considered learning strategies because the desired processing is done for the student by the instructional presentation. Each of the learning strategies cited by Callahan and Merrill can, however, be represented as an analogous instructional strategy by making the process explicit--by repeating material for the student, for example--or by providing the paraphrasing, images, mnemonics, examples, questions, or analogies in external form. The analogous nature of these internal and external representations of processing should not necessarily imply that they rely on equivalent cognitive processes. As Neisser (1976) points out in the case of imagery, for example, construction of images from memory uses processes which may be quite different from perception of images based on immediate sensory data.

Based on the work of Rigney (1979), Bovy (1981) and Salomon (1979), Allen and Merrill (1984) have developed a model for predicting how students of varying aptitude will respond to treatments that include (or omit) recommendations on learning strategies. Listed in the order below, the following treatments reflect an increasing reliance on the student's internal resources for processing information:

1. Treatments that provide the learner with explicit (external) representations (paraphrasings, questions,

examples, analogies etc.) thereby minimizing the need for the student to generate his own representations.

2. Treatments that guide the learner in selecting and applying previously acquired learning strategies.

3. Treatments that leave the student free to select and apply previously acquired learning strategies without external suggestions or interference.

The model predicts that students with low aptitude for a learning task will profit most from the first type of treatment, that students of moderate aptitude will profit most from the second type, and that students of high aptitude will profit most from the third type of treatment.

System Assignment of Learning Strategies

The unanswered question is whether an instructional system can assume the role of guiding the student to select (from previously acquired learning strategies) the most effective strategy for any given part of the learning task. If the concept of system-assignment is to have any meaning, such guidance must be provided while the student is actually engaged in the learning task; otherwise, the student is using a student-assigned strategy.

Allen and Merrill (1984) suggest two reasons for the predicted effectiveness of system-assigned learning strategies: (1) an increase in working memory available for the learning task and (2) an increase in the relevance of learner's information-processing strategies to the performance measure.

Furthermore, Allen and Merrill (1984) suggest that effective system-assigned learning strategies must meet two criteria. First, the strategies should not interfere with the existing

learning strategies of a student who already has a high aptitude for the learning task at hand. Recommending strategies to such a student entails the risk that the new strategies will compete with methods which already work. As Appalacian folk wisdom puts it, "If it ain't broke, don't fix it."

Second, there should be evidence to suggest that the target population has acquired previously a set of learning strategies (or related skills) that are appropriate to the learning task. System-assigned strategies may then serve to guide the student in selecting the most appropriate skill for a given part of the learning task. Since system assignment is defined as direction in the use of previously acquired processing skills, students who lack the prerequisite skills cannot be expected to profit from treatments based on system-assignment.

Studies of learning strategies have typically veered away from investigation of system-assigned treatments. (See for example those in O'Neal, 1978.) Instead, researchers have focused on providing students with a generalized set of learning strategies and study skills; or they have emphasized validation of a specific strategy for a limited task environment. Training in learning strategies usually attempts to cultivate a set of general strategies. During the pretraining phase, the student is taught to use several types of learning strategies. Learners may be taught how to select and apply these strategies, or it may be assumed that they can self-select and apply the appropriate strategies; but in either case, the selection process is managed internally by the student during the actual learning task. In short, these studies are based on cultivation of student-assigned

learning strategies rather than validation of system assignment.

Scope of Study

This study attempts to demonstrate the feasibility of guiding moderate aptitude students to select appropriate learning strategies while they are learning an imaginary classification system.

System-assigned Exemplar-comparison strategies

Ali (1981) has reviewed the use of positive and negative examples in concept teaching. Example/non-example pairs focus attention on the critical attributes that define a concept class. When a system of related concepts is being learned, the exemplars of one concept can be compared with the exemplars of other concepts. In effect, the positive examples of one concept serve as negative examples of other concept classes.

Tennyson and Park (1980) note that the explicit comparison of exemplars is frequently recommended as an instructional strategy. In Rigney's terms, such explicit comparisons represent embedded strategies since the comparisons are provided to the student by the instructional system. These embedded exemplification strategies can, however, be transformed into equivalent system-assigned learning strategies by providing the student with recommendations on <u>how</u> to select or create exemplars. Such strategies would guide the student in selecting exemplars (from the student's own memory or from some external pool of instances) so as to contrast the critical attributes that determine membership in various classes.

Student-assigned strategies are those in which students use their own preferred method for selecting and comparing exemplars.

A study by Callahan and Merrill (1979) provides empirical evidence to support the feasibility of using system-assigned exemplification strategies in concept teaching. This study involved an impoverished learning task in which students were deprived of an adequate number of system-supplied (embedded) examples of a set of defined concepts. Under these circumstances, it was found that when students were directed to recall previously encountered examples of the concepts from memory, they scored higher on a classification test than did students in a control group which received no directions to recall examples from memory.

In Rigney's terms, this study compared the relative effectiveness of a system-assigned detached strategy with a student-assigned detached strategy. The embedded strategy was not included as a treatment, but could have been represented by adding an additional experiment group that would have been shown a carefully chosen set of examples illustrating each concept.

The learning strategies tested in this current study extend the work of Callahan and Merrill in two ways. The Callahan-Merrill treatment guided students to select instances that (1) were stored in the student's own memory (based on previous experience) and (2) served as positive examples of the defined concepts. The treatment described in this current study guided students to select instances which (1) were stored in a computerized data base and (2) served as negative and positive examples of the defined concepts. The strategy treatment used in

the study reported here is, therefore, a better test of the feasibility of representing the example/non-example prescription as an equivalent system-assigned learning strategy.

Research Question

Can system-assigned strategies enhance concept acquisition when compared to student-assigned strategies? This study's hypothesis predicts that when students of moderate academic achievement receive system-assigned learning strategies, they will evidence higher scores on a coordinate concept classification test than similar students who rely on self-selected learning strategies. Rationale: Students of moderate academic aptitude possess previously acquired learning strategies which are relevant to concept acquisition but are independent of conceptual ability. These moderate-aptitude students will thus evidence higher scores when they receive system guidance than when they select learning strategies on their own.

Terminology

For the convenience of the reader, preceding discussion will be summarized as a set of construct definitions. These in turn serve as the basis of experimental variables.

Conceptual ability: the ability to recognize and remember new concepts. Obviously this is a very general construct. It was m[illegible]d in this study by administering the conditions subtest of the Culture Fair Intelligence Test (Institute for Personality and Ability Testing, 1973).

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Coordinate concept classification test: a problem in which the student must classify instances according to a system of defined concepts or categories. By definition, coordinate concepts share a single superordinate class. (Merrill and Tennyson, 1978, p. 144.) The task required of the student in coordinate concept classification problems is to correctly identify any instance with the name of the most-narrowly defined concept which it represents.

Student-assigned strategy: a learning strategy utilized by the student without system guidance.

System-assigned strategy. As used in this study, this term refers to strategies that are delivered over a separate, independently variable information channel--strategies that exclude specific references to subject-matter content. Three system-assigned strategies were used in this study:

1. a strategy for selecting and comparing exemplars from various classes;
2. a strategy for remembering the critical attributes of each concept;
3. a strategy for reviewing concept definitions.

Subject-matter Content

The classification scheme used in this study is loosely based on the imaginary science of Xenograde Systems (Merrill, 1965). As implemented in this current extension of the original Xenograde "curriculum" the scheme groups imaginary particle systems into ten classes on the basis of the type, number and behavior of various sub-particles. In order to control for rote-memory effects, the names of the classes are based on the

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first ten letters of the alphabet (Alphonic, Betonic, Catatonic, etc.)

Computer Displays

Many of the constructs in this study were operationalized using specially designed computer displays designed by the investigator and developed by his associates (Eucker, Cochran, Allen & Merrill, 1982). These programs are intended as a general purpose research tool for investigating instructional design variables related to concept learning. The major features of the system are outlined below. Complete descriptions can be found in Eucker et al.

The programs present three types of displays: (1) definition displays, (2) instance selection and presentation displays, and (3) item displays for a computer-administered classification test.

Definition displays. These displays present a brief definition of each of the ten Xenograde Classes. Class definitions are based on characteristics such as the number of subparticles contained within a system's nucleus, the behavior of subparticles, the number of satellites, and the direction of satellite travel. Other attributes such as nucleus shape are irrelevant to the defined classifications and are varied automatically by the computer program according to a randomizing algorithm. Each display summarizes class attributes--including some that are irrelevant to identification of the specific class. Each display includes an example.

<u>Classification test displays</u>. These displays constitute the coordinate-concept classification test. Each display requires the student to identify an example of one of the various Xenograde classes by selecting the appropriate name from a provided list. Scores on this test served as the dependent variable in the experiment.

<u>Instance selection and presentation displays</u>. Taken together, the instance selection and presentation displays constitute a system for training students to classify specific instances of the Xenograde concepts. These displays allow for a controlled exploration of the classification system. The student selects the attributes she or he wishes to have included in a particular instance. She or he is free to create examples from any of the ten Xenograde classes. Once the attributes have been specified, the student is shown a diagram of the instance and a summary of its attributes. The system allows side-by-side comparison of two different instances. at one time. The first instance selected is labeled "example" by the system; the second instance is labeled "comparison". The student can leave the example in place and select a string of successive comparisons, or can elect to start a new "example" at any time.

<u>Treatments</u>

As previously noted, three strategies were provided in the system-assigned strategy treatment. These orally-administered instructions (summarized below) were based on written protocols.

<u>Strategy for selecting and comparing exemplars</u>. "Create an example of any class you want to learn more about. Then, follow

this rule: Always choose two comparisons for each example. First, choose a comparison which is as different as possible from the example, but still from the same class. This will help you to learn the limits of the class. Then, choose a comparison which is as similar as possible to the example but from a different class. This will help you to see the difference between classes." These instructions were repeated in paraphrase form and a card with a brief summary was placed in front of each student for the remainder of the training period.

Strategy for remembering concept attributes: "Imagine that each one of your fingers is one of of the classes . . . put the classes in some kind of order (10 second pause) . . . imagine that you can attach the special traits of each class to your fingers. This will help you keep the classes organized. . . ."

Strategy for reviewing concept definitions: ". . . try to create an example from each one of the 10 classes."

Student-assigned Strategies Treatment

In Rigney's (1978) usage, the term student-assigned refers to strategies selected and applied according to the student's own predilections. However, in order to control for factors in the system-assigned strategy treatment that might involve motivation or reduction in time-on-task, placebo "strategies" were provided to subjects receiving the student-assigned strategy treatment. These placebos were similar to the strategies described above, except that they were designed to be as non-directive as possible. The placebo method for selection of examples and comparisons was merely ". . . try to identify the special traits which tell each class from all the rest of the classes." The

placebo method for remembering attributes was also non-directive: ". . . try to remember the special traits you've identified." The placebo strategy for reviewing concept definitions was ". . . take the remaining time to review what you've learned."

Measures

Construction of the computer-administered classification test was based on a random sample of the content domain. The sampling procedure employed a computer program that randomly selected attribute conditions for each item. A 30-item test constructed in this manner was piloted on a population of college undergraduates (n = 25). Using Cronbach's alpha coefficient (Merhans and Lehmann, 1975, p. 99), it was found that _ = 0.97. This indicates that item consistency was extremely high, in spite of the homogeneity of the subjects and the small sample size.

A special scoring key was developed in order to increase the ability of the test to measure partial acquisition of concepts. The key compares given responses with correct responses. Points are assigned for each item-response on the basis of the number of critical attributes shared by the given response and the correct response. Using data for the undergraduate subjects, scores adjusted in this way were found to be highly correlated with raw scores, $r = .96$, $p < .001$.

Measurement of conceptual ability. Aptitude for concept learning was measured using the "conditions" subtest of the Culture Fair Intelligence Test (Institute for Personality and Ability Testing, 1973, Form A, Test 4). The total Culture Fair Test correlates moderately well with other measures of

intelligence, average r = .70 (IPAT, p. 11). The test's technical manual cites several studies purporting to show that scores are unaffected by cross-cultural differences. Internal consistency of Form A items was listed as .76. As measured in the undergraduate sample, Cronbach's alpha for the conditions subtest was .65. Validity of the subtest was estimated by correlating subtest scores with performance on the coordinate-concept classification test using the same sample of students, r = .52.

Procedures

A modified Posttest-only Control Group Design (Campbell & Stanley, 1963, p. 25) was used to test the hypothesis.

The Xenograde classification test served as the posttest. The conditions subtest from the Culture Fair Intelligence Test was used in a covariate adjustment of classification test (posttest) scores.

Subject Selection

Subjects were selected from the student body of a continuation high school in Southern California (N = 329). (This is an atypical high school population. According to school administrators, students had diverse reasons--both academic and non-academic--for interrupting normal high school studies.) Grade level equivalence scores on the Wide Range Achievement Test (Guidance Associates, 1976) were used as the criteria for selection. Means (and standard deviations) of the total student body for reading and mathematics were 8.2 (1.96)

and 6.1 (1.55) respectively. The selection criteria established by the investigator required that a student have a minimum reading score of 6.0 and a minimum math score of 5.3. This resulted in a pool of approximately 100 students. The number of students actually participating in the experiment was 39. Means (and standard deviations) for these students were 9.3 (1.39) for reading, and 6.9 (1.19) for math. Distributions for both scores were approximately normal.

Assignment to Treatment Groups

A computer program with a random number generator was used to randomize scheduling of treatments during available school periods. As students were located and recruited, they were assigned to a specific period on a space-available basis.

Apparatus

The experiment was conducted on the high school campus in an unused classroom. Three Apple II computers were placed in study carrels. Charts summarizing Xenograde terminology and a list of definitions of the Xenograde classes were posted on the walls of each carrel. Verbal instructions were administered to students over headphones.

Summary of Instructions to Subjects

A summary of directions to students participating in the experiments follows. Important directions were read from a set of written protocols.

Orientation. Students were told that the experiment was designed to see if it was possible to use video games to teach

people, and that the video game they would play involved learning an imaginary science. Students were informed that participation in the experiment was voluntary. It was announced that the highest scoring student amongst all the participants would win a $25 cash award.

Terminology and definition charts. The investigator directed attention to the charts naming the parts of Xenograde systems and reviewed each of the terms.

Definitions of Xenograde classes. The students were guided through the definition displays. As each display was presented, the investigator read the definitions of Xenograde classes as they appeared on the screen. Students were asked to note similarities and differences between classes, but were instructed not to try to memorize the definitions. Students were also told that the definitions of Xenograde classes posted in the carrel would be removed just before the posttest.

Preview of classification test. Students were led through a portion of the computer-administered classification test. The investigator read the text of the displays, showed students how to start the test, and allowed students to see the first two items. Students were reminded that they would be able to see the list of class names throughout the test and would only be required to supply the first letter of the appropriate name for each item.

Orientation to instance selection and presentation displays. Students were oriented to the use of the instance selector displays and instance presentation displays through a set of written protocols read by the investigator.

Treatment period. Students used the instance selector and instance presentation displays for 40 minutes. The system-assigned and student-assigned (placebo) strategy treatments outlined earlier in this paper were administered to the respective treatment groups during this period. Strategies were read to students at the following time intervals (measured from the start of the period).

10 minutes: strategy for selecting and comparing exemplars
30 minutes: strategy for remembering concepts
35 minutes; strategy for reviewing concepts

Classification test. Students were provided with an answer sheet and were instructed to begin the test.

Data Analysis and Findings

A series of one-way analysis of variance procedures (ANOVAs) was used to check for possible pretreatment ability differences between the experiment groups. No significant difference was found at the .01 level for reading, math, or conceptual ability.

Comparison of Group Means for the Classification Test

Means and standard deviations on the Xenograde Classification Test for the two groups are consistent the hypothesis that system-assigned strategies can improve acquisition of coordinate concepts. Means (and standard deviations) are as follows: system-assigned strategies, 46.6 (24.0), n = 20; student-assigned strategies, 33.8 (17.3), n = 19.

An analysis of covariance procedure (ANCOVA) was used to test the hypothesis (Table 1). The difference between scores for the two groups approached significance, $\underline{F}$ (1, 34) = 3.55, $\underline{p}$ = .07. The covariate was not significant.

Exploratory Data Analysis

A stepwise regression analysis was conducted to determine the sources of error variance in the ANCOVAs. Independent variables included conceptual ability, math achievement and reading achievement. Reading and math ability accounted for nearly half of the variance in classification test scores, $\underline{R}$ = .46, $\underline{F}$(2,32) = 12.86, $\underline{p}$ < .01. Attempts to use math and reading ability for covariate control of classification scores did not result in higher levels of significance.

Correlation of Posttest with Ability Measures Correlations of reading, math, and pretest scores with the posttest ranged from r = .03 to r = -.06 and were not significant ($\underline{p}$ < .10). For the purposes of this study, these measures may therefore be considered orthogonal variables.

Table 2 displays the correlations of each ability measure with the posttest scores for each treatment group. This data shows a moderate and significant correlation between reading and math scores and posttest scores.

Inspection of the table reveals apparent differences between the ability x posttest correlations of the two treatment groups. This possibility was tested using pairwise comparisons based on Fischer's Z transformations (Glass & Stanley, 1970, p. 311). Possible contrasts between intra-group correlations were

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separately tested for reading, math and posttest scores. All but one of these comparisons lacked significance at the .10 level. The exception involved correlation of math scores on the WRAT with performance on the classification test: System-assigned ($\underline{r}$ = .72). vs. student-assigned ($\underline{r}$ = .23). $\underline{z}$ = 1.89, $\underline{p}$. = .06.

In other words, there was a high correlation between math achievement and concept acquisition among students who received the system-assigned strategies and a low correlation between math achievement and concept acquisition among students who used their own strategies. Although this is a borderline effect, it suggests that the effect of the system-assigned strategies was positively influenced by pretreatment mathematics ability.

Conclusions

The direction of differences between group means is consistent with the hypothesis that system-assigned strategies can enhance acquisition of coordinate concepts. The comparison between the two treatment groups approached significance at the .05 level. Regression analysis demonstrated that nearly half of the error variance can be attributed to differences in math and reading ability. Most of the remaining error variance was probably due to unmeasured differences in cognitive ability.

Generalizing these tentative findings is a two-sided issue. On one hand, the use of an atypical group of students from a continuation high school argues against generalizing results to the other high school populations. On the other hand, the detection of a borderline effect in a group with diverse reasons for failure in ordinary school settings should engender some

confidence that the experiment could be repeated with significant results, if a normal group of high school students were used.

Math as a Task-relevant Aptitude

Differences in the math X classification test correlations for students receiving system-assigned strategies and those relying on self-selected strategies suggests that moderate levels of ability in mathematics was a requirement for successful adoption of the system-assigned strategies. This is not surprising since the the recommended strategy for selecting examples and comparisons was stated in terms that required an ability to think in logical terms about set relationships.

The positive influence of mathematics ability on posttest performance also provides indirect support for the global model proposed by Allen and Merrill (1984). The global model predicts that system-assignment will be less effective than student-assignment for students with high aptitude, and less effective than embedding for students with low aptitude. The hypothesis that system-assigned learning strategies would enhance concept acquisition was therefore dependent on the crucial stipulation that the task-relevant skills of students be moderately strong. Due to the small pool of potential subjects, the investigator was forced to violate this important stipulation. Of the participating high school students, 67 percent had math achievement scores that were below the seventh-grade level. It is likely, therefore, that system-assignment was an inappropriate method for many of the experiment subjects and that embedded strategies (such as one

that explicitly compared matched example/non-example pairs) would have been a more effective treatment for these students.

Table 1

Analysis of Covariance

System-assigned vs. Student-assigned Strategies

Source	df	MS	F	p
Covariate Conceptal Ability	1	36.1	.08	.78
Between Group	1	1573.2	3.55	.07
Explained	2	804.6	1.81	.18

Table 2

Correlation of Student Ability with

Classification Performance

Group	n	Conceptual Ability	Reading Achievement	Math Achievement
System-assigned strategy	20	.12	.35	.72 **
Student-assigned strategy	19	.43	.63 *	.23

* $p < .05$
** $p < .01$

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