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ABSTRACT

A 4 x 4 factorial experiment was conducted with 152 college age volunteers to investigate the effects of different forms of mathemagenic information (algorithms, heuristics, attribute elaboration, and attribute isolation) on concept acquisition. Results showed that both definition and instance presentation had a significant effect on students' ability to correctly classify novel instances and their confidence in their responses. It was shown that heuristic definitions produce patterns of confidence that differ from those of other definition types. It can be concluded that: (1) definition and instance presentation both play an important role in concept acquisition, (2) students can benefit both affectively and instructionally from the expository presentation of classification algorithms and heuristics and (3) confidence is more closely related to definition than to inquisitory instance presentation. (Author)

The Effects of Definition and Instance Presentation on Concept Acquisition[1]

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Abstract

A 4 x 4 factorial experiment was conducted with 152 college age volunteers to investigate the effects of different forms of mathemagenic information (algorithms, heuristics, attribute elaboration, and attribute isolation) on concept acquisition. Results showed that both definition and instance presentation had a significant effect on students' ability to correctly classify novel instances (.001) and their confidence in their responses (.01). It was also shown that heuristic definitions produce patterns of confidence that differ from those of other definition types (.01). It can be concluded that: 1) definition and instance presentation both play an important role in concept acquisition, 2) students can benefit both affectively and instructionally from the expository presentation of classification algorithms and heuristics and 3) confidence is more closely related to definition than to inquisitory instance presentation.

The Effects of Definition and Instance Presentation on Concept Acquisition

When an instructional designer or classroom teacher sets out to develop a new course segment, he must make a series of related decisions about what to teach (content) and how to teach it (strategy). For contents heavily laden with conceptual material, he must determine which attributes of one concept are concepts within themselves. For example, he may find that students need to understand the concept of "sentence" before they can be expected to master the concept of "paragraph". Once the structure of the content has been defined, effective strategies must be selected. Decisions must be made concerning both the amount and kinds of instances to be presented. Should they contain cues or prompts (expository presentation) or should the student be required to classify the instance before receiving feedback (inquisitory presentation). What types of instructional helps should be contained in the practice material? How should the definition be worded? How should it be presented?

Definition Presentation

There are two broad categories of rules that apply to the teaching of concept definitions: 1) relational rules and 2) procedural rules. A relational rule describes the connection of one critical attribute to another. Attributes might have a conjunctive or conditional, etc. relationship (Bourne, Ekstrand and Dominowski, 1971). These relationships are essentially determined by the concept itself. A procedural rule is a set of ordered steps designed to simplify the classification task faced by the student. Two of the most common types of procedural rules are algorithms and heuristics. A classification algorithm or heuristic may contain many classification rules in which relational rules are included. Landa (1974) suggests that classification algorithms are effective instructional devices because they add an increment of control over student processing. Rather than allowing students to struggle in an effort to understand when and how to go about the classification task, the algorithm clearly spells out each step and the order in which it should be performed. The same rationale applies to the use of heuristics (which are simplified algorithms). Seldom are either of these two strategies applied in concept instruction. A more typical type of definition would contain a group of lengthy sentences which may or may not describe each of the critical attributes (Markle, 1975). In order to measure the relative benefits of different types of definitions, four levels of definition presentation were manipulated:

1) no definition
2) descriptive definition: a nonordered nondirective listing of the critical attributes of a concept and subordinate concepts.
3) heuristic definition: a descriptive definition plus a simplified procedural rule which accounts for most but not all instances.
4) algorithmic definition: a descriptive definition plus a procedural rule which accounts for every instance.

Instance Presentation

Researchers have found that adding mathemagenic information (instructional helps) to practice instances improves student performance. Merrill and Tennyson (Note 1) found that adding attribute prompts to instances had a significant effect. These prompts directed the students' attention to the critical attributes by emphasizing them with visual and verbal amplification. These instance variables are closely related to the mathemagenic revisions of definitions. Just as the step by step clarification in an algorithm might add control to the student's processing, so might the organized depiction of such an algorithm (in the form of instance feedback) cause the student to more systematically process the information presented in practice instances. In the present study, different forms of mathemegenic instance feedback were matched to each of the levels of definition presentation. The four forms of instance presentation were:

1) no instances
2) inquisitory instances: instances requiring the student to classify as either positive or negative followed by feedback showing only correct classification.
3) inquisitory instances with attribute elaboration: inquisitory instances with feedback which visually or verbally depicts the application of a heuristic definition.
4) inquisitory instances with attribute isolation: inquisitory instances with feedback which visually or verbally depicts the application of an algorithmic definition.

Questions to be Answered

1) Are definitions effective instructional devices for teaching concepts - are they necessary in the presence of rich instance feedback?

2) Are practice instances effective instructional devices for teaching concepts - are they necessary if a procedural rule is presented as a definition?

3) How is student confidence affected by different types of definitions and instance feedback?

METHOD

Subjects

One hundred fifty-two college age students from an introductory psychology class participated in the study. These students volunteered in order to fulfill part of their course requirements. There were approximately three hundred students registered in the class.

Learning Task

The concept of trochaic meter was chosen for this experiment. Trochaic meter is one of four different rhythmic patterns in poetry. The objective of the instruction used in the study was to teach students to classify unencountered instances of poetry as either trochaic or nontrochaic. This particular concept was selected for several reasons.

each instance used in the study. Tennyson, Woolley, and Merrill (1971) conducted an experiment in which an instance probability analysis was performed. The results of this experiment made it possible to construct practice poems and a posttest with positive and negative instances stratified for difficulty level.

Procedures

The experiment was conducted in a single session. A written set of directions was read to the group of students before the treatment was administered. No reference was made to the instructional task in these directions. Once the directions were read to the students, instructional booklets were randomly distributed. The randomization process consisted of sorting the booklets into complete replications (16 different booklets), shuffling the booklets within each replication, and shuffling the order of each replication. Several experimenters distributed these booklets to students, one replication at a time. This helped insure that there would be as equal a number of students per cell as possible.

attribute isolation groups was 13.19, while the mean adjusted for the covariate was 13.17. The effect of the covariate on the means for definition presentation was quite different. The adjusted mean for the groups receiving no definition was raised almost 1 point. Since two of

Instructional Materials

Sixteen different self-instructional booklets were prepared for this experiment. Each booklet contained a special combination of one of the four levels of definition presentation and one of the four levels of instance presentation. Each booklet contained a 10 item free response prerequisites test designed to measure the subject's knowledge of the subordinate concepts of "stress" and "syllabication." Following the instructional materials, each student was required to complete an 18 item forced choice posttest containing unencountered positive and negative instances of trochaic meter.

Prerequisites test. The prerequisites test was included for the purpose of eliminating students from the analysis who had not previously mastered the concepts of syllabication and stress. The results of previous experimentation (Blake, Note 2), indicated that students not already familiar with these two prerequisites could not "hear" the differences among poetic meters. In a pilot study, the criterion score for eliminating students was established. If a student made four or more errors in dividing words into syllables or underlining stressed (accented) syllables, his posttest score was not included in the analysis. Items on the prerequisites test consisted of two and three syllable words selected according to the position of the stressed syllable. The order of the words was systematically arranged according to syllable number and position of stress. If a student incorrectly divided the word into its component syllables or incorrectly marked stress, the test was scored with an error. It is important to note that dividing a word between the wrong letters did not constitute an error. Errors were given only when a student divided a word into the wrong number of syllables.

Posttest. A posttest containing 18 poems was administered following the instruction. Three easy, three medium, and three hard positive instances along with three easy, three medium and three hard negative instances were selected for the posttest. The order of these positive and negative instances was randomized. Before a particular poem could be included on the posttest, several experts judged it on two points: 1) ambiguity of stress, 2) algorithmic consistency. If a poem was judged to be highly ambiguous in stress or if it contained a line which could not be accurately analyzed using the algorithmic definition, it was not included in the posttest. Each student was asked to make two responses on each of the 18 poems. First, he classified it as a negative or positive instance. Second, he gave an estimate of his confidence for his classification response using a four point scale: 1) "very unsure", 2) "somewhat unsure", 3) "somewhat sure," 4) "very sure". This confidence scale was used in an attempt to reduce the chance factor of guessing.

Two separate scores were tabulated for each student. The first score consisted of the number of instances classified correctly (classification score). The second score was obtained by totaling each student's confidence ratings for each item (confidence score).

Definition Presentation

Of the 16 total groups in the experiment, 12 groups received some form of a definition. Of these 12 groups, 9 groups also received practice instances with some type of feedback. The students in these nine groups were instructed to study the pages containing the definition and then remove them from the booklet and use them while completing the practice instances. Students in the three groups receiving no practice instances were instructed to study the definition pages, place them out of sight, and then take the posttest. No group was allowed to look at the definition pages during the posttest. Three different forms of definition presentation were used: 1) descriptive definition, 2) heuristic definition, and 3) algorithmic definition.

Instance Presentation

Of the 16 total groups in the experiment, 12 groups received practice instances with some type of feedback. Of these 12 groups, 9 groups also received some form of definition. Students in the three groups who received no definition, were instructed to do their best on the practice instances before going to the posttest. Three forms of feedback were provided for practice instances: 1) correct classification, 2) attribute elaboration, and 3) attribute isolation.

Presentation AD + HD vs DD

AD vs HD

Instance AI + AE + II vs $\overline{I}$

Presentation AI + AE vs II

AI vs AE

Figure 2 shows the number of students in each cell. A computer program was used in the analysis which allowed for unequal cell size. The program computed estimated means for each cell, as if there had been an equal number of students in each cell. The last step in the data analysis viewed the confidence score as a covariate. It was anticipated that this procedure would reduce the error variance due to guessing.

Control Group

The control group was given an irrelevant article to read while the treatment students were studying.

different types of definitions do impose different amounts of control, but only when practice instances are not presented.

It is interesting that the AD and HD groups performed equally well on the posttest. Interpreting this result has important implications

Treatment Name	Mnemonic
Algorithmic Definition	AD
Heuristic Definition	HD
Descriptive Definition	DD
No Definition	$\bar{D}$

Attribute Isolation	AI
Attribute Elaboration	AE
Inquisitory Instance Feedback	II
No Instances	$\bar{I}$

Figure 1. Mnemonic representation of treatment names.

Definition Presentation

Instance Presentation	AD	HD	DD	D	Row Number
AI	7	10	8	6	31
AE	8	8	6	7	29
II	7	9	8	7	31
I	7	7	8	6	28
Column Number	29	34	30	26	

Figure 2. Number of subjects per cell and treatment.

RESULTS

This section will be divided into three parts. The first part will focus on the analysis of classification scores. Part Two will report the analysis of confidence scores. In the third part, the analysis of covariance will be reported with classification scores as the dependent measure and confidence scores as the covariate. It should be noted that 33 of the 152 original participants were eliminated from the data analysis on the basis of their prerequisites test scores.

Classification Scores

Students who received some form of a definition correctly classified more instances on the posttest than students who received no definition, $F(3, 103) = 9.09$, $P < .005$. Table 1 contains the mean classification scores for each cell and factor. From Table 1 it can be seen that those who received some form of a definition correctly classified approximately two more poems than those who received no definition.

Students who received an algorithmic definition did not perform differently on the posttest from those who received a heuristic definition. Neither was there a difference between the average of the algorithmic and heuristic definition compared with the descriptive definition treatment.

The pattern of differences among the four levels of instance presentation was similar to the pattern obtained for definition presentation. Students receiving some form of practice instances performed significantly better $F(3, 103) = 22.40$, $P < .001$. There were no differences between attribute elaboration and attribute isolation. Neither

Table 1

Mean Number of Instances Correctly

Classified on the Posttest

Definition Presentation

Instance Presentation	AD	HD	DD	$\overline{D}$	Row Means
AI	13.57	13.70	14.00	11.50	13.19
AE	12.88	13.00	14.17	14.00	13.51
II	13.57	13.33	12.00	10.71	12.41
$\overline{I}$	11.29	12.1[illegible]	9.88	7.67	10.24
Column Means	12.83	13.04	12.51	10.97	

was there a difference between the average of the attribute elaboration and attribute isolation compared with simple inquisitory feedback. There were no significant interaction effects.

Confidence Scores

Table 2 shows the mean confidence scores for each cell, as well as each factor. The group obtaining the highest mean confidence received a descriptive definition and attribute elaboration. The group obtaining the lowest mean confidence was the control. It should be noted that the average of the three confidence mean scores for students receiving some form of definition was approximately 10 points higher than the mean obtained by students who received no definition. The mean for those receiving a heuristic definition was approximately four points higher than the mean obtained by those receiving the algorithmic definition. Looking at the factor means for instance presentation, it can be seen that subjects who received some form of practice instances obtained a mean confidence score approximately five points higher than subjects receiving no instances. It should further be noted that students receiving either attribute isolation or attribute elaboration scored on the average approximately four points higher on confidence than those receiving simple inquisitory feedback.

The two-way analysis of variance showed that both main effects and the overall interactions were significant at the .01 level or better. Subjects receiving some form of definition were significantly more confident on the posttest than those receiving no definition ($F(3, 103) = 23.77$, $P < .001$). Those who completed some form of practice

Table 2

Mean Total Confidence Scores

on Posttest

Definition Presentation

Instance Presentation	AD	HD	DD	$\overline{D}$	
AI	40.71	40.40	43.00	30.65	38.70
AE	43.50	39.00	46.00	41.71	42.55
II	32.29	44.67	37.63	32.86	36.86
$\overline{I}$	33.71	43.57	41.88	17.00	34.04
	37.55	41.91	42.13	30.56	

instances were significantly more confident on the posttest than subjects who received no instances, $F(3, 103) = 7.12$, $P < .01$.

Two of the nine interaction terms were significant at the .01 level or better. Figure 3 depicts the AD vs. HD x AI + AE vs II interaction. It can be seen that students receiving a heuristic definition evidenced greater confidence after practicing on simple inquisitory instances than after instances with mathemagenic information added. The algorithmic group's confidence dropped sharply on inquisitory instances when compared to instances with either form of mathemagenic feedback. Figure 4 graphically depicts the patterns of the other significant interaction term (AD + HD + DD vs $\overline{D}$ x AI + AE + I vs $\overline{I}$). Again, the heuristic groups showed greater confidence in the presence of simple inquisitory feedback or no instances. The other groups showed a fairly consistent pattern of decreasing confidence when comparing the groups receiving mathemagenic feedback to groups receiving simple feedback or no instances.

Analysis of Covariance

A final step in the data analysis viewed the confidence scores as a covariate and the classification scores as the dependent measure. Table 3 illustrates the individual cell and factor means adjusted for the covariate.

When comparing the means in Table 3 with those reported in Table 1, it can be seen that the covariate affected the definition dimension more than the instance dimension. For example, the unadjusted mean for

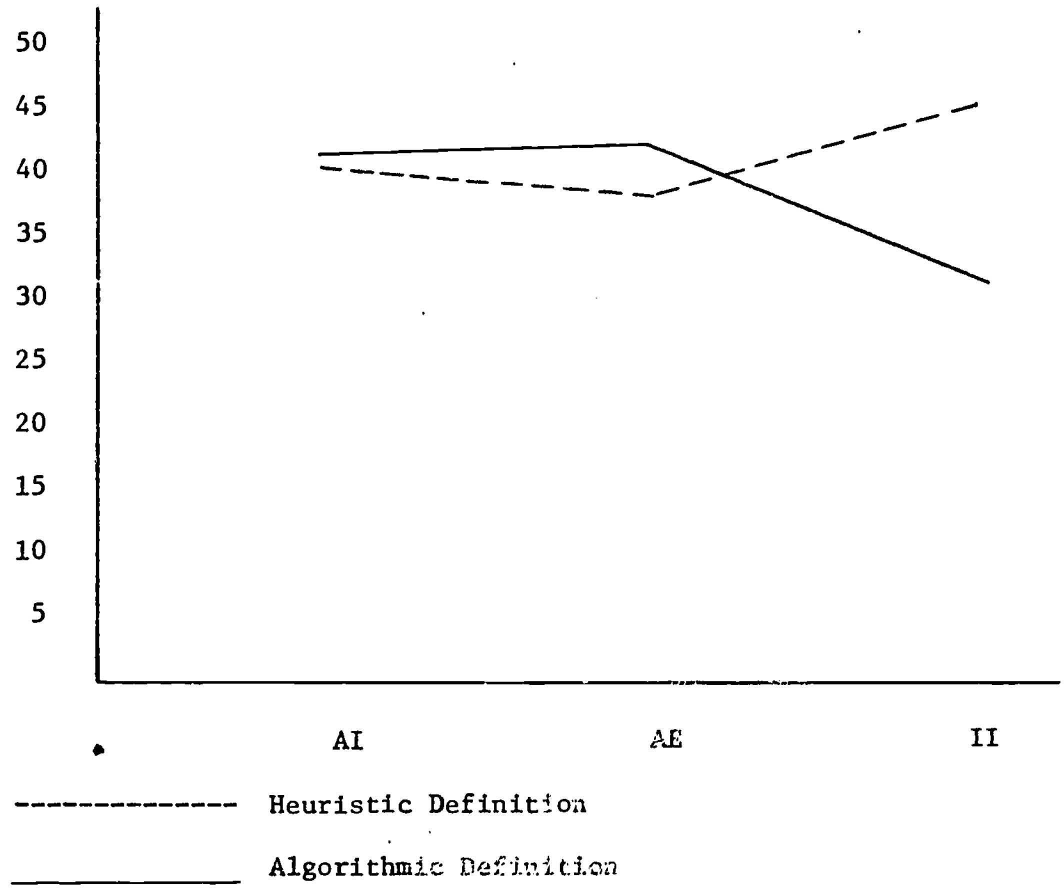

Figure 3. The interaction between algorithmic definitions and heuristic definitions across three types of instance presentation.

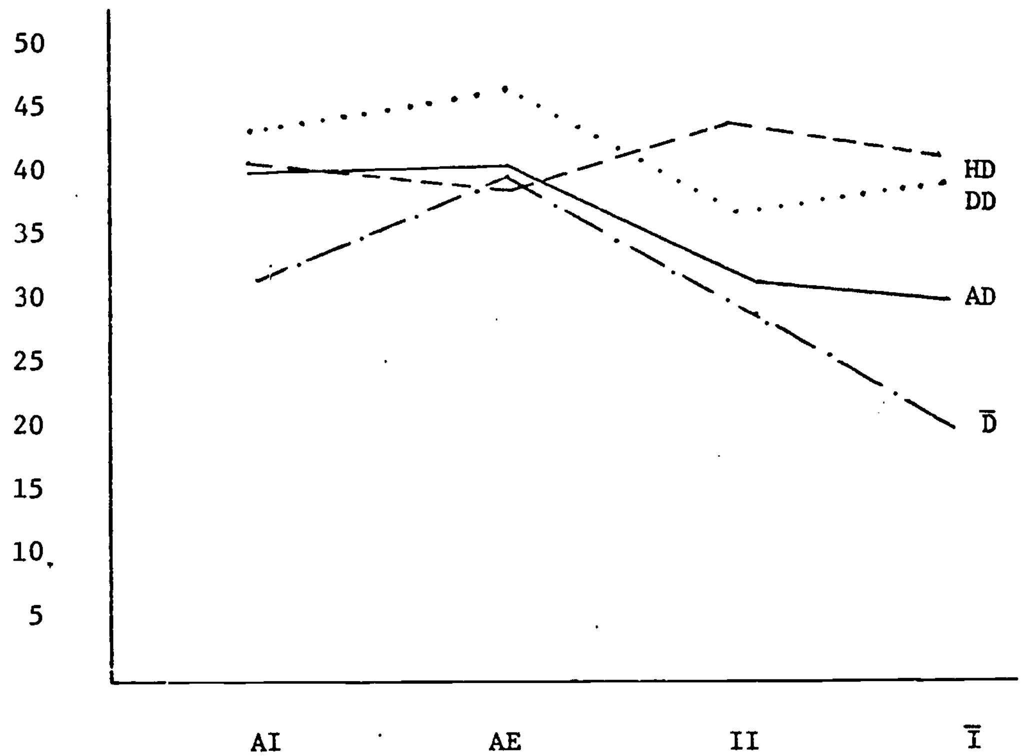

Figure 4. The interaction among all types of definition presentation across all types of instance presentation.

attribute isolation groups was 13.19, while the mean adjusted for the covariate was 13.17. The effect of the covariate on the means for definition presentation was quite different. The adjusted mean for the groups receiving no definition was raised almost 1 point. Since two of the other definition group means were adjusted down by the covariate, the resultant factor means differ less than 1 point. The analysis of covariance showed that confidence scores were more closely related to the type of definition than to the type of instance presentation they received.

Table 3

Mean Number of Instances Classified Correctly on the Posttest After Adjusting for Confidence

Definition Presentation

Instance Presentation	AD	HD	DD	$\overline{D}$	
AI	13.30	13.47	13.45	12.47	13.17
AE	12.16	12.94	13.24	13.60	13.01
II	14.34	12.57	12.11	11.41	12.61
$\overline{I}$	11.88	11.52	9.46	10.32	10.79

DISCUSSION

Definition Presentation

From the present study it can be concluded that definition presentation facilitates concept acquisition. Subjects who received some form of a definition performed better on the posttest than those who received no definition.

Several researchers have concluded that directions or instructions which focus the learner's attention on the critical attributes of the concept do, in fact, facilitate concept acquisition (Underwood and Richardson, 1956; Wittrock (1963); Archer, Bourne and Brown (1965)). There are two suggested reasons for the superiority of definition or direction groups. First, students learn a label for each attribute and, hence, the concept. Second, students experience less confusion (viewing irrelevant attributes as critical or critical attributes as irrelevant or both) because they are told which attributes are critical to the concept.

While there exists a limited amount of research on algorithmic or heuristic definitions, there are some persuasive rationales for their instructional effectiveness. Landa (1974) suggests that the algorithm is an effective instructional strategy especially for tasks requiring careful sequencing. He further states that algorithms are effective because of the amount of control they allow over the student learning process:

> Algorithms have significance for instructional theory because when we teach a student an algorithm for the solution of problems, we not only provide him with a means to control those objects which he will transform with the help of that algorithm, but also with the means to control himself, his own intellectual operations, and his own practical actions (p. xxiii).

Based on the postulate that algorithms provide increased control over student learning processes, it would be hypothesized that a linear relationship exists among the four different levels of definition presentation manipulated in the present study. In other words, if algortihms provide maximum control, then heuristics should provide less, descriptive definitions less than heuristics and no definition least of all. This relationship might be graphically represented as follows:

$$AD > HD > DD > \overline{D}$$

The results of the present study do not support such a relationship. However, it should be noted that the following trend does seem quite stable:

$$ADI = HDI > DDI > \overline{DI}$$

In other words, when we examine the classification score trends of those who received each type of definition with no instance presentation, the algorithmic and heuristic groups appear to be equal with each other but greater than the descriptive definition group which is greater than the no definition group. This would lead us to the conclusion that different types of definitions do impose different amounts of control, but only when practice instances are not presented.

It is interesting that the AD and HD groups performed equally well on the posttest. Interpreting this result has important implications for the emerging theory of instructional strategy design. First, since an algorithm must account for <u>every</u> instance presented to the student, it often becomes overly complex. If the definition is too complex it is of limited instructional value because students will not be able to process it (Case, 1975). Obviously, not all AD students in the present study used the AD correctly. If they had used it correctly, they would have obtained perfect scores. Second, just as Newell and Simon (1967) suggest, students are more accustomed to using heuristics because algorithms are either too complicated or are unknown. For this reason, most students accept and even <u>expect</u> a rule to have exceptions. When a difficult instance appears to be an exception to the algorithmic rule, subjects probably mark the item without forcing it through all steps in the algortihm. Third, since an AD is usually longer (has more steps) than a HD, it is more difficult to remember. Landa (1974) suggests that students should never be required to memorize algorithms. However, to be an efficient instructional tool, some algorithms should be committed to memory. The experimental design in the present study dictated that students not be allowed to view the definition during the posttest. This posed an obvious problem for some subjects. A few wrote comments on their posttest stating that they had forgotten the first or second step in the algorithm. Fourth, AD's usually contain nested or subordinate rules within steps. The trochaic algorithm was no exception. It is the opinion of the authors that few learners are accustomed to processing nested rules. This unfamiliarity reduces the control that a particular algorithm can impose on the learner.

Instance Presentation

A great deal of research has been conducted concerning the variables involved in instance presentation. Few of these studies have simultaneously manipulated the definition and instance dimensions, such as the present study has done. From the results of this study, it can be concluded that some type of practice instances are better than no instances. When comparing groups across definition types, the form of instance feedback does not appear to make a difference. In examining the group means more closely, we find that there are some paired comparisons which are of interest. For example, if we compare the mean score for group DDAI (14.00) with DDAE (14.17) with DDII (12.00), we find the following trend:

$$\text{DDAI} = \text{DDAE} > \text{DDII}$$

This means that both of the rich feedback conditions are equal when subjects receive a descriptive definition but are superior to those who receive simple instance feedback. The trends in the no definition dimension are also interesting. Group DAI had a mean correct of 11.50, Group $\overline{\text{D}}$AE 14.00, and Group $\overline{\text{D}}$II 10.71. This means that subjects who r ived attribute elaboration with no definition performed better than subjects who received attribute isolation or simple inquisitory feedback. The following symbolic representation summarizes this trend:

$$\overline{D}AE > \overline{D}AI = \overline{D}II$$

It would appear that we could make several generalizations concerning instance feedback. First, if a heuristic or algorithmic definition is presented to the learner, instances with correct-incorrect feedback are just as effective as instances which have rich feedback (attribute isolation, attribute elaboration). Second, if a descriptive definition is presented to the learner, both types of rich feedback appear to be of some benefit over simple feedback. Third, if no definition is presented, attribute isolation appears to lose some of its effectiveness while attribute elaboration does not.

Since the $\overline{D}$AE group had relatively little information to process, it is interesting that subjects performed as well as they did. One possible explanation might be that the verbalization contained in the AE feedback was direct enough that subjects were able to easily infer the definition of the concept.

Confidence Scores

The analysis of the second dependent measure (confidence) yielded some interesting results. Generally speaking, the difference patterns for confidence scores were similar to those for classification scores. Those who received some form of a definition were more confident in their responses than those who received no definition. Subjects who received some form of instance feedback were also more confident than subjects who received no instances. These conclusions must be tempered by the fact that there was a significant interaction between the two independent variables. Figure 3 depicts the interaction between algorithmic and heuristic groups. As can be seen in the figure, Group HDII was more confident on the posttest than Group HDAE or HDAI. In contrast, Group ADII was much less confident than Groups ADAE or ADAI. The obvious difference between these two patterns is of special interest because they are not at all parallel to the success patterns obtained from classification scores. Group ADII classified on the average 14.34 poems correctly while Group HDII classified on the average 12.57 poems correctly. This trend is just opposite to the confidence means of 32.29 for Group ADII vs 44.67 for Group HDII. In other words, HD groups were <u>overly</u> confident. They perceived more incorrect answers as being correct than other groups.

Figure 4 depicts another significant interaction effect. It can be seen from Figure 4 that all groups, except the HD group, decline from AE to II. It can further be seen that the HD group remains artificially high even in the absence of practice instances. Again, the discrepancy between the $AD\bar{I}$ (33.71) and the $HD\bar{I}$ (43.57) groups was not like the classification score pattern ($AD\bar{I}$ = 11.29, $HD\bar{I}$ = 12.14). These interaction effects lead us to the conclusion that confidence generally correlates with performance unless the learner is presented with a heuristic definition. If a heuristic definition is given, subjects are highly confident that their responses are correct regardless of the type or presence of practice instances.

The same basic rationale is advanced in explanation of the interaction effects as was suggested earlier in the comparison of algorithms and heuristics. Learners feel more confident with heuristics because: 1) HD's contain less steps and are, hence, easier to process and easier to remember, 2) HD's are more familiar because they are processed and used more naturally by learners, 3) HD's are less sensitive to inconsistencies and, hence, learners are less aware that they are making mistakes on difficult instances. The third statement relates specifically to confidence level and deserves further illustration. In the present study the HD required subjects to read each poem using the trochaic stress pattern (tapping the desk for each stressed syllable), and then decide whether the poem was "mostly" right (trochaic) or "mostly" wrong (nontrochaic). Let us look at one of the poems on the posttest and compare the strategies that might have been used by subjects in the AD and HD groups.

> There they are my fifty men and women,
> Naming me the fifty poems unfinished.

A skilled student in the HD group probably would have read the poem with the trochaic stress pattern:

> THERE they ARE my FIF-ty MEN and WOM-en,
> NAM-ing ME the FIF-ty POEMS un-FIN-ished.

He would have immediately decided that the poem sounded fine and concluded that it was trochaic.

The AD student might have struggled a bit more with this poem. First, he would have attempted to underline stress. If he did not add stress to the first word (there), he would have been confused about subsequent syllables. He may have chosen to stress the following syllables:

There they <u>are</u> my fifty <u>men</u> and <u>wom</u>-en,
Naming <u>me</u> the fif-ty <u>poems</u> un-<u>fin</u>-ished.

He would then have attempted to divide the poem into its component feet.

/There they <u>are</u>/my fif-ty <u>men</u>/and <u>wom</u>/en/
/Naming <u>me</u>/the fif-ty <u>poems</u>/un-<u>fin</u>/ished/

He may then have noticed that one foot in each line (/ my fif-ty <u>men</u>/), (the fif-ty <u>poems</u>/) contained four syllables. Since one of the nested rules in the algorithm states that no foot can have more than three syllables, he would have had to begin again and restress the syllables in the poem. The student using the heuristic never noticed the other possible stress patterns because of the structure of the rule he was using. It is logical to assume, therefore, that the AD student was somewhat less confident of his response (even if he finally analyzed the poem correctly) than the HD student who dealt with no inconsistencies during his analysis.

Covarying Confidence

Covarying confidence dissolved the effects of classification scores on the definition dimension but not on the instance dimension. This means that when the effects of confidence are subtracted from classification scores, there are no longer any visible differences. We can conclude, therefore, that level of confidence is more related to definition presentation than it is to instance presentation. In other words, in concept acquisition, definitions play a more important role in student confidence than do inquisitory instances. Care should be taken in interpreting this result. First, it is evident that different types of definitions spawn different levels of confidence. It is unlikely that any definition produces more confidence than any set of instances. Second, this experiment employed only inquisitory instances. Perhaps students lost some confidence produced by a clear definition when they went to the practice instances and found that they were making some mistakes. These errors (which would not be present with expository instances) may have decreased students' confidence when they arrived at the posttest.

Suggestions for Further Research

More data needs to be gathered concerning the use of instances with different types of definitions. The difficulty level of practice instances needs to be held constant in order to answer questions concerning the relationship between number of practice instances and type of definition. Do students who receive a HD require fewer practice instances to reach mastery than do AD or DD groups? While there exists a body of literature on the optimum combinations and types of instances for concept attainment, there is still some controversy over the use of negative instances and the ideal sequencing of these instances (Clark, 1971). Much of the disagreement could be allayed if the learning task were more carefully standardized to the type of tasks dealt with in the classroom.

Several pressing questions need to be posed concerning definition presentation. First, is it better to teach an algorithm in one instructional display, or one step at a time in a series of displays interspersed with practice instances? Second, does instructional sequence for learning algorithms make a difference? Third, what are the benefits of other forms of mathemagenic information in definitions such as analogies or metaphors? All of these strategies could be more easily investigated if a tutorial approach were employed. The tutor could insure that each subject, in fact, used the definition or instances presented to him, as well as ask specific questions while the subject was processing the information. These inquiries could help researchers develop a more accurate theoretical rationale for the obtained differences.

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