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AUTHOR   Allen, Brockenbrough S.
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ABSTRACT
         To control for interactions in learning research due
to subjects' prior knowledge of the instructional material presented,
an imaginary curriculum was presented with a computer assisted
technique based on Carl Berieter's imaginary science of Xenograde
systems. The curriculum consisted of a classification system for ten
conceptual classes of fictitious planets. The computer system,
written in Apple PASCAL, presented three types of displays: (1)
definition of the concept's attributes and classes; (2) instance
selection and presentation, which allowed trainees to explore the
classification system in a hierarchical or tabular format; and (3) a
test of concept acquisition. The instruction was presented within a
science fiction context; the first screen welcomed subjects to the
Starcruiser Academy Science Officer Training Course. Subjects in the
first study were 38 high school students. The treatment group, who
received advice on selecting pairs of examples to maximize learning,
scored moderately higher than the control group. In a second
experiment, undergraduate education majors were exposed to either
hierarchical presentation of materials, matrix or tabular
presentation, or a combination of both. Results strongly favored the
hierarchy-only approach. (Extensive appendices include a number of
the presented screens and instructions accompanying the
classification test). (GDC)

COMPUTER-BASED IMAGINARY SCIENCES AND RESEARCH ON CONCEPT ACQUISITIONS

BROCKENBROUGH S. ALLEN
Educational Technology Program
Department of Development, Administration, and Technology
San Diego State University

COMPUTER-BASED IMAGINARY SCIENCES AND RESEARCH ON CONCEPT ACQUISITION*

BROCKENBROUGH S. ALLEN
Educational Technology Program
Department of Development, Administration, and Technology
San Diego State University

Abstract

Outlines advantages of imaginary sciences for research on instructional design variables; reviews particular benefits of imaginary sciences for computer-based research; briefly describes one example of a computer-based research tool in which an imaginary science is used to facilitate research on concept acquisition.

General Value of Imaginary Sciences for Research on Instruction

Control of extraneous sources of variance is the chief obstacle to demonstration of significant treatment effects in most experimental studies. Research on instruction is often handicapped by uncontrolled interactions between subject matter, previous experience of subjects, and the instructional methods under investigation. One way to control for such interactions is to use an imaginary subject matter that resembles real-world content but which is 1) more easily manipulated for experimental purposes and 2) more easily adapted to the limitations of delivery systems that are used to represent subject matter content in the experimental treatments.

Prerequisite Knowledge. Prior knowledge is one of the most influential variables affecting instructional outcomes. Every subject matter requires a prerequisite body of knowledge. Differing levels of knowledge and skill results in group heterogeneity that is often difficult to control. One advantage of imaginary subject matter is that dependence on prerequisite-knowledge can be more easily controlled: it is impossible for any of the students to have learned the subject matter prior to the study. Obviously, even an imaginary subject matter requires previously learned skills. However, the use of an imaginary subject matter allows content to be modified to require certain skills but not others. Real-world subject matter cannot so easily be modified.

Manipulation of the Subject Matter. Instructional researchers sometimes spend weeks trying to find a concept, rule or principle with the characteristics appropriate to a particular investigation. Changing an existing subject matter in ways that destroy correspondence with the real world is usually considered unacceptable because of the danger that the student will acquire misconceptions about real-world content that will cause difficulties for him or her at a later time. An imaginary subject matter (so identified for the student) can be changed at will to include any content or to vary difficulty levels without teaching false concepts.

An imaginary subject matter allows the investigator to manipulate many factors that are impossible to change in real-world subject matter. These include: the structure of the content, the interrelationship between content components, the attributes of the components and the nature of prerequisite knowledge and skills. The malleability of imaginary subject matter enables more precise design of experimental treatments than is possible with real-world subject matter. For example, in the imaginary concept system described later in this paper, concept names were chosen so as to help control for rote memory effects: ten defined concepts were given imaginary names beginning with the first ten letters of the alphabet.

Ecological Integrity. In crafting treatments based on real-world subject matter, it is not uncommon for researchers to select isolated bits of content that have properties appropriate to investigation of a particular instructional phenomenon. The problem with this piecemeal approach is that the real-world subject-matter may not have the properties appropriate to subsequent investigations of related phenomena by the investigator or by colleagues who seek to extend the original work.

An imaginary science permits the investigator to add content appropriate to expanded investigations while maintaining a coherent "microworld" (Papert, 1981) that is governed by its own internally consistent set of rules and laws. Researchers can then study the interaction of instructional variables (previously investigated in earlier versions of the microworld) in the context of of an expanded but consistent body of "knowledge".

Power and Compactness. Real world subject matter domains often contain numerous content elements and relationships that are irrelevant to an experiment's hypotheses. An investigator's concern for accuracy of content, mastery of prerequisite skills, or maintenance of ecological integrity may force him or her to include such content in treatments even though the content has little to do with with his or her research questions.

Inclusion of such irrelevant content can impair the efficiency of an experiment by requiring the investigators to spend more time preparing subjects and administering treatments. When experimental resources are scarce, the inclusion of this extra content can have a indirect impact on experimental findings: longer treatment periods reduce the number of subjects that can be tested within a given time span or with given equipment. Since the power to detect differences between treatments is a function of the number of subjects (or observations), the effect of the additional subject matter content is to increase the likelihood of Type 1 (Kirk, 1968, p. 29) errors, ie failure to detect treatment differences that do, in fact, exist.

The use of imaginary sciences allows investigators to represent fundamental content relationships in a very compact form. By manipulating the structure of the content, investigators can omit many content relationships and elements that are not germane to the hypotheses being tested.

Value of Imaginary Sciences for Computer-based Research

Johnson (1982) has outlined some of the advantages of the microcomputer as a tool for educational research. These include replicability and standardization of treatments across experimental settings, more precise data collection, cost savings in administration of complex treatments to large numbers of subjects, more efficient management of experimental procedures, and more cost-effective processing and analysis of data.

An obvious advantage of microcomputers for educational research is their ability to simulate dynamic stimuli and adapt stimuli to individual students on the basis of measured responses. However, most inexpensive microcomputers place significant restrictions on the representation of subject matter content. For example, screen size and resolution often limit the type of content that can be

represented as well as the the fidelity of the representations. It may be difficult and costly to transform graphic and pictorial representations of "real world" phenomena into usable computer displays. Memory size and processing speed may further restrict the capabilities of a system for representing subject matter.

Imaginary sciences can help researchers to optimize the use of these limited computing resources by allowing the specific details of the subject matter to be altered so as to fit the representational capabilities of the computer system. The research tool described in this paper, for example, used an imaginary system consisting of ten defined concepts. Names for these concepts were all less than eight letters long because this configuration made optimal use of a 40 by 24 character screen display. A similar optimization strategy involved the creation of attributes of the concept classes so as to make efficient use of Pascal graphics utilities.

External Validity of Findings Based on Imaginary Sciences

Critics sometimes argue that findings based on imaginary subject matter cannot be generalized. In many cases, however, the malleability of imaginary content allows much greater flexibility in simulating fundamental structural characteristics of content that appear across diverse subject matter domains than does the use of a specific "real" domain. Results of experiments based on carefully-constructed imaginary sciences should have greater validity than experiments than those based on "real" content with atypical subject matter organization.

The validity of any concept system depends on its ability to represent sets of objects and events that exist in the observers' environment and to do so in ways that allow prediction or explanation of causal and correlative phenomena involving these objects or events.

The utility of concepts for communicating with others depends on consensual validation (or at least on a common understanding) of the concept system by a linguistic or philosophical community. In this sense, all concepts are imaginary. They can be challenged on the basis of both validity and utility, and they may be displaced by systems that permit more complete explanation and communication of the observed environment.

There are two principle differences between imaginary sciences and real sciences. First, in imaginary sciences, it is the investigator who determines (ideally by deliberate design) the adequacy of the concept system for explaining and predicting events that occur in the imaginary microworld. Second, the validity and utility of the imaginary concepts for predicting and explaining events (or for communicating with others about them) may not extend beyond the immediate limits of the microworld.

However, the external validity of experimental results does not necessarily depend on how accurately the imaginary concepts describe the "real" world. Nor does external validity necessarily depend on the similarity or fidelity of specific examples in the imaginary world to counterparts in the real world. The critical issue in generalizing findings based on an imaginary sciences is how well its imaginary content simulates the relationship between subject matter elements as these relationships are depicted in real sciences.

Ensuing sections of this paper explore two issues: 1) how relationships that are relevant to concept teaching can be operationalized as part of an imaginary science and 2) how an imaginary science can be used for computer-based research on concept acquisition.

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Research on Concept Acquisition

Tennyson and Park (1980) define a concept as "a specific set of objects, symbols or events which share a common set of characteristics (critical attributes) and [which] can be referenced by a particular name or symbol" (p.56).

Concept attainment requires an ability to generalize class attributes to newly-encountered instances. The most common way to measure mastery of conceptual relationships is to require individuals to classify or categorize instances of related concepts.

Concepts rarely exist in isolation. In typical school settings, individuals must master interrelated sets of concepts--networks that involve superordinate, subordinate, and coordinate relationships (Merrill & Tennyson, 1978). Taxonomic hierarchies represent network information so that "each location or node represents one or more features that its branching or lower-level nodes have in common" (Wilcox, Merrill, & Black, 1981, p. 8). Wilcox and his associates identify a number of synonyms for taxonomic hierarchies. These include decision tree, conceptual hierarchy and conceptual network.

According to Tennyson and Park (1980), research on concept teaching has focused on the following areas: "(a) the relationship between examples, (b) the relationship between examples and non-examples, (c) the ordering of examples and instructional help, (d) developing a procedure for selecting an appropriate number of examples, and (e) the relationship between coordinate concepts" (p. 55).

Issues that should be considered in designing a system of imaginary concepts include the following:

1. definitions and names of concept classes;
2. variation in the critical attributes that define membership in a concept class;
3. the nature and range of irrelevant attributes;
4. representation of specific instances of concept classes;
5. contrasts between examples and non-examples;
7. hierarchical (superordinate, subordinate, coordinate) relationships between concept classes;
8. analogous relationships between different portions of a conceptual network.

The issues that should be considered in designing computer-based tools for research on concept acquisition include the following:

1. feasibility of using computer displays to represent specific instances;
2. feasibility of using the computer to represent set-subset relationships between concept attributes (eg, superordinate, subordinate, and coordinate relationships);
3. possibilities for simultaneous comparison of two more instances of the same concept;
4. possibilities for simultaneous comparison of two more instances of the different concepts;
5. options for learner control and system control over instances to be examined by the learner;
6. access to helps that explicate the relationship between concept definitions and specific instances;
8. control of nuisance variables, especially those relating to pre-treatment aptitude, knowledge, and skill;
9. use of outcome measures for assessing concept acquisition.

An Imaginary Science for Computer-based
Research on Concept Acquisition

Over 20 years has elapsed since Carl Berieter developed the imaginary science of Xenograde Systems. Originally conceived as a framework for the investigation of instructional variables, Xenograde has been used from the 1960's onward in scores of studies. Many of these have involved computer-based implementations. Treatments based on Xenograde span three generations of CAI technology, beginning with Merrill (1965).

The following description outlines an extension of the original Xenograde system adapted for research on instructional variables associated with concept acquisition.

Subject-matter Content. As implemented in this extension of the original Xenograde "curriculum," the concept system groups imaginary particle systems into ten classes on the basis of the type, number and behavior of various sub-particles. Basic terminology is outlined in Figure 1. The names of the concepts classes are based on the first ten letters of the alphabet in order to control for rote-memory effects. An overview of the classifications can be obtained by reading the list of Xenograde Class Definitions in Figure 2.

The structure of the classification system permits learners to derive (or for instruction to explain) a number of classification rules. These are best understood through inspection of the hierarchical display in Figure 3a.

Some examples of possible rules: (1) Nucleus shape doesn't matter in determining classifications. (2) If an instance is particulate, classify it on the basis of alphon behavior and number. (3) If an instance is homogeneous, classify it on the basis of satellite behavior and number.

Computer Displays. The imaginary concept system is depicted through specially-designed computer displays designed by the investigator and developed by his associates (Eucker, Cochran, Allen & Merrill, 1982). The programs controlling these displays are intended as a general purpose research tool for investigating instructional design variables related to concept learning and are written in Apple Pascal (Apple Computer Inc, 1980). The major features of the system are outlined below. The reader should refer to Figures 3 through 5 for details.

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 Xenograde classes and are similar to those shown in Figure 2. Each display summarizes a particular concept's attributes, including some that are irrelevant to identification of the specific class. Each display includes one example.

Instance Selection and Presentation Displays. These displays allow for a controlled exploration of the classification system, using simple branching options. Taken together, the instance selection and presentation displays constitute a system for training students to classify specific instances of the Xenograde concepts. An overview of the branch sequences can be obtained by referring to Figures 3 and 4. The instance selection and presentation displays are represented in two different versions. One version (Figure 3) represents the information in hierarchical form; the other version (Figure 4) represents the information in the form of a table or matrix of attributes.

Classification Test Displays. (See Figure 5.) These displays constitute a test of concept acquisition. Each item/display requires the student to identify an example of one of the various Xenograde classes. Scores on this test is designed to serve as an outcome measure for experiments that require an assessment of classification performance.

Construction and Reliability of the Classification Test. The computer-administered test was based on a 30-item sample of the content domain. The sampling procedure employed a computer program that randomly selected

attribute conditions for each item. As administered to students, test items
were the same for each subject, except that patterns were independently varied
within the alphon-attribute condition by pseudo-random routines. An item which
displayed an example of the Etonic class would thus have variations in alphon
arrangement across test administrations, but these variations would still
conform to the criterial attributes for the Etonic class.

The reliability of this test was determined by administering it to 60
high-school students following their use of the instance-presentation and
instance selection displays for a 40-minute period. Scores evidenced a bimodal
distribution that cleanly split subjects into a group with high scores and a
group with low scores. 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 relatively the small sample size and the
homogeneity of the subject pool.

Studies Using the Xenograde Concept System

Two studies serve to illustrate possible applications of this imaginary
concept system. In a study on learning strategies (Allen, 1984), the question
was whether a strategy for comparing examples and non-examples of concept
classes could be taught as a system-assigned (Allen & Merrill, 1985) learning
strategy. Thirty-eight high school students were randomly assigned to one of
two experiment groups. Each group received preliminary instruction in basic
terminology (Figure 1), reviewed the definition displays (Figure 2), and
previewed the classification test (Figure 5). Subjects then used the matrix
version of the instance selection and presentation displays (Figure 4) for forty
minutes. During this period, the treatment group received advice on how to
select pairs of instances so as to 1) maximize contrasts between examples of the
same class and 2) minimize contrasts between examples of different classes.
(The first operation produces diverse examples of one class. The second
operation results in comparison of an example from one class with a similar
non-example.) The control group received non-directive placebo strategies.
Scores on the classification test indicated a moderate treatment effect favoring
system-assigned learning strategies.

A second study (Allen, 1983) compared the effectiveness of three different
approaches for teaching a classification system. Subjects were students in
elementary and secondary teaching credential programs. Each received
preliminary instruction in basic terminology (Figure 1), reviewed the definition
displays (Figure 2), and previewed a sample test item (Figure 5). The subjects
were then randomly assigned to one of three 32-minute treatments. One group
used the hierarchical version of the instance selection and presentation
displays. A second group used the matrix version. A third group alternated
between the two versions at eight-minute intervals. Scores on the
classification test strongly favored the hierarchy-only treatment.

A third experiment--still in the planning stages--will make use of
analogies that were deliberately built into the Xenograde concept system. The
two major branches of the classification system (particulate and homogeneous)
have analogous organizational structures. These are best understood through an
examination of Figure 3. Some examples:

1. Alphons are to particulate systems as satellites are to
   homogeneous systems. (Both are sub-particles useful for making
   classification decisions at subordinate levels).

2. Pulsating is to alphons as alternating is to orbit direction.
   (Both involve alternating states.)

3. <u>Clustered</u> is to dispersed as <u>same</u> <u>orbit</u> <u>direction</u> is to opposed orbit direction.. (Clustered and dispersed imply, respectively, attraction and repulsion; same direction and opposed directions imply, respectively, alignment and opposition of forces.)

4. In particulate systems, the <u>number</u> <u>of</u> <u>alphons</u> forms a pattern beginning with Alphonic: any, even, odd, even, odd. In homogeneous systems, the <u>number</u> <u>of</u> <u>satellites</u> forms a pattern beginning with Fatonic: one, two, three, two, three.

The question to be addressed in this proposed study is whether explicating the analogous relationship between the two branches of the hierarchy will facilitate acquisition of the entire coordinate concept scheme. The hypothesis is that an understanding of the analogies will reduce the rote memory burden of the learning task by reducing the number of relationships the learners must master. The assumption is that if learners master one half of the network, they can learn the other half by forming analogies.

Summary

Research on instruction has long been hampered by the difficulty of constructing treatments that precisely reflect the variables of interest to investigators, by the difficulty of replicating and extending treatments, and by the lack of adequate controls over extraneous sources of variance. Computer-based imaginary sciences expand the opportunities for addressing these problems by loosening the constraints that real-world subject matter imposes on experiment design.

But there may be a more subtle benefit to imaginary sciences: the invention of imaginary subject matter is a creative process. The goal of this process is to produce an accurate simulation of deep structures common to many "real world" subject matter domains. The intelligent design of imaginary subject matter therefore requires that researchers extract the essential relationships embodied in specific real world subject matter domains and represent them in a more generalizable and yet more compact form--a form more suitable to experimental verification of theories and general hypotheses. It seems reasonable to expect that instructional scientists who pursue this inventive activity in the service of their experimental goals will have new insights about the relationship between instructional strategies and instructional content--insights that would not occur had their thinking been restricted to content based on the "real" world.

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    Instructional Development, 5 (1), 8-13.

WELCOME TO THE STARCRUISER ACADEMY SCIENCE OFFICER TRAINING COURSE.

During the next few hours, you will be trained to recognize and identify various planets throughout the Xenograde System. As a Science Officer on board one of the Empire's many starcruisers, your responsibility will be to identify and correctly classify all planets viewed on the Planet Inspection Console. This classification is then relayed to the crew, so they can determine whether the planet is a safe landing site. Many of the planets throughout the system emit harmful radiation, produce diseases, or are covered with exploding volcanoes and other dangers. As a Science Officer, you must know the traits and characteristics which classify the planets into ten major categories.

ABOUT THE TRAINING

The training section is divided into two sections. The training manual will teach you the vocabulary and terminology of the parts of the Xenograde planets. Once you have mastered the terminology, you will be ready to begin training on the Planet Inspection Console.

FIGURE 1. Pages from manual explaining Xenograde terminology.

PARTS OF A TYPICAL PLANET SYSTEM

PLANET INSPECTION CONSOLE
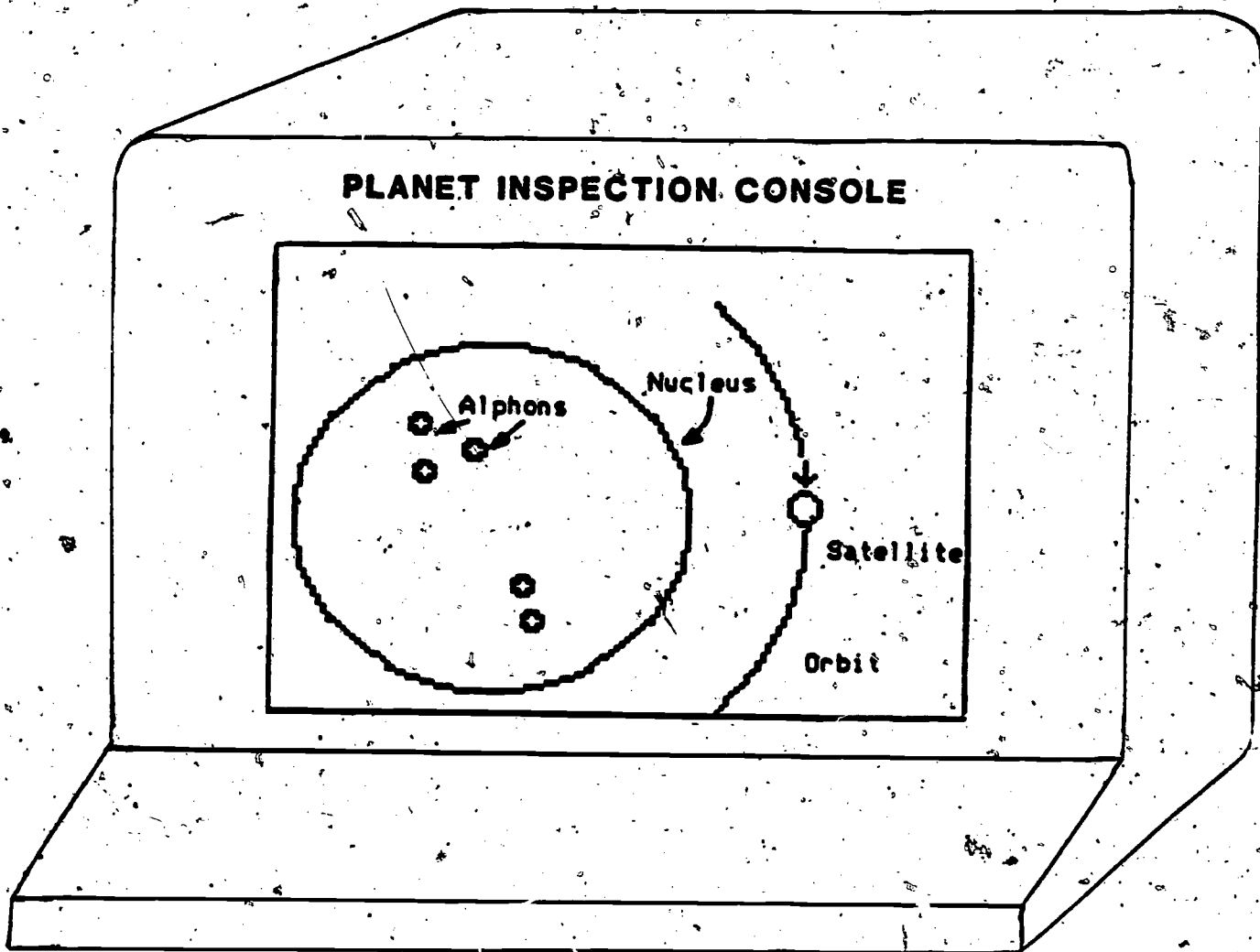
The screen above shows the parts of a typical Xenograde planet.
The large round object is called the nucleus. Inside the nucleus
are tiny particles called alphons. Satellites travel around the
nucleus in a path called an orbit. You can tell the direction of
the orbit by looking at the arrow above the satellite.

FIGURE 1 (continued)   12

NUCLEUS SHAPE

The nucleus comes in four shapes: spherical, 2-lobed, 3-lobed, and 4-lobed. Here are some examples:

SPHERICAL NUCLEUS

2-LOBED NUCLEUS

3-LOBED NUCLEUS

4-LOBED NUCLEUS

Figure 1 (continued)

13
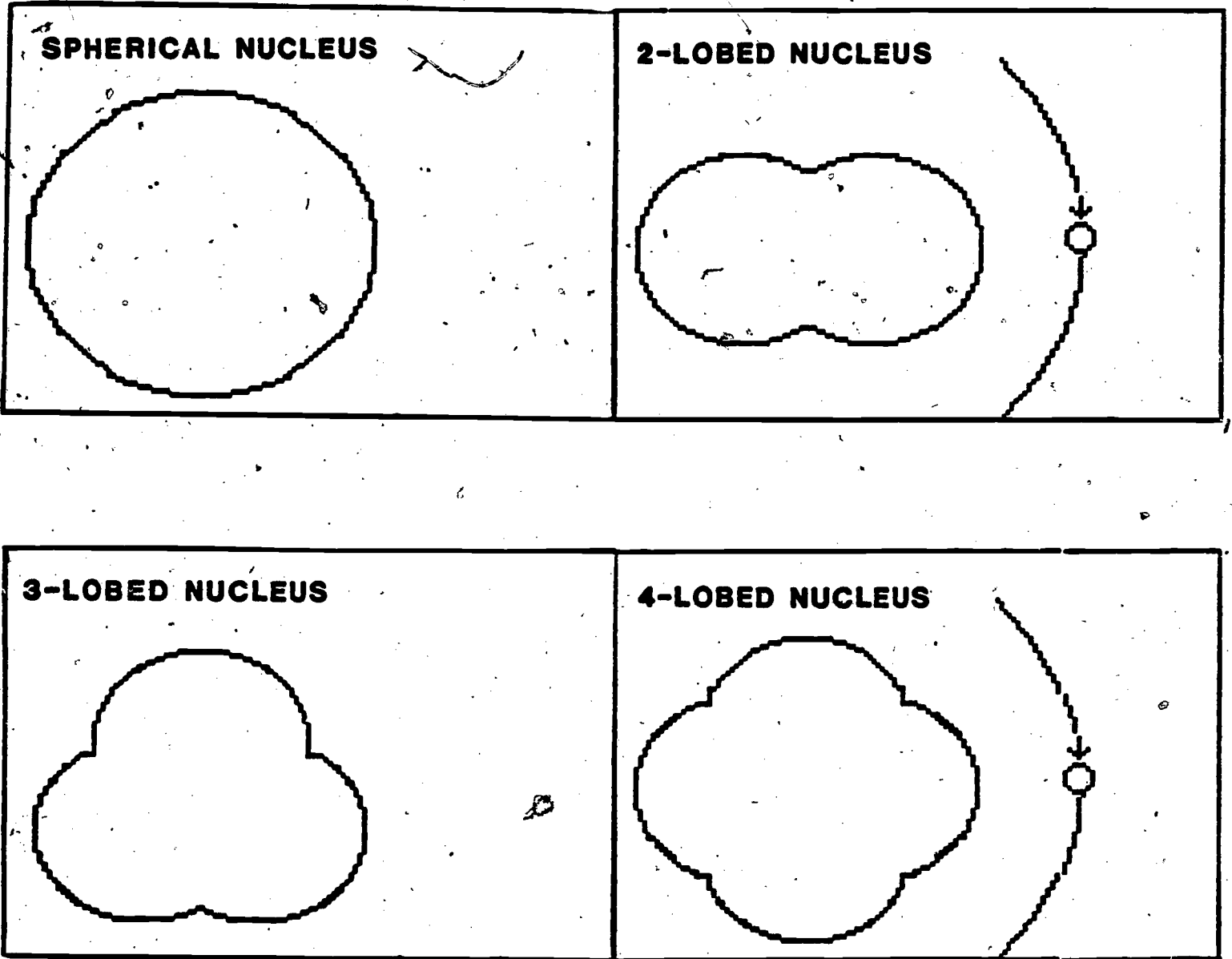
There are two <u>types</u> of nucleus. If the nucleus contains <u>no alphons</u>, it is called homogenous. A nucleus with alphons inside it is called particulate. Below are examples of each:
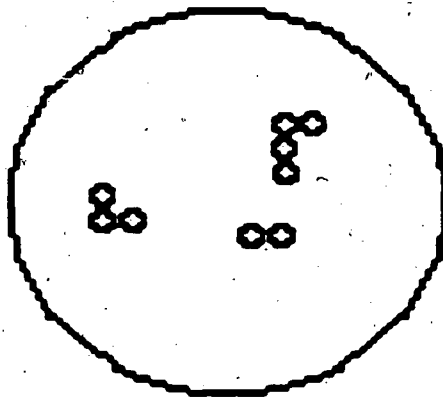
HOMOGENOUS NUCLEUS
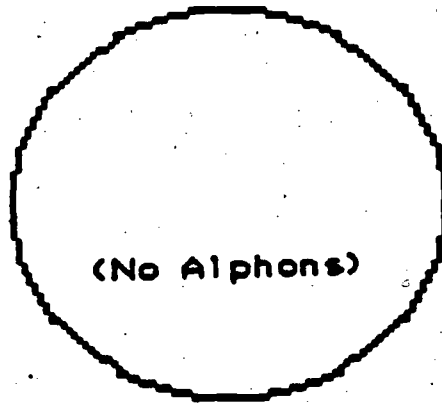
(No Alphons)

PARTICULATE NUCLEUS

Figure 1 (continued) 14
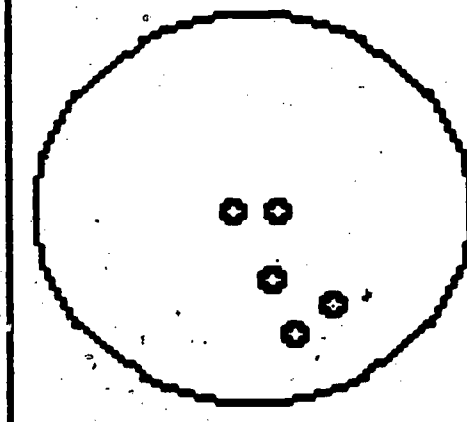
ALPHON BEHAVIOR

Alphons behave differently on different types of Xenograde planets. There are three kinds of alphon behavior: clustered, dispersed and pulsating. The following are examples of each:
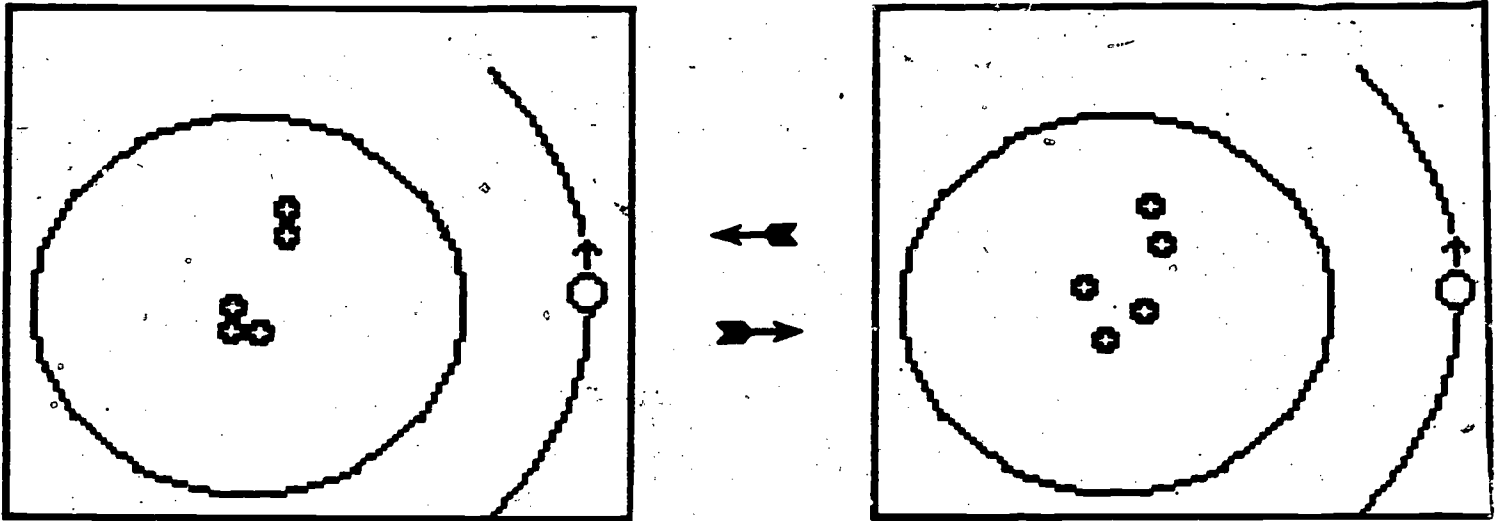

CLUSTERED ALPHONS

Clustered alphons form tight little groups in which two or more of the alphons are touching each other.
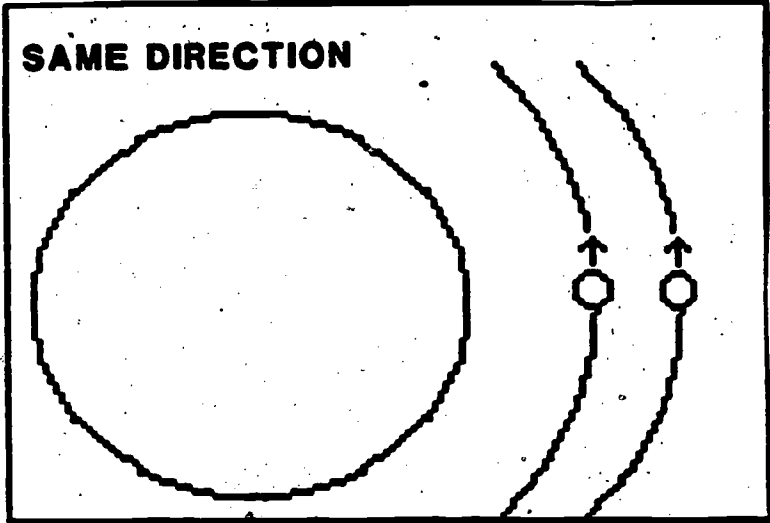

DISPERSED ALPHONS
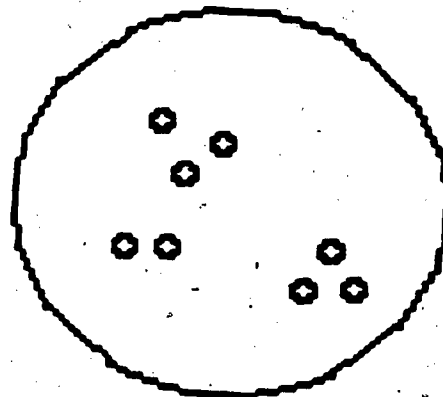
Dispersed alphons never touch each other.

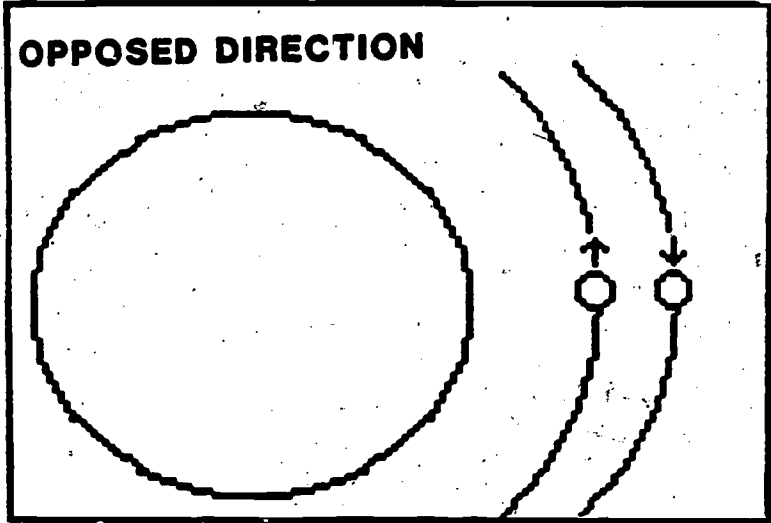Figure 1 (continued)   15

PULSATING ALPHONS

Pulsating Alphons alternate
between clustered and dispersed
states.

Figure 1 (continued) 16

Satellites may travel in the same direction.

Satellites may be opposed and travel in opposite directions.

Figure 1 (continued)   17

ALPHONIC

Example : Alphonic | Definition of :
Alphonic
>Spherical or Lobed
>Particulate Nucl's
>Odd or Even number
of Pulsating Alphs
>Alternte, Same, or
Opposed Orbit Dir
>1, 2, or 3 Sats

BETONIC

Example : Betonic | Definition of :
Betonic
>Spherical or Lobed
>Particulate Nucl's
>Even number
of Clustered Alphs
>Alternte, Same, or
Opposed Orbit Dir
>1, 2, or 3 Sats

CATATONIC

Example : Catatonic | Definition of :
Catatonic
>Spherical or Lobed
>Particulate Nucl's
>Odd number
of Clustered Alphs
>Alternte, Same, or
Opposed Orbit Dir
>1, 2, or 3 Sats

DELTONIC

Example : Deltonic | Definition of :
Deltonic
>Spherical or Lobed
>Particulate Nucl's
>Even number
of Dispersed Alphs
>Alternte, Same, or
Opposed Orbit Dir
>1, 2, or 3 Sats

ETONIC

Example : Etonic | Definition of :
Etonic
>Spherical or Lobed
>Particulate Nucl's
>Odd number
of Dispersed Alphs
>Alternte, Same, or
Opposed Orbit Dir
>1, 2, or 3 Sats

FATONIC

Example : Fatonic | Definition of :
Fatonic
>Spherical or Lobed
>Homogenous Nucleus
No Alphons
>Alternating Orbit
Directions
>1 Satellite

GAMMONIC

Example : Gammonic | Definition of :
Gammonic
>Spherical or Lobed
>Homogenous Nucleus
No Alphons
>Same Orbit
Directions
>2 Satellites

HAPPONIC

Example : Happonic | Definition of :
Happonic
>Spherical or Lobed
>Homogenous Nucleus
No Alphons
>Same Orbit
Directions
>3 Satellites

ISONIC

Example : Isonic | Definition of :
Isonic
>Spherical or Lobed
>Homogenous Nucleus
No Alphons
>Opposed Orbit
Directions
>2 Satellites

JUPPONIC

Example : Jupponic | Definition of :
Jupponic
>Spherical or Lobed
>Homogenous Nucleus
No Alphons
>Opposed Orbit
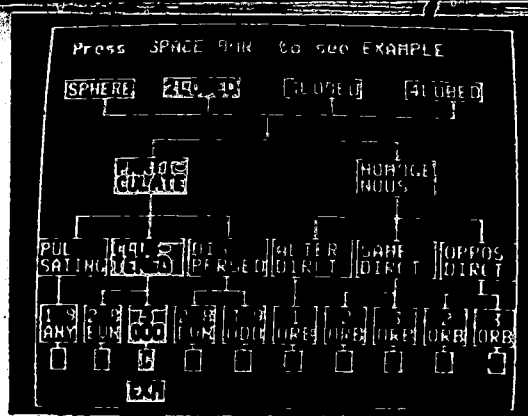Directions
>3 Satellites

FIGURE 2. Xenograde concept definitions.

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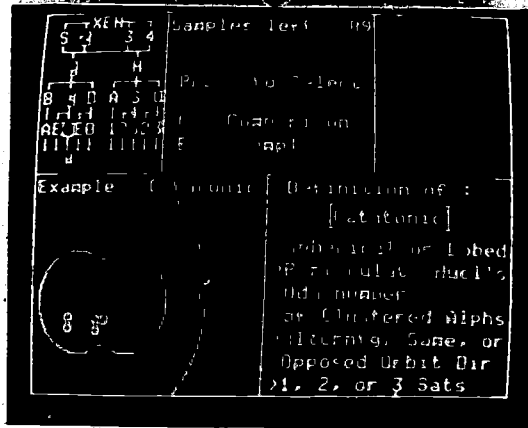CAPTION FOR FOLLOWING PAGE

Figure 3.   Instance selection and presentation displays
              (hierarchical format). The program controlling these
              displays allows for exploration of the classification
              system via simple branching options.

    3a.   Instance selector display. This is the key feature of
              the program. It allows the user to create an instance of
              any class by selecting a series of attributes. The user
              must specify all the attributes critical to
              classification. In addition, the user must specify the
              nucleus shape, an irrelevant attribute for all classes.
              Figure 4 shows the displays for the matrix version of
              this program.

    3b.   Instance presentation displays. Once the user has
              specified a series of attributes, he or she advances the
              program to the instance presentation display. This
              display contains four components (starting in the upper
              left and proceeding counterclockwise):

                1. memory aid summarizing the attributes selected;
                2. diagram of the instance;
                3. definition of the class to which the instance belongs;
                4. menu for selecting the next display.

    3c.   Example option. After viewing the instance presentation
              display, the menu allows the user to select one of two
              options: the example option returns the program to the
              selector and allows specification of a new example.

    3d.   Comparison option. This option returns the program to the
              selector but continues to display the attributes of the
              previously selected example. In this option, the user
              specifies the attributes of a comparative instance and
              advances the program again to the instance presentation
              display (3f) The instance presentation display then
              presents the comparison side-by-side with the previously
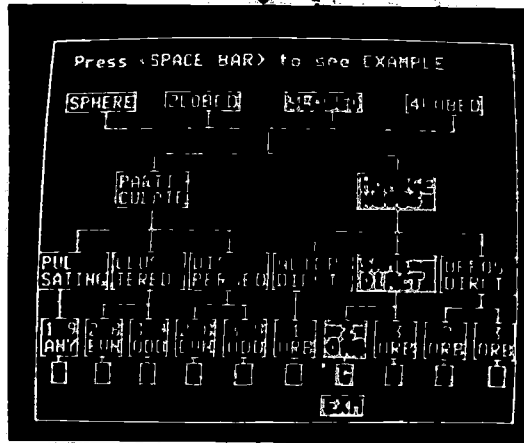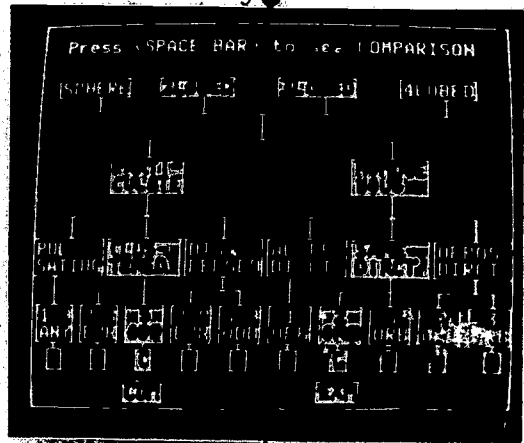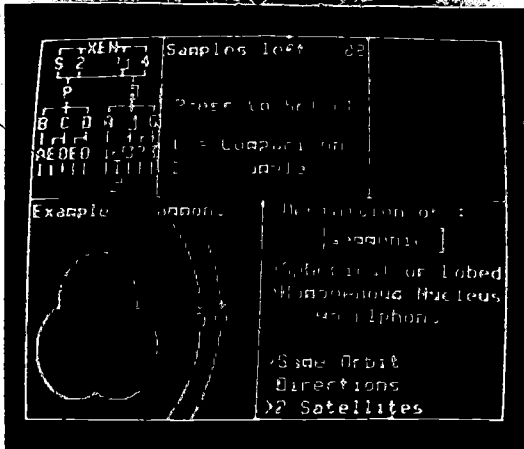   selected example.

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3a.

Press SPACE BAR to see EXAMPLE

SPHERE ... CLOSED 4LOBED

3b.

3c.

Press (SPACE BAR) to see EXAMPLE

SPHERE PLOBED ... 4LOBED

3d.

Samples left

Example ...

Definition of :
[Harmonic]
Spherical or Lobed
Homogeneous Nucleus
one Alphon
>Same Orbit
Directions
>2 Satellites

3e.

Press (SPACE BAR) to see COMPARISON

SPHERE ... 4LOBED
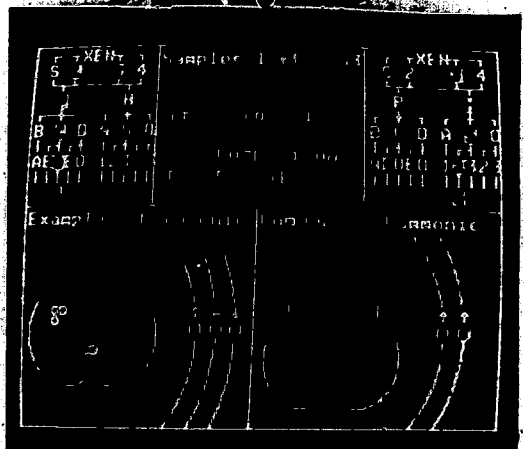
3f.

CAPTION FOR FOLLOWING PAGE

Figure 4.   Instance selection and presentation displays (matrix
             format).

     4a.   The matrix format represents the same selection decisions
             in the same order as the hierarchical format and requires
             the same keystrokes to execute a given decision. Both
             versions of the program independently vary certain
             irrelevant attributes, such as the location of alphons,
             on the basis of pseudo-random routines. The number and
             direction of orbits is varied in the same way, but only
             for instances of particulate classes. The result of
             these variations is a pool of several hundred thousand
             instances.

     4b.   In the matrix format of the instance presentation
             display, the memory aid (upper left) is presented as an
             abbreviated table rather than as a hierarchy. The
             example and comparison options play the same role in both
             the hierarchical and matrix versions of the program.
             Through the example option, the user may select an
             instance to exemplify any concept. He or she may then
             use the comparison option to select additional instances
             (one at a time) to serve as comparisons. A new example
             may be selected at any time, or it may be held constant
             while the comparisons are varied. When an example and a
             comparison are instances of the same class, they serve as
             dual examples, allowing the subject to explore
             within-concept diversity. When the example and
             comparison are instances of different concepts, the
             comparison serves as a non-example of the concept.

4a.

Press <SPACE BAR> to see EXAMPLE

NUCLS SHAPE	NUCLS TYPE	ALPHON ACTIV	DOF ALP	ORBIT ACTIV	DOF ORB	CLS
		EXAMPLE				
Sphere	Parti culate	Pul sating	1 3 ong	Alter dirct	1 orb	
2lobed	Homo genou	Clus tered	2-4 evn	Same dirct	2 orb	
3lobed						
4lobed		Dis persed	3-5 odd	Oppos dirct	3 orb	

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4b.

S d P A A
H
3   D E D
4
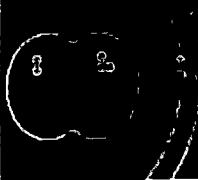
Class
ABCDE FGHI

Example : Cationic

Samples left : 03

Press to Select

C = Comparison
E = Example

Definition of :
Cationic
Spherical or lobed
Particulate Nucl's
Odd number
of Clustered Alphs
Alterntg, Same, or
Opposed Orbit Dir
>1, 2, or 3 Sats

4c.

Press <SPACE BAR> to see EXAMPLE

NUCLS SHAPE	NUCLS TYPE	ALPHON ACTIV	DOF ALP	ORBIT ACTIV	DOF ORB	CLS
		EXAMPLE				
Sphere	Parti culate	Pul sating	1 3 ong	Alter dirct	1 orb	
2lobed	Homo genou	Clus tered	2-4 evn	Same dirct	orb	
3lobed						
4lobed		Dis persed	3 5 odd	Oppos dirct	3 orb	

4e.

Press <SPACE BAR> to see COMPARISON

NUCLS SHAPE	NUCLS TYPE	ALPHON ACTIV	DOF ALP	ORBIT ACTIV	DOF ORB	CLS
		EXAMPLE				
		COMPARISON				
Sphere	Parti culate	Pul sating	1 ong	Alter dirct	1	
2lobed	Homo genou	Clus erd	4 evn	ame dirct	orb	
3lobed						
4lobed		Dis persed	3 odd	Oppos dirct	3 orb	

4d.

S d P A A
2 H C 0 S
3
4

Class
ABCDE FGHI

Example : Dextronic

Samples left

Press to Select

C = Comp.
E = Example

Definition of :
Dextronic
Spherical or lobed
Particulate Nucl's
Even number
of Clustered Alphs
alterntg, Same, or
Opposed Orbit Dir
1, 2, or 3 Sats

4f.

S d P A A
H
3
4

Class
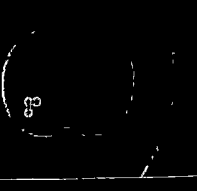ABCDE FGHI

Example :

Samples left : 00

Press to select

Comparison

S d P A
C H C 0 S 2

Class
BCDE FGHI

Deltonic

CAPTION FOR FOLLOWING PAGE

Figure 5.   Sample classification test display. These displays
introduce the student to the classification test.
Displays for the individual test items are identical to
those shown here except that they omit the directions.
The test only required students to designate the first
letter of the appropriate Xenograde class. Because
certain portions of the control program for the test were
incomplete at the time of one experiment, students wrote
item responses on a test form instead of keying answers
into the computer.

IN ORDER TO PERFORM YOUR BEST ON THE XENOGRADE MASTERY TEST, YOU
NEED TO KNOW WHAT THE TEST WILL LOOK LIKE AND WHAT YOU NEED TO
LEARN.

The test will show you a diagram of a planet system and you'll be
asked to type in the name of the <u>kind</u> of planet which the diagram
represents.

HERE IS A SAMPLE "PAGE" FROM THE TEST:

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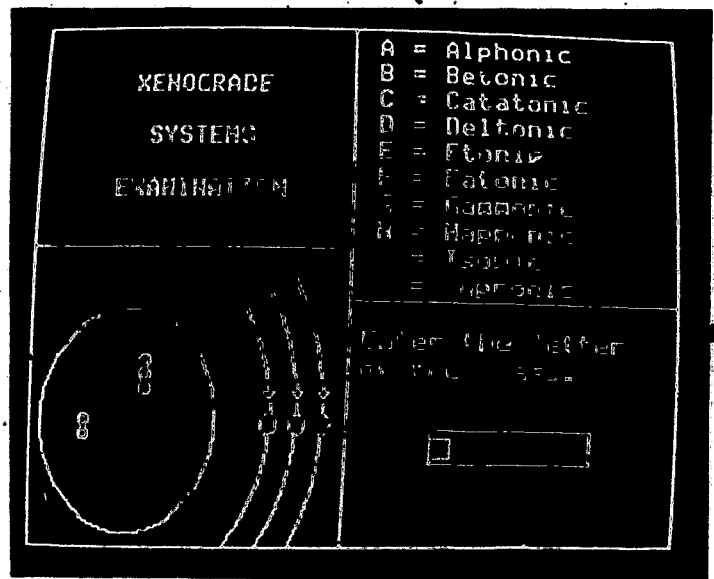
You <u>DON'T</u> have to remember the exact name of the types of planets
you'll be learning because each "page" of the test has a list of
names to choose from.

You <u>DO</u> need to learn to tell the different kinds of planets apart
from each other.

You <u>DO</u> need to remember the first letter of each type of planet.

There is a time limit for each answer, but you can change your
answer anytime before the time is up by simply typing in a new
letter.

THE TEST IS MUCH EASIER THAN IT LOOKS. YOU'LL RECEIVE EXTENSIVE
TRAINING BEFORE YOU TAKE THE TEST. YOU'LL ALSO HAVE A CHANCE TO
TAKE A PRACTICE TEST.

FIGURE 5   25