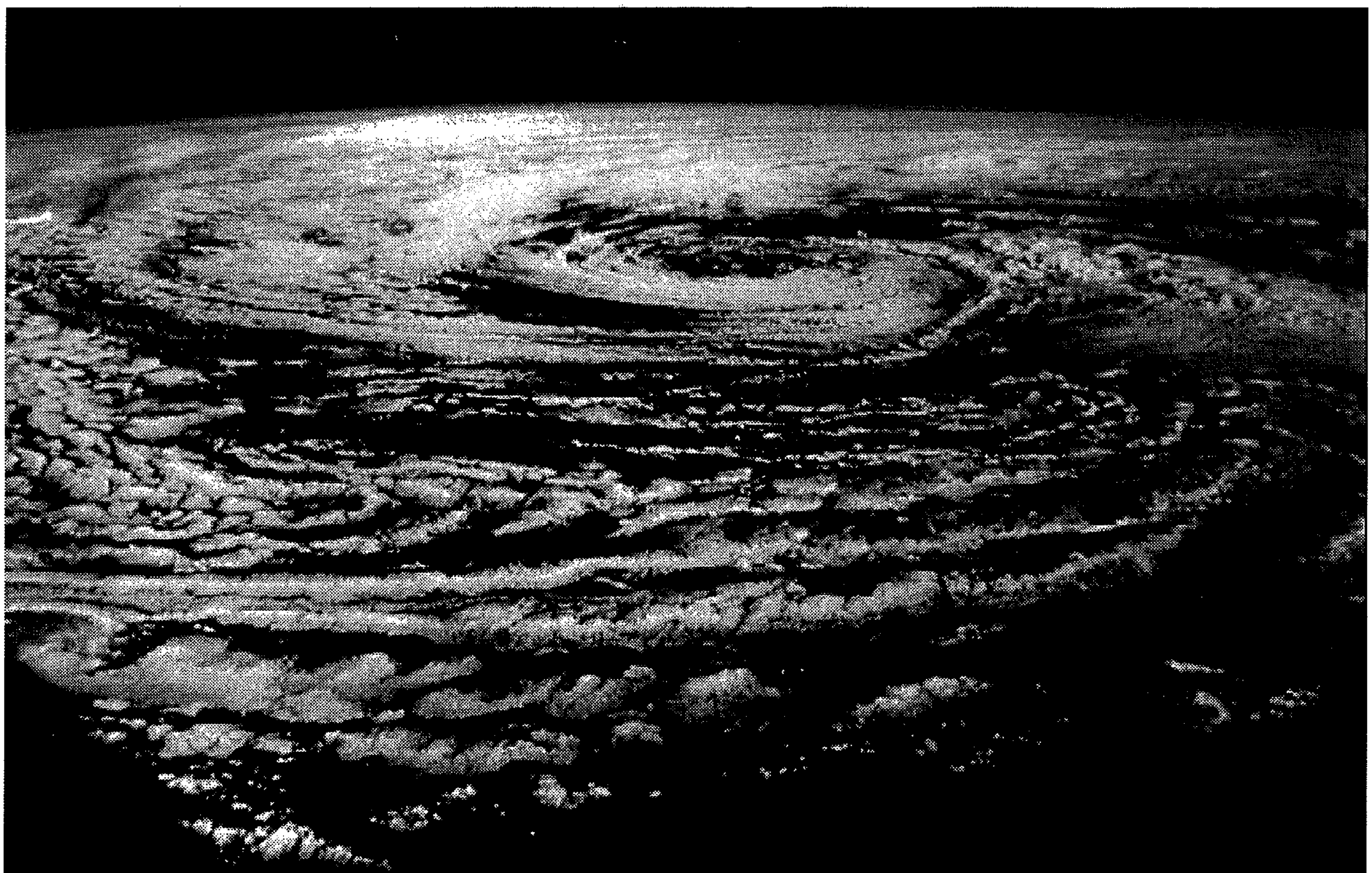

Behavioral Research and Teaching

Improving Science Performance Outcomes via Instructional Framing and Rule-Based Learning

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Abstract

Increasingly, professional organizations are developing standards for achieving high levels of performance; in science, the American Association for the Advancement of Science has defined 12 general areas within which students must perform. For students with disabilities, various types of support are required to ensure they are provided adequate opportunities to learn and achieve at these levels. In this study, we investigated one such system of support, using a rule-based instructional structure delivered by the content teacher. We found that a curriculum-instructional modification using rule-based learning principles resulted in significantly higher performance than a traditionally taught method emphasizing factual information. Yet, the treatment program was effective only for one of the two students with learning disabilities. We interpret our findings by reference to other systems of support that may be needed for students with disabilities to achieve high levels of performance in science.

Instructional Framing and Rule-Based Learning

Due to the criticism aimed at public education for failing to provide quality or even adequate education for all students, reforms are currently underway to develop higher standards for content, instructional delivery, and assessment methods (Goals 2000). The National Science Education Standards, in particular, have been developed as an effort to improve science education. Content standards place emphasis on attaining understanding through inquiry, technology, science in personal and social perspectives, and the history of science (Bybee & Champagne, 1995). The emphasis on science as inquiry will require new instructional methods for many science teachers. Consequently, assessments also must focus on demonstrations of understanding through the use of information in problem solving or critical thinking contexts rather than traditional memorization of factual information.

When considering improved standards for science education, we also need to consider the inclusion of students with special learning needs within the science classroom. Goals 2000 was developed to promote higher standards for "all" students not exempting students who require special services merely because of their basic skills deficits. "Although it is not new to include thinking, problem solving, and reasoning in someone's school curriculum, it is new to include it in everyone's curriculum" (Resnick, 1987, p.7). All students are capable of becoming more complex thinkers provided the content, instruction, and assessment components are interrelated and provide the opportunity for higher levels of achievement.

In this study, we investigate attainment of mastery standards in science, with particular emphasis on the outcomes for students with learning disabilities. The purpose of the study is to understand the results from a 2-week unit on astronomy that was part of a normal eighth-grade classroom in which five students with learning disabilities were included. Using the American Association for the Advancement of Science Benchmarks (Project 2061, 1993), we describe the results both in relation to mastery and in relation to a specific instructional support system that focused on teacher presentation of a rule basis for problem solving. The literature we review to vindicate this focus includes consideration of the standards being promulgated in the general education science curriculum (including the focus on problem solving using performance assessment systems), the support systems being advanced in special education for including students with disabilities in science classes, and the focus we have taken that emphasizes problem solving.

Science Standards

In Benchmarks for Scientific Literacy (Project 2061, 1993), standards have been specified in the following areas: (a) the nature of science, (b) the nature of mathematics, (c) the nature of technology, (d) the physical setting, (e) the living environment, (f) the human organism, (g) human society, (h) the designed world, (i) the mathematical world, (j) historical perspectives, (k) common themes, and (l) habits of mind. For example, in the area of the physical setting (the universe), "By the end of the eighth grade, students should know that...

> •The sun is a medium-sized star located near the edge of a disk-shaped galaxy of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night. The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot.
>
> •The sun is many thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth, but light from the next nearest star takes a few years to arrive. The trip to that star would take the fastest rocket thousands of years. Some distant galaxies are so far away that their light takes several billion years to reach the earth. People on earth, therefore, see them as they were that long ago in the past.
>
> • Nine planets of very different size, composition, and surface features move around the sun in nearly circular orbits. Some planets have a great variety of moons and even flat rings of rock and ice particles orbiting around them. Some of these planets and moons show evidence of geologic activity. The earth is orbited by one moon, many artificial satellites, and debris.
>
> • Large numbers of chunks of rock orbit the sun. Some of those that the earth meets in its yearly orbit around the sun glow and disintegrate from friction as they plunge through the atmosphere—and sometimes impact the ground. Other chunks of rocks mixed with ice have long, off-center orbits that carry them close to the sun, where the sun's radiation (of light and particles) boils off frozen material from their surfaces and pushes it into a long, illuminated tail. (p. 64)

These higher science standards not only redefine what is important for students to learn and do, they also should guide the science education system toward the goal of improving outcomes for all students. Because these higher levels of achievement remain the ultimate goal of educational reforms, alternative performance assessments are being developed in terms of promoting and more accurately measuring achievement (Bybee & Champagne, 1995), and in helping teachers identify the skills that need to be practiced if students are to reach a level of mastery. All students must be provided with an opportunity to apply this higher-level knowledge to solving science problems. However, if performance assessment is to be consistent with curricular and instructional goals, all three factors must overlap and interact in terms of revitalizing education. It is unthinkable to expect students to perform at a level higher than memorization without structured exposure to conceptual knowledge and without an opportunity to develop the typically neglected higher-level thinking skills within an instructional setting. We, therefore, focus our attention on the critical interaction between assessment, curricular content, and instruction occurring within the science classroom to support all students, especially those with disabilities. "Assessment can be a powerful tool for reform, since changing the nature of assessment can lead to changing the nature of instruction" (Raizen & Kaser, 1989, cited in Koehler, 1993, p. 11).

Supporting Students With Disabilities in Science Classes

Two recent reviews of science instruction have presented a range of critical variables to consider in supporting students with disabilities in science content areas. In a review of 66 reports published from 1954 to 1992, Mastropieri and Scruggs (1992) found that instructional variables, text adaptations, and mnemonic and other elaborative techniques all had a positive effect on student learning, behavior, and motivation; as they also note, however, only three studies were conducted in special education settings that addressed instructional variables (enthusiasm, structure, and study skills). In a considerably different review (not of research, but of actual classroom practices), Scruggs and Mastropieri (1994) identified seven variables “which appeared to be meaningfully associated with observed mainstreaming success, across categories of disability and grade level. These seven variables included administrative support; support from special education personnel; an accepting, positive classroom atmosphere; appropriate curriculum; effective general teaching skills; peer assistance; and disability-specific teaching skills” (p. 794). In this study, it is important to note that the dependent measure was teacher perception (about what things make mainstreaming successful, reactions to the district science curriculum, specific adaptations made in science for students with disabilities, and helpfulness of administrative support).

Other research on science instruction for students with disabilities is reported in a special issue of RASE (1994, volume 15, issue number 2) in which a number of different tacks are presented. In general, each approach provides a partially specified solution to serving students with disabilities in content classes.

For Cawley (1994), the key issue is the use of themes as an alternative curriculum framework. This strategy avoids many of the limitations of relying on only a direct instruction versus a student-centered learning approach. In this strategy, a theme is a "unifying representation of major principles. Themes are superordinated organizers under which major principles from each of the many fields can be grouped" (p. 70). Although a theme may provide unification for major principles, it is not sufficient in and of itself to support manipulation of information. The underlying principles contain the critical elements that transfer across disciplines and allow for application of information.

For Mastropieri and Scruggs (1994), the central dilemma appears to be the use of a text versus a hands-on science curriculum. "The little research evidence that does exist suggests that appropriately implemented activities-oriented approaches may be, overall, more facilitative of science learning for students with disabilities than textbook approaches" (p. 84). Irrespective of any firm conclusions, however, they note that if a content-based approach is adopted, special education may play a more important role in helping students with the requisite basic skills, study skills, and alternative media presentations of content; in contrast, with an activities-based approach, special education support may need to focus more on peer mediation, supported inquiry, cooperative learning, specific coaching to facilitate thinking, and activity adaptations.

Woodward (1994) focuses on several components in science instruction: direct instruction, mnemonics, graphic organizers, and curriculum revisions, the latter of which has been most seriously and systematically developed by him and others (see Carnine & Kameenui, 1992). In his support structures for students with disabilities, models are used to formulate specific curriculum revisions along with graphic representations. Although these techniques can be effective when supporting students with disabilities, the content and students' use of the information must be considered in terms of achievement.

Lovitt and Horton (1994) describe techniques for adapting science textbooks for youth with learning disabilities. They suggest four techniques for adaptation: (a) study guides, (b) graphic organizers, (c) vocabulary drill in a precision-teaching model, and (d) computer-assisted instruction. Although these adaptations may make reading text or comprehending vocabulary easier, the adaptations still rely on the basic form and structure of the text and ignore the big idea being presented.

Parmer, Deluca, and Janczak (1994) consider the relationship between science and the language abilities of students with mild disabilities, with listening skills considered more influential in allowing them access to the content than reading skills. They conclude with the recommendation for more teaching approaches that do not require reading and/or more use of hands-on activities. Students still must have the activity framed by some conceptual knowledge. Critical information must be transmitted to students, and then they must have an opportunity to develop the skills necessary to communicate their knowledge.

Finally, in a long line of research, Mastropieri and Scruggs (1991) suggest that an effective method for teaching students to recall information is to focus on key words through mnemonics. Although this method is successful for teaching key words, it lacks an emphasis on the big idea, which encompasses all the lesser vocabulary. Memorizing attributes of key terms is not in itself a means of improving higher-level skills—the goal of higher academic standards where students must go beyond a correct response and demonstrate conceptual knowledge. To achieve higher-level thinking skills, students must be exposed to the higher-level knowledge forms, (e.g., concepts and principles).

When developing support systems for students with disabilities in science classes, consideration must be given to what we expect students to do with the information. Not only should students be exposed to higher-level knowledge forms, they must have an opportunity to move beyond lower-level skills to a level where mastery is exhibited through the manipulation of information in accordance with the new educational standards in science.

Instruction in Content Areas That Emphasizes Problem Solving

While these support systems may work for learning content in special education classes, we question the degree to which they will work for learning problem solving that is aligned with the assessment reforms in the various content disciplines, particularly science. Quite likely, they may be partially effective in organizing content information, yet, "opportunity to learn" critical thinking (more operationally defined as problem solving) may be generally limited. The central issue is how to systematically provide students an opportunity to also learn the critical information that provides the context for complex thinking (and leads to improvement in problem solving).

1. To investigate this issue, we propose a more thorough understanding of instruction in general education content classes in which students with disabilities are placed. The content teacher, serving as the discipline expert, therefore, serves as the primary deliverer of instructional content. If students with disabilities are to succeed, they need to be receiving content from those who know it best.

2. We also propose moving the emphasis of instruction from facts to concepts. We argue that teachers must focus instruction on higher-level knowledge forms. Not only must concept learning depend on concept definition being presented to students with examples and nonexamples (Prater, 1993), but also principle learning is related to presenting definitions and examples of principles.

3. Finally, we propose moving the emphasis away from large issues (like type of text or use of activities) to specific issues (like content and format of instructional presentation). The core issue, particularly in many areas of science where activities are marginal as a forum for meaningful involvement, is how phenomena are explained. For us, the interaction between the teacher and the student is the most important instructional event, like that described in the research by Brady, Swank, Taylor, and Freiberg (1992). Rather than simply focusing on academic versus nonacademic, however, we propose addressing specific rule explanations with embedded concepts and principles.

The purpose of this study, therefore, is to examine the relationship between instruction and achievement with a group of students receiving instruction from their general education science teacher: One group receives rule-based (higher-level knowledge) instruction, and the other group receives nonrule-based instruction. Using a restructured science unit on the solar system to provide a focus on the overriding rules explaining relationships between concepts, we coordinate planning for instruction and classroom activities with performance assessment tasks to measure achievement in an area of science in which standards are being developed and emphasized.

Methods

This study was conducted in a middle school with approximately 450 students and 25 teachers, within a district of about 4,500 students. This school was ranked 75th in socio-economic status (from the bottom of a pool of about 550 schools in the state). The project took place during the final 3 weeks of the 1994-95 school year. The components of the study included curriculum restructuring, instructional modifications, activities development, and performance assessments.

Subjects

One eighth-grade science teacher with two science classes participated in this study. She holds a Master's degree in curriculum and instruction and had 8 years of teaching experience. The teacher had been involved with the research team for 5 years while volunteering for various studies. Due to the recent inclusion of special education students into the content area classes, this teacher was interested in improving her techniques for supporting all students' science achievement.

A total of 34 students participated in the study by attending class during the intervention period and completing the final graphic and essay task as well as the final fact test. Their average age was 14.3 years (with no differences between the two groups); the group included 17 females and 17 males, who were unequally distributed between the two class periods (with significantly more females and fewer males in Period 1); 94% of the student population was Caucasion, with 3% Asian-Pacific and 3% Hispanic. Four students with learning disabilities were receiving special education services (2 in each experimental condition), and their assistance areas were spread across multiple basic skill area (see Table 1 for specific demographics statistics and frequency counts).

During an informal interview prior to the study, the teacher provided her opinion about the general make-up of the two classes and noted that generally the first period class (hereafter noted as Period 1) was overall a well-behaved class that had a high level of engagement throughout each class session and completed most assignments. On the other hand, the fourth period class (hereafter noted as Period 4) generally had a high rate of off-task behavior and inconsistently turned in assignments (see Figure 1).

Procedures

We began this study by engaging the teacher and researchers in determining the content for a 2-week science unit on a study of the solar system. The curriculum was then restructured to include information most critical to student understanding, i.e., the overriding principle-based rules within the study of the solar system. The teacher and researchers worked collaboratively to develop the curriculum and instructional methods, e.g., lecture notes, graphic organizers, lab activities, classroom assignments, and problem-solving assessment tasks.

The design of the study included a different instructional focus for each of the two classes, i.e., rule-based and nonrule-based. For Period 1 (control group), the teacher was to focus instruction on nonrule-based planetary information with activities and questions supporting planetary information and no connections stated explicitly. Information in Period 4 (treatment group) was to be presented as a set of principle-based planetary rules where all activities and questions were supported by rules. A comparison of student outcomes on problem-solving tasks, in relation to the instructional component (rule based vs. nonrule based), was completed to determine if the use of rules was effective.

Curriculum Restructuring

Gaining a critical understanding of the information presented within the solar system curriculum necessitated a content focus on more than the many facts about the planets within the solar system. After reviewing the curriculum, we concluded that although many critical facts (nonrule-based information) related to the planets were discussed, the rules connecting the facts and providing information for generalization were not present. Therefore, a list of critical information was extracted and restructured in the form of "planetary rules" (see Figure 2). The occurrence of planetary rules within instruction became a dependent measure for monitoring the integrity of the treatment group.

Instructional Methods

The teacher used a traditional lecture style for delivering information and required students to take notes from an overhead projector. The study was designed so that Period 1 would receive all planetary information as factual statements with no connections between information explicitly stated, while Period 4 would receive information as specific rules with explicit connections and examples to reinforce learning of the rules. For example, Period 1 was taught that Uranus is a large, massive outer planet that has a strong gravitational pull and a thick atmosphere. However, Period 4 received the information with connections that could be applied to other planets, i.e. large, massive planets like Uranus have a strong gravitational pull and thus thicker atmospheres. Most instructional lectures were followed by a classroom activity. All lectures were either transcribed verbatim or monitored by the researchers who observed engaged time and/or rule occurrence observations.

The classroom activities and assignments were developed to enhance students' understanding of the planetary information. The framework for one activity was based on the distances between planets and between the planets and the sun relating to two of the planetary rules. Although the rules were implicit, only Period 4 responded to higher-order questions after the activity. Period 1 responded to nonrule-based questions. Another activity provided students with the opportunity to engage in a computer-assisted program on the solar system listing factual information for Period 1 and rule-based information for Period 4. Students also constructed a model of a planetary orbit and completed worksheets that included either fact-based or rule-based questions respectively. An equal number of activities and questions were provided for each class, however the types of questions (rule based or nonrule based) differed. Although the rules in Period 1 were implied given the consistency of nonrule-based information for each planet, they were not explicitly stated as rules with the critical links made between concepts. However, a number of instructional violations occurred where the rules were stated inadvertently in Period 1. See Figure 3 for actual planetary rule use by teacher during instruction. Furthermore, the opportunity to manipulate rule-based information during activities was inconsistently provided in Period 4 due to the limited nature of teacher questions or time to complete worksheets. See Figure 4 for a depiction of dialogue within the rule-based class.

<u>Student Measures, Data Collection, and Analysis</u>

A pre-assessment measure was developed to gain an understanding of students' attitudes about school, science, and astronomy and to gain a baseline of their astronomy knowledge specific to the planetary rules. A mid-unit problem-solving task was developed to monitor student progress in manipulating the planetary rules. This midterm test was given half way through the unit and asked, "What would happen if Mars was hit by an asteroid and a chunk of it broke off and went into an orbit? Describe the orbit and the planetary conditions on it." Finally, a graphic representation task, problem-solving essay task, and a fact test were designed as an end-unit assessment measure where students were provided an opportunity to apply their knowledge about the planetary rules using different response modes. Students were required to provide a graphic depiction of a newly discovered solar system, an explanation of which planet they would land on for further exploration of this new solar system, and a fact test on the planets.

Specific scoring criteria for the mid-unit focused on the presence of a rationale using proximity to the sun and other planetary rules, as well as the use of terms such as temperture, gravity, and atmosphere. For the final test, the graphic depiction was scored for accuracy of information based on the planetary rules, the explanation was scored using a flowchart, and the fact test was scored with an answer key.

All data were entered into a file and analyzed according to the variable type: frequency counts and chi-squares were used to analyze categorical variables and descriptive statistics with both analysis of variance and t-tests used to analyse test performance. Upon an initial analysis of the data file, 3 extreme outliers were found in the treatment group with z-scores on the final test over 4 points above the mean. As such extreme scores are unlikely and have a huge impact on small data sets, the data file was trimmed. "Under this procedure equal numbers of the lowest and highest observations are removed from the sample: the resulting reduced (or trimmed) sample is treated as the sample data" (Winer, p. 51). Therefore, these 3 students' records were excised from the file, along with the 3 lowest students; this was done for both the treatment and the control groups.

Results

We have organized the results into eight major sections: (a) classroom demographics of all students including comparisons between the two treatment groups (Period 1, the control group, and Period 4, the experimental group); (b) reliability analyses of the subjectively scored tests (the graphic display and the essay); (c) analysis of a mid-unit task scored by both the teacher and researchers; (d) analysis of the final measures (graphic display, essay quality, and a fact test); (e) frequency counts for five rated items, including statistical comparisons between periods; (f) a multiple regression with the graphic display, the fact test, and the rated items regressed on the essay to explain the most variance; (g) three different *t*-tests in which the total end-of-unit performance is analyzed comparing the two periods with subjects selected out to maximize differences; and finally, (h) student samples of a pre-assessment survey of background knowledge, mid-unit task performance, and final task performance (both graphic and essay).

In analyzing classroom demographics, both as a total group and comparing the two periods, we found (a) a normal distribution of science grades (the mode being a grade of B and many Cs, with few As, Ds, or Fs), with no differences by period; (b) a grade point average of 2.8 for spring quarter and 2.7 for the year, again with no differences between periods; and (c) absence rates averaging about 3 days in the spring quarter and 9 days for the year, with no differences between the two groups in either the spring or the yearly levels. See Tables 2 and 3.

In scoring the two components of the final task, we used an 8-point scale on the graphic display (counting independent features of the graphic with the maximum set by the highest scoring student in the class) and a 1-5 rating scale for the final essay. For both scoring systems, we had a graduate student in a Master's degree program trained on a set of five protocols; she then independently scored the remaining 41 protocols. We calculated reliability in two ways: (a) by comparing the two scores in the form of a fraction (small number over the large number, creating a real number; and (b) by counting the number of exact agreements in assigned score between the researchers and the reliability judge. For the graphic display, the former procedure resulted in an average of .87 with the latter analysis of agreement resulting in 71%; for the final essay, the results were .90 and 85%, respectively. See Table 4.

On the mid-unit task, there were no significant differences in performance between Periods 1 and 4. Both periods performed around 3 points for the first part and around 1 point for the second part. See Table 5.

For the three separate parts in the final test (graphic display, essay, and fact test), we conducted a multivariate analysis of variance. No significant differences were found between Periods 1 and 4. See Table 6.

The four rated items were analyzed by computing the frequency count and percentage of students within each class period responding to each value on the rating scale. For the first item, more students in Period 1 liked school better; for item two, more students in Period 1 rated their status in school higher; for the third item, students in Period 4 rated their enjoyment of astronomy slightly higher; finally, on the last two items dealing with background knowledge, students in Period 1 rated their knowledge higher of both the planets in general and Venus/Mars in particular. See Table 7.

We used a regression analysis to determine the significant contribution of seven criterion measures: (a) graphic display, (b) fact test, and (c) the five ratings from the survey. We found that a subset of three performance measures and one rating item accounted for only 24% of the total variance on the final essay task, with only one variable making a nearly significant contribution (performance on the fact part of the final test). See Table 8.

Finally, we totaled the three measures using z-scores on the graphic display, essay, and fact test to obtain both subtest and total test scores and then analyzed the results with four t-tests. We found significant differences in performance between the periods on the facts part of the final test, no significant differences on the graphic depiction of the solar system, no significant difference on the explanation behind their graphic depiction, and, yet, a significant difference when all three parts of the test were added together. Performance for students in the treatment group was significantly higher than the performance of students in the control group. See Table 9.

Two special education students' responses to four outcome measures are depicted in Figures 5 and 6. The first student included in Period 4 received scores as follows: pre-assessment = 0, mid-unit task = 0, final graphic representation = 6, and final problem-solving essay = 1. The student begins with the inability to respond to a pre-assessment question designed to analyze prior knowledge about the solar system. On the mid-unit task, the student uses important concepts, i.e. temperature, gravity, and atmosphere, but is not able to support choices with explanations. For the graphic representation, the student accurately depicts knowledge of six key concepts. However, on the final problem-solving essay the student begins to discuss distance from the sun and perhaps its relation to temperature, but does not reach the critical connection. The remainder of the response provides no rationale for the choice (see Figure 4).

The second student included in Period 1 received scores as follows: pre-assessment = 1, mid-unit task = 1, final graphic representation = 3, and final problem-solving essay = 2. This student describes some prior knowledge regarding elements necessary to support life on the pre-assessment task. The mid-unit task represents some knowledge regarding temperature and distance from the sun. The graphic representation indicates understanding of three concepts, while the final problem-solving essay uses limited rule-based knowledge about mass and gravity.

Discussion

We approached the study by linking instructional design with performance assessment, hypothesizing that students with disabilities would be better supported with an explicit focus on principles to help reduce the sheer amount of information, and an assessment task that incorporated both a drawing (schematic) and written problem-solving essay (in addition to a traditional fact test). We found significant differences in performance in favor of the rule-based treatment; however, the small sample size makes our findings tentative.

These findings also must be qualified with reference to a few anomalies in our study, most of which are in our favor. For example, the two periods differed considerably in several respects: (a) The control class (Period 1) was much better behaved and less off task (as we had been warned by the teacher, which led us to select the worst class for the treatment); (b) the first class had significantly fewer boys; (c) the rules used within instructional dialogue were inadvertently applied in the control class (in addition to simply having a better organized store of facts than had been offered with the book); and (d) finally, the two classes differed on many perceptions (i.e., liking school, science, or astronomy and background knowledge), which may have mediated attention to the content. For all these reasons, it is possible that the differences would have been even greater.

Our last analysis, in which we converted final test performance to standard scores and totaled them, was predicated on the need to create a more robust outcome measure that would take advantage of the various test strategies (using drawing, writing, and selecting responses) and be sensitive to the powerful dialogue we saw in the classroom. Indeed, we had reasoned from the beginning that, for instruction to be effective for special education students, it must work for general education students. Because our sample size was too small to conduct a subanalysis of special education students alone, we simply looked at one student in each condition.

Of more substantive concern is the role of rules within instruction. In our study, more opportunities existed for the treatment group than the control group to hear examples of the rules or to interact with the information in a more complex manner. Although rules were stated explicitly as intended during lecture for Period 4, the use of concrete examples related to rules and the opportunity to interact with information (see figure 6) was critical. For example, using Cawley's (1994) perspective, themes have been used within "guided meaning," which incorporate both the direct instruction of modeling from teachers and opportunities for constructivistic reflections from students. We achieved this balance, though such themes may be beyond studying within a single unit of science and are better left to investigate over iterations across multiple units, which thereby allow them to be instantiated.

Furthermore, it may have been that, even with the direct instruction approaches, a blend of strategies was necessary, incorporating the higher-order models of Woodard (1994) and Carnine and Kameenui (1992), as well as the mnemonic strategies of Mastropieri and Scruggs (1991). Although our rules were closely aligned to the "big ideas" and higher-order models, they were briefly used (within a 2-week unit that also incorporated other activities and projects); we may never have achieved a critical mass or multiple examples to attain more significant effects. We also taught a unit with a heavy store of facts, making it difficult to simply remember many of the facts; this type of problem has been most directly solved by using mnemonic strategies. Basically, our treatment may have reflected a minimum, though ironically, it was on the fact test that our treatment group was significantly better than the control group. We also learned that the only significant contributor to final essay performance was the facts test. Even with several variables in the mix, however, only a small percentage of the variance was accounted.

Somehow, as researchers of classroom performance, we must begin collecting a broader database of student characteristics and performances to begin explaining what variables are important in explaining student problem solving. Future research definitely needs to be done on the instructional dialogue, particularly in reference to the manner in which students act upon information and teachers reflect upon student performances. Research also needs to be conducted on the "opportunity to learn" in which students engage in complex thinking tasks at all levels from the classroom to the content-grade level (Porter, 1993a). Finally, we need to know more about the standards themselves. As the various professional groups establish their own standards and as states move to various high-stakes accountability models, we need to know more about the kind of instruction that fosters such achievement, particularly for students with disabilities.

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Table 1.

Descriptive Statistics and Frequency Counts for Subject Demographic Variables

	Count	Mean	SD	StdErr	Min	Max
Age	34	14.3	0.8	0.11	12.52	17.71

AGE-YRS

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Period	1	.7	.7	1.2	.2824
Residual	32	18.0	.6		

AGE-YRS

	Count	Mean	Std. Dev.	Std. Err.
Period 1	19	14.4	.9	.2
Period 4	15	14.2	.6	.2

Gender*

	Period 1	Period 4	Totals
Female	13	4	17
Male	6	11	17
Totals	19	15	34

Ethnicity

	Count	Percent
Asian/Pacific	1	2.9
Hispanic	1	2.9
White	32	94.1
Total	34	100.00

Observed Frequencies for Period and Status

	Gen	Spec	Totals
Period 1	17	2	19
Period 4	13	2	15
Totals	30	4	34

Special Education Areas of Assist

	Count	Percent
Math	1	25.00
Rdg, Math, WE	1	25.00
Rdg, WE, Spl	1	25.00
Rdg, WE	1	25.00
Total	4	100.00

$*X^2 = 5.8$ (p=.02)

Table 2.

Frequency Counts and Descriptive Statistics on Classroom Variables for Subjects

	S-SciGr Count	S-SciGr Percent
A	2	6.5
B	14	45.2
C	10	32.3
D	3	9.7
F, NG	1	3.2
P	1	3.2
Total	31	100.00

	S-TriGPA	GPA-Ovl	S-TriAbs	YTDAbs
Count	34	34	34	33
Mean	2.8	2.7	2.5	9.6
Std. Dev.	.8	.9	2.6	9.3
Std. Error	.1	.1	.4	1.6
Minimum	.9	.9	0.0	1.0
Maximum	4.0	4.0	13.5	42.0
# Missing	0	0	0	1

Table 3.

Comparisons Between Periods: Grade Point Averages and Absences, Spring Quarter and Yearly

Spring-TriGPA

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Per	1	.33	.33	.48	.4947
Residual	32	22.26	.70		

Means Table for S-TriGPA

	Count	Mean	Std. Dev.	Std. Err.
Period 1	19	2.86	.92	.21
Period 4	15	2.66	.72	.18

GPA-Ovl

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Per	1	.2	.2	.2	.6309
Residual	32	24.0	.7		

GPA-Ovl

	Count	Mean	Std. Dev.	Std. Err.
Period 1	19	2.8	1.0	.2
Period 4	15	2.6	.7	.2

Spring-TriAbs

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Period	1	8.29	8.29	1.24	.2747
Residual	32	214.89	6.72		

Means Table for S-TriAbs

	Count	Mean	Std. Dev.	Std. Err.
Period 1	19	2.11	1.77	.41
Period 4	15	3.10	3.37	.87

Average YTDAbs

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Period	1	2.68	2.68	.03	.8638
Residual	31	2774.84	89.51		

Means Table for Average YTDAbs

	Count	Mean	Std. Dev.	Std. Err.
Period 1	18	9.36	10.54	2.48
Period 4	15	9.93	7.95	2.05

Table 4.

Descriptive Statistics for Reliability of Graphic Display and Final Essay Scoring

	Graphic Display
Mean	.87
Std. Dev.	.28
Std. Error	.04
Count	41.00
Minimum	0.00
Maximum	1.00
# Missing	5.00

Frequency Distribution for Graphic Display: Agreement and Disagreement

	Count	Percent
Disagreement	12	29.27
Agreement	29	70.73
Total	41	100.00

	Final Essay
Mean	.90
Std. Dev.	.26
Std. Error	.04
Count	41.00
Minimum	0.00
Maximum	1.00
# Missing	5.00

Frequency Distribution for Final Essay: Agreement and Disagreement

	Count	Percent
Disagreement	7	15.22
Agreement	39	84.78
Total	46	100.00

Table 5.

ANOVA for Mid-Unit Test: Teacher and Researcher Scoring

MUTsk1/2Tchr

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Period	1	.68	.68	1.02	.3214
Residual	30	20.04	.67		

Means Table for MUTsk1/2Tchr

	Count	Mean	Std. Dev.	Std. Err.
Period 1	18	2.78	.81	.19
Period 4	14	3.07	.83	.22

MUTsk1/2QScr

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Period	1	2.50	2.50	2.18	.1506
Residual	30	34.47	1.15		

Means Table for MUTsk1/2QScr

	Count	Mean	Std. Dev.	Std. Err.
Period 1	18	1.28	1.27	.30
Period 4	14	.71	.73	.19

Table 6.

One-Way ANOVA for Final Test: Graphic Display, Essay, and Fact Test

FnlTskGO

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Period	1	.8	.8	.2	.6944
Residual	32	155.4	4.9		

Means Table for FnlTskGO

	Count	Mean	Std. Dev.	Std. Err.
Period 1	19	3.6	1.8	.4
Period 4	15	3.9	2.7	.7

FnlTskEs

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Period	1	.8	.8	1.6	.2189
Residual	32	16.3	.5		

Means Table for FnlTskEs

	Count	Mean	Std. Dev.	Std. Err.
Period 1	19	1.2	.5	.1
Period 4	15	1.5	.9	.2

FnlTskFT

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Period	1	13.8	13.8	9.3	.0046
Residual	32	47.7	1.5		

Means Table for FnlTskFT

	Count	Mean	Std. Dev.	Std. Err.
Period 1	19	5.3	1.2	.3
Period 4	15	6.6	1.3	.3

Table 7.

Student Ratings of Information Source Value

How well do you like school?

Rating	Total Count	Total %	Per. 1 Count	Per. 1 %	Per. 4 Count	Per. 4 %
0	0	0.0	0	0.0	0	0.0
1	1	2.9	1	5.3	0	0.0
2	2	5.9	0	0.0	2	13.3
3	16	47.1	8	42.1	8	53.3
4	12	35.3	8	42.1	4	26.7
5	3	8.8	2	10.5	1	6.7
Total	34	100.0	19	100.0	15	100.0

How well are you doing in science?

Rating	Total Count	Total %	Per. 1 Count	Per. 1 %	Per. 4 Count	Per. 4 %
0	0	0.0	0	0.0	0	0.0
1	2	5.9	2	10.5	0	0.0
2	4	11.8	1	5.3	3	20.0
3	12	35.3	5	26.3	7	46.7
4	10	29.4	8	42.1	2	13.3
5	6	17.6	3	15.8	3	20.0
Total	34	100.0	19	100.0	15	100.0

How well do you like astronomy?

Rating	Total Count	Total %	Per. 1 Count	Per. 1 %	Per. 4 Count	Per. 4 %
0	0	0.0	0	0.0	0	0.0
1	2	5.9	1	5.3	1	6.7
2	8	23.5	6	31.6	2	13.3
3	13	38.2	7	36.8	6	40.0
4	6	17.6	3	15.8	3	20.0
5	5	14.7	2	10.5	3	20.0
Total	34	100.0	19	100.0	15	100.0

What planetary conditions do you think are necessary for life, as we know it, to exist?

Rating	Total Count	Total %	Per. 1 Count	Per. 1 %	Per. 4 Count	Per. 4 %
0	0	0.0	0	0.0	0	0.0
1	4	11.8	0	0.0	4	26.7
2	19	55.9	11	57.9	8	53.3
3	8	23.5	5	26.3	3	20.0
4	3	8.8	3	15.8	0	0.0
5	0	0.0	0	0.0	0	0.0
Total	34	100.0	19	100.0	15	100.0

Tell why you think the two planets closest to Earth (Mars & Venus) are not thought to support life?

Rating	Total Count	Total %	Per. 1 Count	Per. 1 %	Per. 4 Count	Per. 4 %
0	9	26.5	3	15.8	6	40.0
1	14	41.2	9	47.4	5	33.3
2	10	29.4	6	31.6	4	26.7
3	1	2.9	1	5.3	0	0.0
4	0	0.0	0	0.0	0	0.0
5	0	0.0	0	0.0	0	0.0
Total	34	100.0	19	100.0	15	100.0

Table 8.

Regression Analysis with Graphic Display, Fact Test, and Five Ratings Regressed on Final Essay

Regression Summary

Count	32
Num. Missing	2
R	.486
R Squared	.236
Adjusted R Squared	.123
RMS Residual	.618

Regression Coefficients

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	-.250	.699	-.250	-.358	.7234
FnlTskGO	.055	.054	.187	1.020	.3168
FnlTskFT	.161	.083	.342	1.939	.0630
MUTsk1/2Tchr	.002	.150	.002	.012	.9904
PrAs-StatSch	.131	.108	.208	1.215	.2348

Table 9.

Student's t-tests Comparing Two Periods on Final Task Total (Graphic Display and Essay Combined) with Three Subject Selection Schemes

For ZFnlTstFct	Mean Diff.	DF	t-Value	P-Value	
Period 1, Period 4	-.940	32	-3.045	.0046	
	Count	Mean	Variance	Std. Dev.	Std. Err
Period 1	19	-.415	.718	.847	.194
Period 4	15	.526	.904	.951	.246

For ZFnlTskGO	Mean Diff.	DF	t-Value	P-Value	
Period 1, Period 4	-.139	32	-.397	.6944	
	Count	Mean	Variance	Std. Dev.	Std. Err
Period 1	19	-.061	.663	.814	.187
Period 4	15	.078	1.494	1.222	.316

For ZFnlEssTsk	Mean Diff.	DF	t-Value	P-Value	
Period 1, Period 4	-.4	32	-1.3	.2189	
	Count	Mean	Variance	Std. Dev.	Std. Err
Period 1	19	-.2	.5	.7	.2
Period 4	15	.2	1.6	1.3	.3

For ZFnlTst	Mean Diff.	DF	t-Value	P-Value	
Period 1, Period 4	-1.5	32	-2.2	.0338	
	Count	Mean	Variance	Std. Dev.	Std. Err
Period 1	19	-.7	3.1	1.7	.4
Period 4	15	.8	4.9	2.2	.6

Figure Captions

Figure 1. Rates of off-task behavior in Periods 1 (control) and 4 (treatment) based on 3 observations.

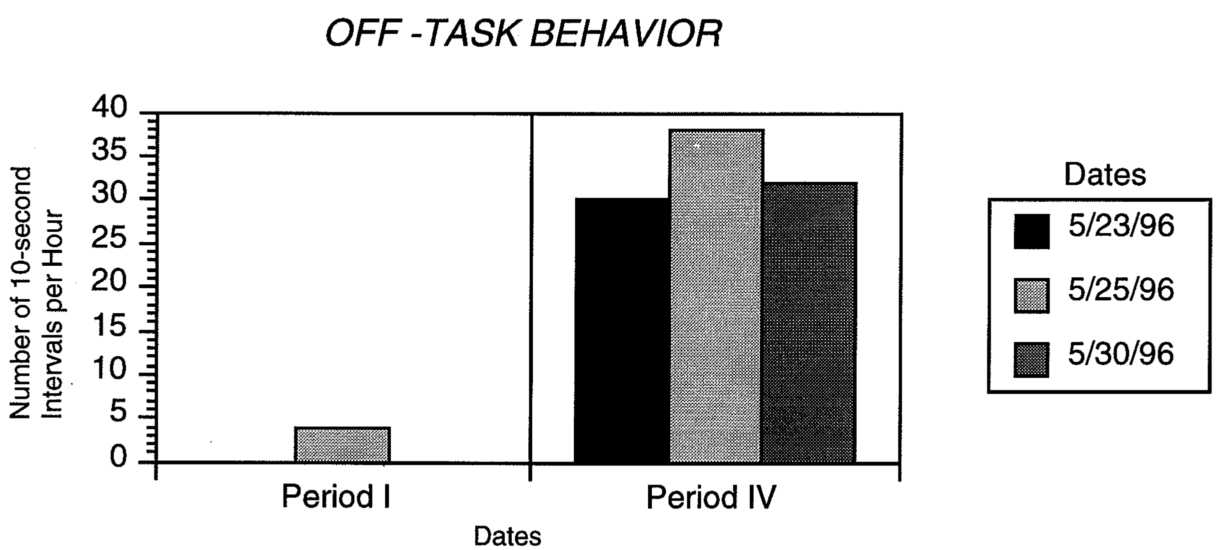
Figure 2. Planetary rules used as basis for instruction and assessment with Period 4.

Figure 3. Occurrence of rules explicitly stated by teacher during lecture in Periods 1 and 4.

Figure 4. Transcription of teacher/student dialogue during interactive instruction for Period 4.

Figure 5. Special education student outcomes for assessment measures (Period 4).

Figure 6. Special education student outcomes for assessment measures (Period 1).


OFF -TASK BEHAVIOR
Number of 10-second Intervals per Hour
40
35
30
25
20
15
10
5
0
Period I
Period IV
Dates
Dates
5/23/96
5/25/96
5/30/96

Planetary Rules

1. Smaller planets are nearest the sun; the largest planets are farther away (with the exception of Pluto).

2. Planets with greater mass have greater gravitational pull and thus thicker atmospheres.

3. Planets with greater mass have greater gravitational pull and thus more moons and rings.

4. Most planets get most of their energy from the sun.

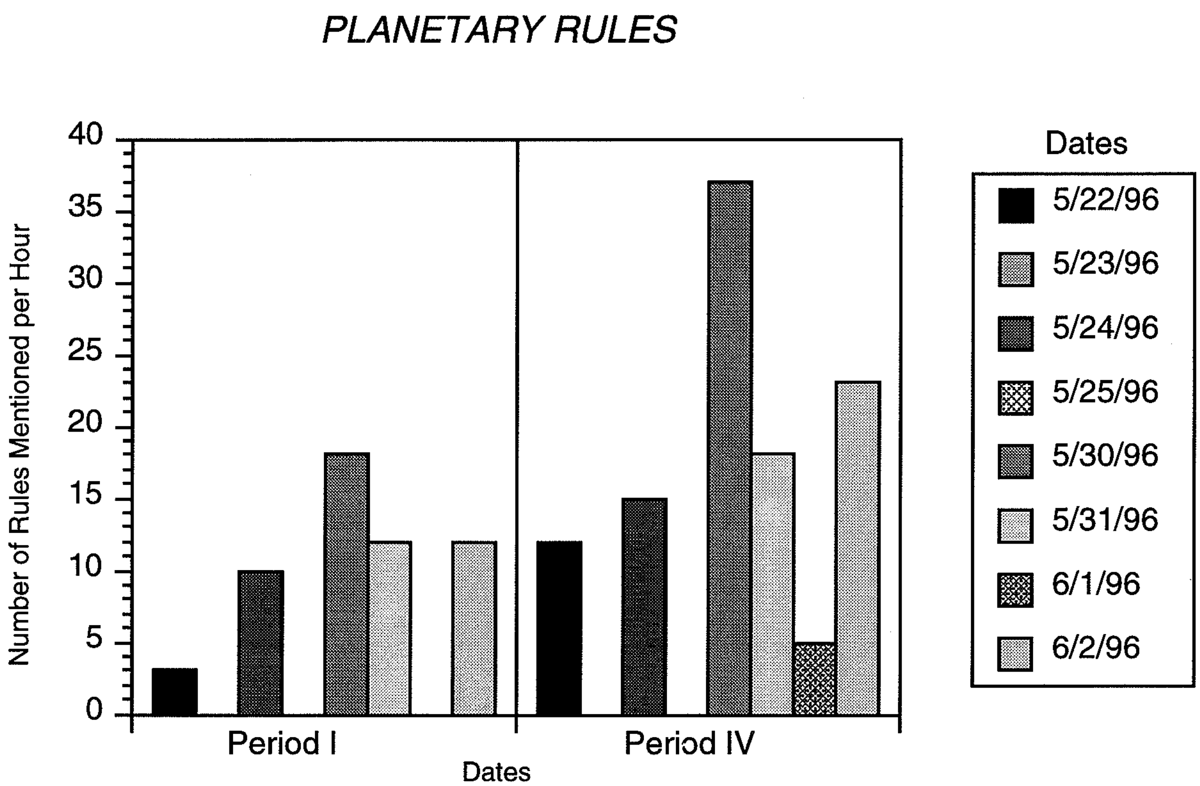
    a. Distance from the sun affects temperature - planets nearest the sun generally have higher temperatures.

    b. Thick atmospheres trap heat and raise temperatures.

5. Surface features of planets are determined partially by atmosphere and presence of agents of erosion.

    a. Planets with thick atmospheres are not covered with craters. Objects from space are burned away by a thick atmosphere before they can reach the surface and leave marks.

    b. Presence of ice, wind, and water constantly change the surface of a planet.


PLANETARY RULES
Number of Rules Mentioned per Hour
0
5
10
15
20
25
30
35
40
Period I
Period IV
Dates
Dates
5/22/96
5/23/96
5/24/96
5/25/96
5/30/96
5/31/96
6/1/96
6/2/96

Instructional Dialogue
Period 4 (Treatment)

T = *Teacher*
S = *Student*

T What is an atmosphere?

T Does Earth have an atmosphere?

S The sky.

S A gaseous mass around a planet or a star.

T How is it held there?

S By gravitational pull.

T Right, by gravitational pull.

T Here it says, "planets with greater mass have greater gravitational pull thus greater atmosphere."

T (*Shows planet overhead*). What are these four [*inner*] planets?

S Terrestrial planets.

T Right. How are they different from these five?

S Bigger.

T What else.

S The outer ones are more gaseous, the inner are less.

T Which ones have moons?

S All of them.

T The ones that are larger have more moons. Which ones have atmospheres? Does Venus have an atmosphere?

S No.

T How about Mercury?

S It has some but not enough to do anything.

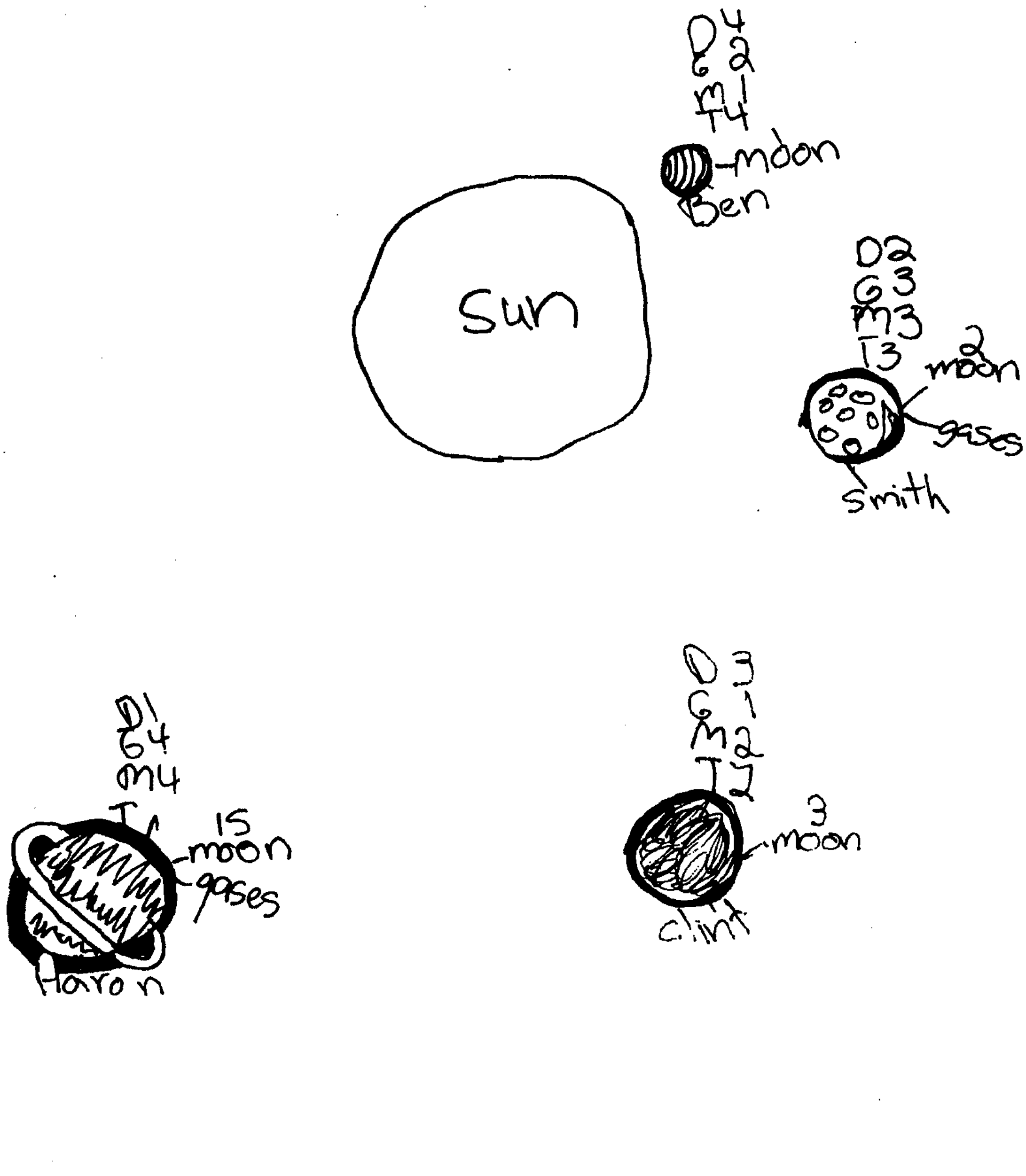
T Well right, atmospheres are different. Earth has a perfect atmosphere for our life. They all have some atmosphere, but some have more than others.

Pre-Assessment
(*student left blank*)

Mid-Unit Task
I think it will orbit in bettwen mars and Asteroids. Because it would not be able to go eany where eals.

Hight temperaturs large gravity pull. it would have an atmosphere a little smaller than our atmosphere.

Final Problem-Solving Essay
I chose to land on smith Because It is a good distance away from the sun, and it has 2 moons. I also explaned it Because it is the same size as our earth.

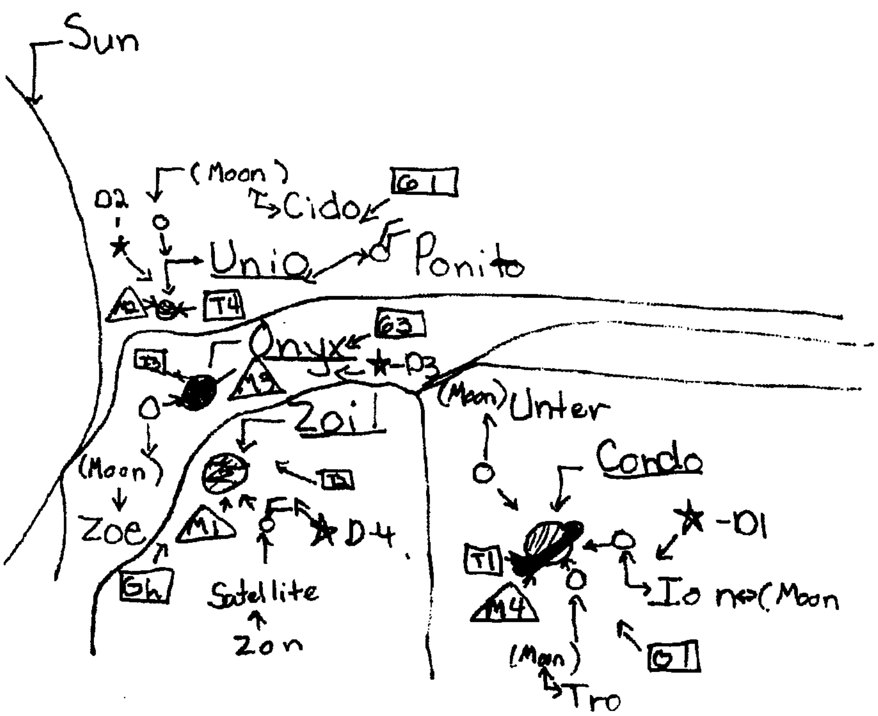


Pre-Assessment
Mars of Venus does not have oxygen, plants, animals, or water and food, and I belive that that we should not even try because if we were ment to be up there we would allready be there.

Mid-Unit Task
I belive the new planet was thrown above mars sitting between Earth and Mars. Since the asteroid hit Mars in such a way that it took a new orbit behind Earth.

The new planets temperature would most likely be hotter since now it is closer to the sun. The new planets atmosphere would probably be thiner. The new planet would now be the 4th planet from the sun.

Final Problem-Solving Essay
I belive The planet Onyx could hold life. Since Temp is not cold or hot, enough gravity for everthing on the planet to stay stable, because there is so much mass. It also has a medium density. The gasses on Onyx are, Oxygen, Co^2, nitrogen, Water vapor, and Helium which makes it a livible planet. Unio could no be explored because it is a gaseos planet - sulfer - Methane - CO2 which make it hard to explore. Zoil has the most density, Gravity and Mass is the lowest. And its temp is medium cold. Zoil also has gas storms. Cordo has a very thin atomosphere but Onyx has a thick but also thin enough to let Ultra Violet rays in. Cordo's gases are Methane, Water vaper, and Co2. So out of all these planets I belive Onyx is the only one that could hold life.

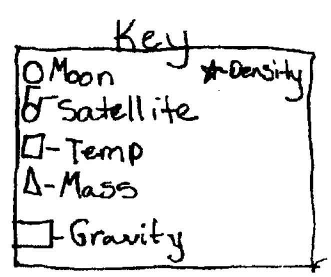


Unio - Gases
Sulfur - Methane - CO2

Cordo - Gases
Methane - Water Vapor
CO2

Onyx - Gases
Oxygen CO2 - nitrogen - water vapor
Helium

Zoil - Gases
nitrogen - sulfer - helium



Author Note

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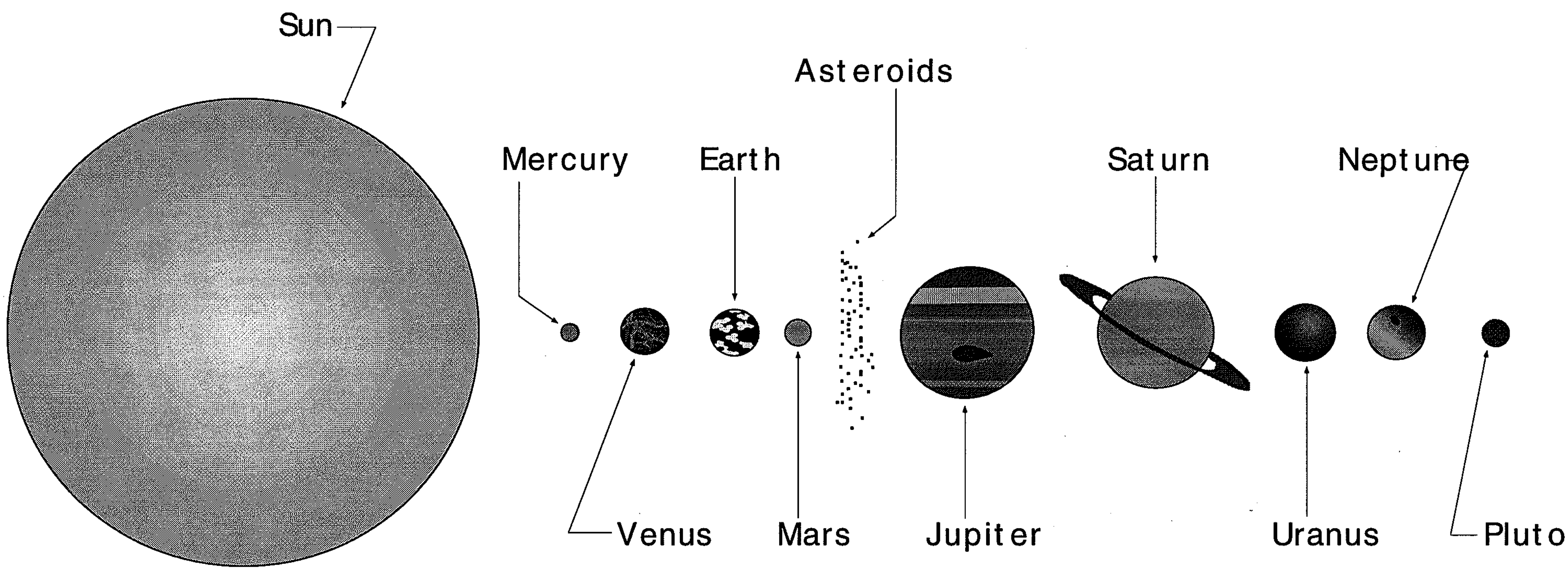
The Planets



Sun
Asteroids
Mercury
Earth
Saturn
Neptune
Venus
Mars
Jupiter
Uranus
Pluto

Characteristics of the Planets
(facts)

The inner planets, Earth and its three nearest planetary neighbors, all have surfaces made of solid rock. Because of the size and the composition of these planets, they are classified as Earth-like, or **terrestrial planets**.

terrestrial planets: Earth-like planets.

Mercury:
- Mercury is the closest planet to the sun.
- Mercury is a smaller sized planet.
- Mercury has extremely hot daytime temperatures of up to 425 degrees Celsius.
- Mercury has a very thin atmosphere.
- Night time temperatures on Mercury become as cold at -170 degrees Celsius.
- Mercury is covered with craters, cliffs, and smooth planes.
- Mercury has no moons.

Venus:
- Venus is the second planet from the sun.
- Venus is a smaller sized planet.
- Venus is similar in diameter and mass to Earth.
- Venus has daytime temperatures up to 500 degrees Celsius.
- Venus has a thick atmosphere of acid and carbon dioxide.
- Venus's surface is very hot. Nighttime temperatures remain as hot.
- Venus has land forms similar to those on Earth. Volcanoes, mountains, basins like oceans, and elevated areas like contents cover the planet. No craters cover the surface.
- Venus has no moons.

Earth:
- Earth is the third closest planet to the sun.
- Earth is one of the smaller planets.
- Earth has relatively warm temperatures.
- Earth has an atmosphere. This cloudy, thick atmosphere is mostly made up of nitrogen (78%) with the remaining portion made up of 20% oxygen, and under 1% water and carbon dioxide.
- The Earth's surface is not covered by craters.
- Earth is the only planet where water is found in all three of its forms: solid, liquid, and gas.
- The Earth only has one moon.

Mars:

- Mars is the fourth closest planet to the sun.
- Mars is one of the smaller sized planets.
- Actual temperatures on Mars range from a high of about -20 degrees Celsius to a low of -140 degrees Celsius.
- Mars has a thin carbon dioxide atmosphere.
- Mars has a reddish-colored, barren, rocky, windswept surface with many craters.
- Long channels on the surface of Mars look as if they were carved by flowing water at some time in Mars's past. A northern polar ice cap of Mars is made up of frozen water and carbon dioxide.
- Mars has two moons.

The outer planets, Jupiter, Saturn, Uranus, Neptune and Pluto, are in orbits beyond that of Mars. The **gaseous giant planets**, which include Jupiter, Saturn, Uranus, and Neptune, are large, low-density planets composed mainly of gases. Pluto differs from the other planets and is therefore not classified with this group.

gaseous giant planets: large, low-density planets composed mainly of gases.

Jupiter:

- Jupiter is the fifth planet from the sun.
- Jupiter is the largest planet in the solar system.
- Jupiter does not receive much energy from the sun.
- Jupiter is 300 times the mass of Earth. It is not massive enough to become a star, but its interior is very hot and gives off energy. Jupiter therefore gives off more energy than it receives.
- Jupiter has an atmosphere composed of hydrogen and helium. The only part of Jupiter that has been seen is its outer covering of clouds. Within these clouds are continuous storms of swirling gas.
- Jupiter's atmosphere of hydrogen and helium gases turns into a liquid ocean as you travel deeper into this planet. Below this ocean is a solid rocky core about the size of Earth.
- Jupiter has 16 moons! In addition, scientists have discovered a faint ring around the planet.

Saturn:

- Saturn is the sixth planet from the sun.
- Saturn does not receive much energy from the sun.
- Saturn is the 2nd largest planet. It is not massive enough to become a star, but its interior is hot and gives off energy. Saturn gives off more energy than it receives.
- Saturn has an atmosphere with hydrogen and helium. Saturn is entirely covered by clouds. It too has rotating storms caused by the high speed of the jet stream.
- Saturn has an ocean of liquid helium and hydrogen below the atmosphere. This ocean surrounds a small rocky core.
- Saturn has at least 18 moons orbiting it. In addition, Saturn is circled by several broad rings, each of which is made up of hundreds of smaller, narrower rings. Each ring is composed of millions of particles ranging in size from specks of dust to chunks of rock several meters in diameter.

Uranus:

- Uranus is the seventh planet from the sun.
- Uranus is does not receive much energy from the sun.
- Uranus is about 4 times larger than Earth.
- Uranus is surrounded by an atmosphere of hydrogen and helium with thick underlying clouds of methane which gives the planet its blue-green color. High altitude winds move around the planet at 350 km/hr, more than twice as fast as the fastest surface winds on Earth.
- Like Jupiter and Saturn, Uranus has a liquid mantle surrounding a rocky core.
- Uranus has five larger moons and ten smaller ones. In addition, a set of rings made of boulders more than a meter wide surround the planet.

Neptune:

- Neptune is the eighth planet from the sun.
- Neptune does not receive much energy from the sun.
- Neptune is a larger sized planet.
- Neptune has an atmosphere much like that of Uranus. Neptune looks greenish through a telescope because its atmosphere contains methane.
- Neptune's structure is much like that of Uranus.
- Neptune has at least eight moons. In addition, observations sometimes show signs of rings and sometimes do not. Scientists think there may be rings that do not completely surround the planet.

Pluto:

- Pluto is the ninth planet from the sun.
- Pluto is the smallest planet (the size of our moon).
- Pluto is one of the coldest places in the solar system.
- Pluto is has a thin atmosphere of methane.
- Pluto is composed of rock and ice.
- Pluto has one moon, Charon. Charon's diameter is one half of Pluto's, and its orbit is so close to Pluto that the two bodies can be thought of as a double planet.

	Distance from sun	Size	Atmosphere	Temperature	Structure	Moons/ Rings	Life?
Mercury							
Venus							
Earth							
Mars							
Jupiter							
Saturn							
Uranus							
Neptune							
Pluto							

HUBBLE LAB WORKSHEET
(1st Period)

Getting Warmed Up:

1. Locate the image of Mars. Describe what you see: ______________________

____

2. What is the mass of Mars? ______________________________________

3. What is the surface gravity of Mars? ______________________________

4. What is the revolution period of Mars? ____________________________

5. Locate the image of Saturn. Describe what you see: ______________________

____

6. What is the mass of Saturn? ____________________________________

7. What is the mean orbital velocity of Saturn? __________________________

8. Locate the image of Uranus. Describe what you see: _____________________

____

9. What is the revolution period of Uranus? ___________________________

10. What is the mean orbital velocity of Uranus? __________________________

Think About It:

11. How long does it take Mercury to revolve around the sun? ________________

12. How long does it take Jupiter to revolve around the sun? _________________

13. What does revolution mean? ______________________________________

____

____

14. What is the mass of Jupiter? ______________________________________

15. What is the mass of Mercury? _____________________________________

16. What is the surface gravity of Jupiter? ______________________________

17. What is the surface gravity of Mercury? ______________________________

18. Which planet has the greatest surface gravity? ______________________________

19. Looking at the images of Jupiter and Mercury, describe the atmospheres of each:

Jupiter: ____

Mercury: ____

20. Which planet has a thicker atmosphere? ______________________________

21. What do you think the atmosphere is made up of? ______________________

____

____

22. Describe the surface features of Mercury: ____________________________

____

____

23. Jupiter's thick atmosphere makes it impossible to see its surface. What do you think the surface might look like? ______________________________

____

____

PLANETARY WORKSHEET
(1st Period)

1. Which planet has the largest diameter? ________________

   Which planet has the smallest diameter? ______________

   Describe the largest and smallest planet in relation to earth's size.

____

____

____

____

____

2. How many satellites (or moons) does Pluto have? _______

   How many satellites (or moons) does Saturn have?

   What do you think their moons look like?

____

____

____

____

____

3. Which planet has the greatest mass and surface gravity? _____________

   Which planet has the least mass and surface gravity? ________________

   Describe what the surface features look like on these two planets.

____

____

____

____

____

4. What is the third planet to the sun? ____________

What is the seventh planet to the sun? ______________

Describe the temperatures of these two planets.

____

____

____

____

____

5. Which planet is closer to the sun: Mercury or Venus?

Describe the temperatures on both planets.

____

____

____

____

____

INNER PLANETS
Mercury, Venus, Earth, Mars
(Facts)

1. What are temperatures like on Mercury? ____________________

2. What is Mercury's size in relation to the other planets? ____________________

____

3. How many moons does Mercury have? ____________________

4. Describe Venus's atmosphere: ____________________

____

5. What are temperatures like on Venus? ____________________

____

6. Describe the surface features of Venus: ____________________

____

7. What is Earth's size in relation to the other planets? ____________________

____

8. How many moons does the Earth have? ____________________

9. What are temperatures like on Mars? ____________________

____

10. Describe the atmosphere on Mars: ____________________

____

11. Describe the surface features of Mars: ____________________

____

12. How many moons does Mars have? ____________________

____

OUTER PLANETS
Jupiter, Saturn, Uranus, Neptune and Pluto
(1st Period)

1. The outer planets have (more / fewer) moons than the inner planets.

   Describe what Jupiter's moons look like.

   ____
   ____
   ____
   ____

2. Saturn has a thicker atmosphere than Mercury. (True / False).

   Describe the atmosphere of Mercury.

   ____
   ____
   ____
   ____

3. Neptune's revolution around the sun is (shorter / longer) than Earth's revolution around the sun.

   Describe what the revolutionary path of the planets is like.

   ____
   ____
   ____
   ____

4. The outer planet, Uranus, has greater gravitational attraction than the inner planet, Mars. (True / False)

   Describe the mass of Uranus and Mars.

   ____

   ____

   ____

   ____

5. The outer planets have:

   a. greater mass and less gravitational attraction than inner planets.
   b. greater mass and greater gravitational attraction than inner planets.
   c. lesser mass and greater gravitational attraction than inner planets.
   d. lesser mass and lesser gravitational attraction than inner planets.

   Tell what the gravity is like on Jupiter.

   ____

   ____

   ____

   ____

6. If it were possible to place Saturn in water, it would:

   a. sink
   b. float

   Describe what the surface of Saturn is like.

   ____

   ____

   ____

   ____

Control Group - Instructional Soundbite

T Density has to do with how much mass is packed in to the volume. If the mass is great, and the volume is great, the gravity is great. When the hypothetical piece broke off Mars, a lot of you said it would have the same gravity as Mars. Would it?

S No.

T It has the same density, but not the same mass. Do you think the gravitational pull would be the same?

S No.

T It wouldn't have the same gravity as Mars. What's atmosphere?

S Gases and stuff that are held in by gravitational force.

T Right, the gases surrounding a planet and held by gravity of the planet. Would this little piece that broke off have the same atmosphere? Would it have some of the same elements?

S It would be a thinner atmosphere.

T What is temperature? What happens to molecules when something is heated?

S The molecules move fast.

T So temperature has to do with how fast the molecules move. So the temperature increases when? When is the temperature hotter?

T When it's closer to the sun. Why is the Earth warm?

S The atmosphere.

May 31, 1995
First Period

(Complete Lab Activity today)

T Rereads mid-unit task. It might orbit around Mars as a moon or it might get stuck in a ring. What does this student mean.

S A new orbit.

T Right, it might have an orbit of its own. I saw one student who had it in the asteroid belt. What does orbit mean?
The temp might be hot because closer to the sun. Less gravitational pull because of mass. Again, did some of you have answers like this? If you just said it's going to be hot, is that a good answer. No because it says tell why, remember to tell why.
Teacher reads another student's work. Number two says atmosphere would be thinner and be the fourth planet from the sun. Good answer or not?

S #l depends upon which side of Mars was off.

T But if it has a new orbit of its own, no matter what it doesn't move.

T #2 is good, but what's it missing. It says the atmosphere is thinner, but does it tell why.

S No.

T Hello, why would it be thinner?

S It would have to say because it had less mass so less atmosphere.

S Could a piece of Mars really come off?

T Yes.

T Remember this article. Our own moon is thought to be a huge rock that was drawn into our gravitational pull and became our moon.

T If you start now, you will have time to do this activity. You need a ruler. I'll pass out the instructions. You can cut out these planets from overhead, or you can cut your own. 1 AU = 1 cm. If you start with Mercury you find the average distance to the sun on this chart (appendix), this one is .387 so what is this going to be in cm?

S .4

T Right so you can change to 4 mm. (Goes on to write out chart on board). This is going to take the whole paper for the sun. So just make a portion of the sun on the edge of your paper so you will be able to get all the planets on the paper. Then Pluto will be on the far edge of the paper away from the sun. Grab rulers and colored pencils.

June 2, 1995
1st Period:

(Students given time to complete inner/outer worksheets)

T Some of you confused gravity with mass.

Gravity is a force. It's not something's tangible. You can't weigh it. It's an attraction between two objects. The sun has the greatest mass in our solar system. But you can't measure it's gravity. Gravity is a force. On your sheet I said ...you were supposed to look at temp., gravity, and atmosphere. Gravity is related to mass, the more mass, the more gravity. Density is mass over volume. How much mass is in a certain volume.
If I had a cube of butter and gold, which would have more mass?

S Gold.

T Gold, it would have more density. The volume would be the same, but gold would have more density. Density has to do with how much mass is packed in to the volume. If the mass is great, and the volume is great, the gravity is great. When the piece broke off Mars a lot of you said it would have the same gravity as Mars. Would it?

S No.

T It has the same density, but not the same mass. Do you think the gravitational pull would be the same? No.

S No.

T It wouldn't have the same gravity as Mars.

T Atmosphere. What's atmosphere?

S Gases and stuff that are held in by gravitational force.

T Right, the gases surrounding a planet and held by gravity of planet. Would this little piece that broke off have the same atmosphere? Would it have some of the same elements?

S It would be a thinner atmosphere.

T What is temperature? What happens to molecules when something is heated?

S The molecules move fast.

T So temp. has to do with how fast the molecules move. So the temp. increases when? When is the temp. hotter?

T Closer to the sun. Why is the Earth warm? The atmosphere.

S Atmosphere.

T On your quizzes a lot of you said the atmosphere or gravity would be a certain way, but you don't have the why it would be that way. *Teacher reads some student responses that are good.*

T Some of you really need to work on your handwriting.

T Your test is going to be mostly an essay with a few questions about inner and outer planets. So let's go over some of that now.

T What are the temp. like on Mercury?

S Very hot.

T Continues to read questions from inner/outer worksheets with students answering. (Following are soundbites when rules are mentioned.)

T Why do you think it's hotter?

S Mass.

T And what else?

S Atmosphere.

T Why is it cold on Mars?

S Small

T It has no atmosphere. So the heat it gets doesn't stay on it.

T Why does it have those surface features and Earth doesn't?

S Cuz the water's still here.

T But why does Mars have lots of craters?

S Because it's away from the sun.

T Where do craters come from? What protects our Earth from those things?

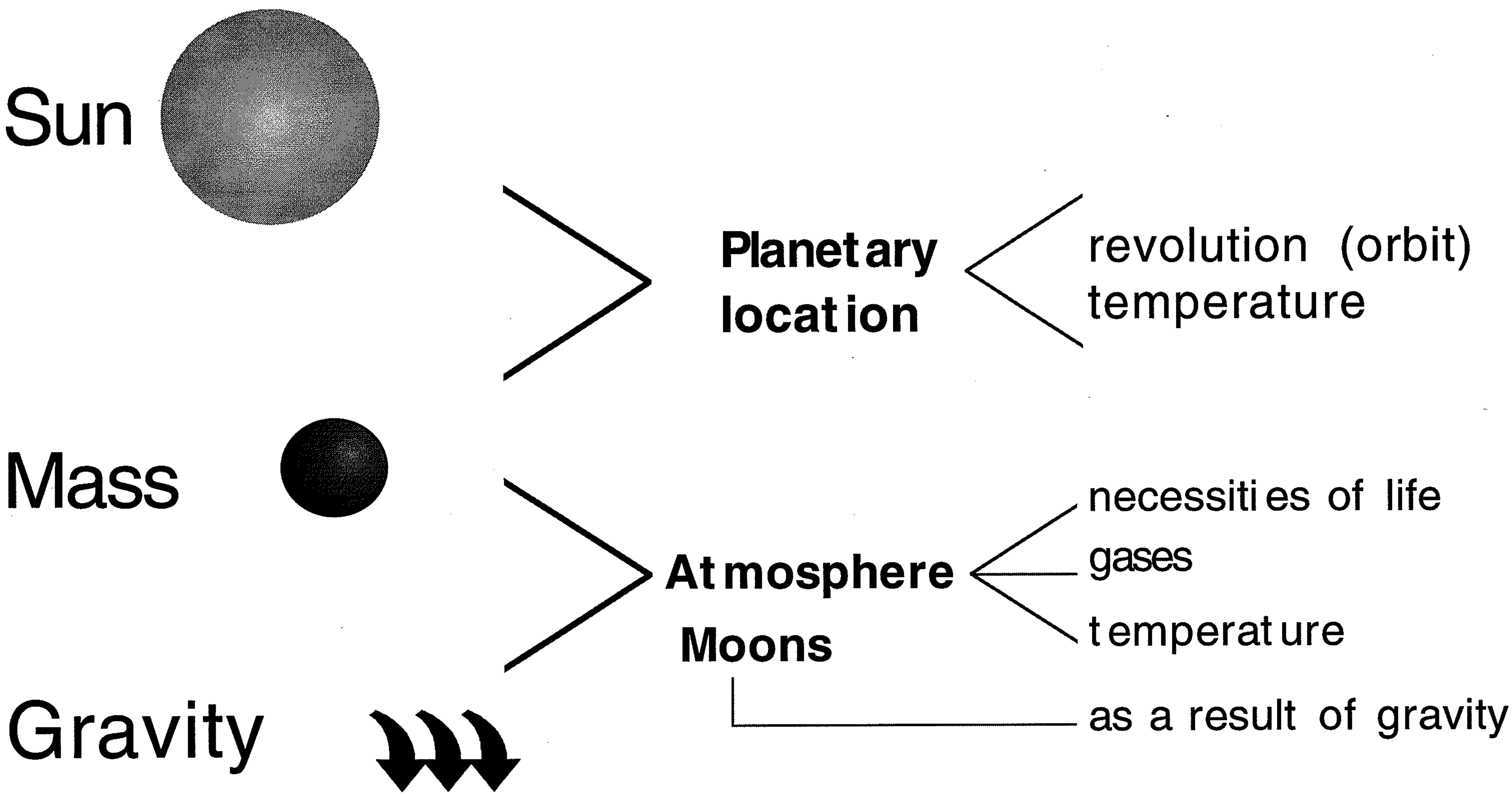
S Atmosphere.

T The atmosphere provides protection from all the asteroids and things coming toward the planets.

T Pass those sheets forward now.

T The test is Monday. You need to understand the difference between the inner and outer planets and you need to understand some things about the solar system. Remember gravity is a force. Make sure you tell why. That's all for today.

Planetary Influences



Planetary Rules

1. Smaller planets are nearest the sun; the largest planets are farther away (with the exception of Pluto).

2. Planets with greater mass have greater gravitational pull and thus thicker atmospheres.

3. Planets with greater mass have greater gravitational pull and thus more moons and rings.

4. Most planets get most of their energy from the sun.

   a. Distance from the sun affects temperature - planets nearest the sun generally have higher temperatures.

   b. Thick atmospheres trap in heat and raise temperatures.

5. Surface features of planets are determined partially by atmosphere and presence of agents of erosion.

   a. Planets with thick atmospheres are not covered with craters. Objects from space are burned away by a thick atmosphere before they can reach the surface and leave marks.

   b. Presence of ice, wind, and water constantly change the surface of a planet.

Astronomy Unit

Introduction:

- Aristotle, a Greek philosopher, believed that the Earth was the center of the universe.
- For more than 1800 years people agreed with this.
- Copernicus / Galileo proved Aristotle wrong.
- In the early 1600's Johannes Kepler, a German astronomer, proposed 3 laws.

KEPLER'S LAWS

1. The orbit of each planet around the sun is an **ellipse**.

   ellipse: an oval that has two points called foci.

2. A planet moves faster when it is closer to the sun.

   (insert figure 23-3)

3. The greater the diameter of the planet's orbit, the greater the planet's **period of revolution**.

   period of revolution: the length of time the planet takes to orbit, or revolve around, the sun.

   (insert figure 23-7)

- Kepler's laws fit his observations and explained how the planets move, but Kepler did not know why his laws were true.
- In the mid 1600's, English scientist Isaac Newton developed theories of motion that explained why Kepler's laws are true!

NEWTON'S LAWS OF MOTION

1. If no force acts on a moving object, the object will keep moving at the same speed and in the same direction. If an object is at rest, it will remain at rest.

   (In space, there are few forces to change an object's motion. Once an object starts moving it will keep moving.)

2. When a force acts on an object, the object will change speed, direction, or both.

   (A space shuttle's speed and direction change only when a force acts on it.)

3. When you push on any object with a force, the object pushes back at you with a force of the same strength.

   (When the burning gases are forced out of the back of a rocket, a force of equal strength in the opposite direction pushes the rocket forward.)

- One of Newton's greatest contributions to our understanding of the solar system is his law of gravity.
- Newton wondered why the moon kept orbiting the earth. According to his first law of motion, the moon would move in a straight line unless some force was acting on it. He realized that a force must pull the moon toward the earth. He called this force **gravity**.

gravity: the force by which every mass attracts and is attracted by every other mass.

(insert figure 23-5)

NEWTON'S LAW OF GRAVITY

The more massive two objects are or the closer together they are, the greater is the force of gravity between them.

Questions to think about:

1. The sun is much more massive than the Earth, so why does the moon revolve around the Earth rather than the sun?

2. How does the law of gravity help to explain Kepler's second law?

- Despite this great contribution, even Newton did not know why gravity exists.
- In 1915, Albert Einstein presented a theory that explains why gravity exists. His theory states that a mass makes a sort of dent in space. Einstein's theory uses mathematical equations to tell how an object tends to fall into a dent in space. This tendency to fall toward the dent is what we call gravity.

So how did the solar system form?

- Scientists believe that gravity was the main force in the formation of the solar system.
- Scientist think that about 5 billion years ago gravity pulled together a large cloud of gas and dust.
- As gravity pulled a large cloud of gas and dust closer together, the cloud became smaller and started spinning faster.
- The effect of the spin and gravity pulled the cloud into a disk.
- Gravity pulled so much material to the center of the disk that the pressure and heat formed the sun.
- Gravity pulled gas and dust into large hot clumps that cooled into planets and other objects.

(insert figure 23-6)

Characteristics of the Planets

(Problem Solving)

The inner planets, Earth and its three nearest planetary neighbors, all have surfaces made of solid rock. Because of the size and the composition of these planets, they are classified as Earth-like, or **terrestrial planets.**

terrestrial planets: Earth-like planets.

Mercury:

- Mercury is near the sun, thus it is a smaller sized planet.
- Mercury is the closest planet to the sun, thus it has extremely hot daytime temperatures of up to 425 degrees Celsius.
- Mercury has a low mass, thus the planet's gravity is too weak to keep much of an atmosphere.
- Because Mercury doesn't have much of an atmosphere, night time temperatures become as cold at -170 degrees Celsius.
- Mercury is covered with craters, cliffs, and smooth planes. (Mercury has virtually no atmosphere, objects streaking from space are not hindered or burned away. They strike the planet, producing its many craters. Since there is no wind or water on Mercury, its craters remain undisturbed for millions of years.)
- Because Mercury has a low mass, it does not have any moons.

Venus:

- Venus is the second closest planet to the sun, thus it is one of the smaller planets.
- Venus is near the sun, thus it has daytime temperatures up to 500 degrees Celsius.
- Venus is similar in diameter and mass to Earth.
- Venus has enough mass and gravitational force to hold onto an atmosphere. Acid and carbon dioxide in the atmosphere trap sunlight and contribute to making the planet's surface very hot. Nighttime temperatures remain as hot because the atmosphere traps in the heat.
- Venus has land forms similar to those on Earth. Volcanoes, mountains, basins like oceans, and elevated areas like contents cover the planet. Note: Venus' atmosphere protects the surface from being covered by craters.
- Because Venus is one of the smaller-sized planets and thus has a relatively low mass, it has no moons.

Earth:

- Earth is the third closest planet to the sun, thus it is one of the smaller planets.
- Earth is close enough to the sun to have relatively warm temperatures.
- Earth has enough mass and gravitational force to hold onto an atmosphere. This cloudy, thick atmosphere is mostly made up of nitrogen (78%) with the remaining portion made up of 20% oxygen, and under 1% water and carbon dioxide. This atmosphere allows temperatures to remain relatively stable over

night.
- The Earth's atmosphere protects the surface from being covered by craters. In addition, water, wind and ice are constantly eroding the surface.
- The Earth is one of the smaller planets and thus only has one moon.

Mars:
- Mars is the fourth closest planet to the sun (still considered an inner planet), thus it is one of the smaller sized planets.
- Mars is farther away from the sun than the Earth, thus temperatures are colder. Actual temperatures range from a high of about -20 degrees Celsius to a low of -140 degrees Celsius.
- Mars has a lower mass than Earth and thus the gravitational force is only strong enough to hold onto a thin carbon dioxide atmosphere.
- Mars has a reddish-colored, barren, rocky, windswept surface with many craters. The thin atmosphere allows objects from space to reach the surface unimpeded. Absence of flowing water reduces erosion of craters so they persist for millions of years.
- Long channels on the surface of Mars look as if they were carved by flowing water at some time in Mars's past. A northern polar ice cap of Mars is made up of frozen water and carbon dioxide.
- Mars is one of the smaller sized planets, thus it only has two moons.

The outer planets, Jupiter, Saturn, Uranus, Neptune and Pluto, are in orbits beyond that of Mars. The **gaseous giant planets**, which include Jupiter, Saturn, Uranus, and Neptune, are large, low-density planets composed mainly of gases. Pluto differs from the other planets and is therefore not classified with this group.

gaseous giant planets: large, low-density planets composed mainly of gases.

Jupiter:
- Jupiter is the fifth planet from the sun (an outer planet) thus it is a larger sized planet.
- Jupiter is an outer planet and thus does not receive much energy from the sun.
- Jupiter is 300 times the mass of Earth. It is not massive enough to become a star, but its interior is very hot and gives off energy. Jupiter therefore gives off more energy than it receives.
- Jupiter has great mass and thus has an atmosphere composed of hydrogen and helium. The only part of Jupiter that has been seen is its outer covering of clouds. Within these clouds are continuous storms of swirling gas.
- Because Jupiter is so massive, its strong gravitational pull may turn Jupiter's atmosphere of hydrogen and helium gases into a liquid ocean as you travel deeper into this planet. Below this ocean is a solid rocky core about the size of Earth.
- Jupiter is a larger planet and thus is has 16 moons! In addition, scientists have discovered a faint ring around the planet.

Saturn:

- Saturn is the sixth planet from the sun (an outer planet) and thus is a larger sized planet.
- Because Saturn is an outer planet, it does not receive much energy from the sun.
- Saturn is the 2nd largest planet. It is not massive enough to become a star, but its interior is hot and gives off energy. Thus Saturn gives off more energy than it receives.
- Because of its large mass, it's gravitational force holds onto an atmosphere that contains hydrogen and helium. Saturn is entirely covered by clouds. It too has rotating storms caused by the high speed of the jet stream.
- Because Saturn is so massive, its gravitational pull may form an ocean of liquid helium and hydrogen below the atmosphere. This ocean surrounds a small rocky core.
- Saturn is so massive that it has at least 18 moons orbiting it. In addition, Saturn is circled by several broad rings, each of which is made up of hundreds of smaller, narrower rings. Each ring is composed of millions of particles ranging in size from specks of dust to chunks of rock several meters in diameter.

Uranus:

- Uranus is the seventh planet from the sun (an outer planet) and thus is a larger sized planet.
- Uranus is an outer planet and thus does not receive much energy from the sun.
- Uranus is about 4 times larger than Earth. It's large mass and gravitational pull cause Uranus to be surrounded by an atmosphere of hydrogen and helium with thick underlying clouds of methane which gives the planet its blue-green color. High altitude winds move around the planet at 350 km/hr, more than twice as fast as the fastest surface winds on Earth.
- Like Jupiter and Saturn, Uranus's large gravitational pull results in it having a liquid mantle surrounding a rocky core.
- Because Uranus is a larger planet, it has five larger moons and ten smaller ones. In addition, a set of rings made of boulders more than a meter wide surround the planet.

Neptune:

- Neptune is the eighth planet from the sun (an outer planet) and thus is a larger sized planet.
- Neptune is an outer planet and thus does not receive much energy from the sun.
- Neptune is a massive planet , thus its gravitational pull holds on to an atmosphere. Neptune's atmosphere is much like that of Uranus. Neptune looks greenish through a telescope because its atmosphere contains methane.
- Neptune's structure is much like that of Uranus.
- Because Neptune is one of the larger planets, it has at least eight moons. In addition, observations sometimes show signs of rings and sometimes do not. Scientists think there may be rings that do not completely surround the planet.

Pluto:

- Pluto is the ninth planet from the sun (an outer planet) but Pluto is the exception to the rule and is actually the smallest planet!
- Pluto is the most distant planet from the sun and thus is one of the coldest places in the solar system.
- Pluto is small (the size of our moon) and thus it doesn't have a thick, dense atmosphere like the gaseous giant planets. It has a thin atmosphere of methane.
- Pluto is composed of rock and ice.
- Pluto is a small planet, thus it only has one moon, Charon. Charon's diameter is one half of Pluto's, and its orbit is so close to Pluto that the two bodies can be thought of as a double planet.

HUBBLE LAB WORKSHEET
(3rd Period)

Getting Warmed Up:

1. Locate the image of Mars. Describe what you see: ______________________________

____

2. What is the mass of Mars? ____

3. What is the surface gravity of Mars? ____

4. What is the revolution period of Mars? ______________________________________

5. Locate the image of Saturn. Describe what you see: ____________________________

____

6. What is the mass of Saturn? ____

7. What is the mean orbital velocity of Saturn? _________________________________

8. Locate the image of Uranus. Describe what you see: ___________________________

____

9. What is the revolution period of Uranus? ____________________________________

10. What is the mean orbital velocity of Uranus? _________________________________

Think About It:

11. How long does it take Mercury to revolve around the sun? ______________________

12. How long does it take Jupiter to revolve around the sun? _______________________

13. Why do you think it takes Jupiter longer than Mercury to revolve around the sun?

____

____

14. What is the mass of Jupiter? ____

15. What is the mass of Mercury? ____

16. Using what you know about mass, which planet do you predict will have the greatest surface gravity? ______________________________

17. What is the surface gravity of Jupiter? ______________________________

18. What is the surface gravity of Mercury? ______________________________

19. Looking at the images of Jupiter and Mercury, describe the atmospheres of each:

Jupiter: ______________________________

Mercury: ______________________________

20. Which planet has a thicker atmosphere? ______________________________

21. Using what you know about mass and atmosphere, explain why. ______________________________

____

____

22. Describe the surface features of Mercury: ______________________________

____

23. Using what you know about atmosphere and agents of erosion, explain why Mercury's surface looks the way it does. ______________________________

____

24. Jupiter's thick atmosphere makes it impossible to see its surface. Knowing only that Jupiter has a thick atmosphere, what prediction could you make regarding its surface? ______________________________

____

____

PLANETARY WORKSHEET
(3rd Period)

1. Which planet has the largest diameter? ______________________

   Which planet has the smallest diameter? ____________________

   Why do you think the largest planets are furthest from the sun?

____

____

____

____

____

2. How many satellites (or moons) does Pluto have? ________

   How many satellites (or moons) does Saturn have? _______

   Why do you think Saturn has more moons than Pluto?

____

____

____

____

____

3. Which planet has the greatest mass and surface gravity? ______________

   Which planet has the least mass and surface gravity? ________________

   Tell what you think the atmosphere is like on the two planets and why.

____

____

____

____

____

4. What is the second planet to the sun?________________

What is the seventh planet to the sun?________________

Explain the suns influence on planets both near to it and from from it.

____

____

____

____

____

5. Which planet is closer to the sun? Mercury or Venus?__________

Why do you think the temperatures are higher on Venus than on Mercury, which is much closer to the sun?

____

____

____

____

____

INNER PLANETS
Mercury, Venus, Earth, Mars
(Problem Solving)

1. Mercury is the closest planet to the sun. What does that tell you about the temperature of this planet? ____________________

2. Given that Mercury is one of the planets nearest the sun, what is its size in relation to the other planets? ____________________

3. Using the above information about Mercury's size / mass, does Mercury have many moons? ____________________

4. Venus is similar in diameter and mass to Earth. Does it have enough gravitational force to hold onto an atmosphere? ____________________

5. Even though Venus is the second planet from the sun, its temperatures are warmer than Mercury's. Using what you know about atmospheres, explain why. ____________________

____

6. Using what you know about atmosphere, would Venus's surface likely to be covered by craters? ____________________

7. Earth is an inner planet. What does that tell you about its size? ____________________

____

8. Using what you know about Earth's size and mass, explain why it only has one moon. ____________________

9. Mars is farther away from the sun than the Earth. Using what you know about distance from the sun, what would you say the temperatures are like on Mars?

____

10. Mars has a lower mass that Earth. Using what you know about mass and gravity, does Mars have a thick atmosphere? ______________________________

11. Given the fact that there is an absence of flowing water on Mars and using what you know about atmospheres, would you be likely to see many craters on the surface?

____

12. Given that Mars has a low mass, does it have many moons? ______________

____

OUTER PLANETS
Jupiter, Saturn, Uranus, Neptune, Pluto
(3rd Period)

1. The outer planets have (more / fewer) moons than the inner planets.

   Using what you know about mass, tell why you think this is so.

   ___
   ___
   ___

2. Saturn has a thicker atmosphere than Mercury. (True / False)

   Using what you know about the mass of outer planets, why do you think they have this type of atmosphere?

   ___
   ___
   ___

3. Neptune's revolution around the sun is (shorter / longer) than Earth's revolution around the sun.

   Explain why the outer planets have this period of revolution.

   ___
   ___
   ___

4. The outer planet, Uranus, has greater gravitational attraction than the inner planet, Mars. (True / False)

   Using what you know about the mass of the outer planets, why do you think they have a strong gravitational attraction?

   ___
   ___
   ___

5. The outer planets have:

a. greater mass and less gravitational attraction than inner planets.
b. greater mass and greater gravitational attraction than inner planets.
c. lesser mass and greater gravitational attraction than inner planets.
d. lesser mass and lesser gravitational attraction than inner planets.

Because Jupiter has a thick atmosphere, what do you predict the surface features are like?

____

____

____

6. If it were possible to place Saturn in water, it would:

a. sink
b. float

Using what you know about Saturn's density, tell why this would occur.

____

____

____

Answer Sheet (3rd Period Outer Planets)

1. more moons
2. true
3. longer
4. true
5. b
6. float

PLANETARY ORBITS
Questions

1. If you changed the length of the string or the distance between the tacks, what effect would that have on the ellipse?

2. If the Earth's orbit changed and became more elliptical, what planetary conditions might change?

Treatment Group - Instructional Soundbite

T Read the second rule.

S Planets with greater mass have greater gravitational pull and thus thicker atmospheres.

T What is gravitational pull?

T Tell another student what you think it is first.

S *Students discuss amongst themselves.*

T Someone tell me what it is.

S It's like how big something is and it pulls in stuff.

T It has to do with how big something is. Gravity is a force. I used the idea the other day of a sheet (holding it tight and throwing a ball in the center). Objects would roll toward the dent in the center. That's like the gravitational pull.

T What is atmosphere? Does Earth have an atmosphere?

S Yes, the sky.

T Not simply the sky.

S It's the gaseous mass around a planet or a star.

T How is it held there?

S By gravitational pull.

T Right, by gravitational pull.

T Here it says planets with greater mass have greater gravitational pull thus greater atmosphere.

May 22, 1995
3rd Period Transcription

T Last week you took some preliminary notes on solar system. Get out those notes.

(Students get out notes 55 seconds)

T Shows poster of solar system. This poster has some nifty info about our solar system. Tomorrow we will do a lab on ellipses or orbits. This shows you exactly what is going around our sun. Here are some comets and it shows some asteroids. This shows a tiny picture of our place in our galaxy. What is the name of the galaxy we are in?

S Spiral.

T Spiral galaxy. You can't see it on this picture. It has arms that go out like this. We're actually in one of those arms. What we see when we look out is the Milky Way.
We're out here, no where near the center. It's too dense. Of course our galaxy is huge. We're going to focus on the solar system. I told you about some of the things we're going to do. 1. We will look at Planetary Rules. 2. Hypothesis of why our planets are like they are.
3. Comparing and contrasting terrestrial and gaseous planets. The first thing I will do is give you a copy of the planetary rules. They will organize what we will talk about.

S Small planets are near the sun, large planets are away.

T So Ben, what do you think some of the small planets are?

S Pluto

T Is Pluto near?

T Read the rule again.

S Student reads.

T Think about what Ben said, Pluto is small, it is also different. When you looked at the rule and it said the small planets are near the sun. The small ones are away. Earth.....

And then comes the asteroid belt. And then the large gaseous planets here. Read #2.

S *Student reads.*

T We talked about atmosphere. Which planets would you predict have thick atmospheres?

S Saturn and Jupiter.

S Which is bigger, Mars or Pluto?

T Mars has greater mass, but I don't know what is larger.

T You will look at a lot of what's going on with planets in the computer lab.

S *Reads next rule.*

T Which planet has a lot of moons?

S Saturn and Jupiter.

T How many does Jupiter have?

S 17.

T How many moons do we have?

S 1.

T Right. One kid said, "doesn't the moon go around other planets?" Well no, it only goes around Earth.

T #4?

S *Distance rule read.*

T What do you think the temperature is on Mercury?

S Hot.

T Very hot, how about Venus?

S Venus is a lot hotter than Mercury.

T If you looked at the sun, the ones that are near the sun are a lot hotter. The planets near the sun are terrestrial.

T Do you think any other planets have atmospheres that trap heat?

S Yes.

T What's the one gas that causes trouble?

S Carbon dioxide.

T Carbon dioxide.

S *Reads (erosion)*

T What are some agents of erosion?

S Water, heat.

T Good.

S *Reads (erosion).*

T We will refer back to these rules again. What's one problem you see with this picture?

S They're all in a line.

T In a line. Another?

S Neptune and Pluto are close together, but sometimes they go out of orbit.

S Some planets appear the same size here and they really aren't.

T What's **really** not accurate?

T What about the distances?

S They're not accurate.

T Right. Pluto is way out. It's not spaced accurately, it's just to show you the relationship between each other.

T I want to talk about where the solar system came from.

S Do we need to take notes?

T Yes, you will need a few notes.

T Write down the Nebular Hypothesis. We'll talk about what that means. Remember a hypothesis is an explanation about why something happened. What happened is a universe, very cold place and you're out there, a piece of gas or dust. Just a dust cloud which is called a nebula. This is a hypothesis of where our solar system came from. This hypothesis is that this cloud of gas and dust was just there in space. (Writes Nebular Hypothesis on board - explains the origin of solar system)

1) nebula = cloud of gases
2) star explodes - super nova

T When these explosions take place, the nebula which is hydrogen and helium, there is incredible heat and the heavy elements stream into space and they rain down on this nebula cloud - they seed the nebula cloud. They can seed clouds to make them rain. What's seeding? Do you know what they do when they seed clouds, they make it rain. The nebula cloud, because of gravitation, this began to collapse on itself and started spinning around, as it was spinning (due to gravitation and pull) the protosun (before our sun) the heavier things started coming forward and the lighter went out.

S Is there gravity in space?

T Of course. Or our planet would just go flying away. As this cooled and became more subtle, we had the formation of the protoplanets and kept forming until it became our solar system 5 billion years ago.

S Is it still forming?

T Good question. Nothing is static or stays the same forever. Our sun will eventually collapse according to scientists, and life as we know it will not be here. There will be a huge increase in heat first. Eventually our sun will go dead.

T Questions or comments?

S Besides the ones we have, do you think there's another planet with the same atmosphere as ours?

T Actually, if you mean just our solar system. We do not have telescopes that have been in space and we can look at Saturn, Venus, Jupiter, radar that looks below the atmosphere. We can tell what's in them. If you asked if there's life. There may be some form of bacteria. There are some similarities between atmospheres. The difference is the amount of water vapor we have.

S You know how some people believe in evolution, if we evolve, how come we aren't still evolving?

T We are.

S Into what?

T You can't observe evolution, it doesn't happen in a generation.

T We will do a little history of some ideas. Aristotle was a philosopher (Greek).

S An astronomer.

T Right. He lived a long time ago, 2000 yrs. ago. He did more than look at the stars. He had ideas about medicine, he was a very forward thinking person. At that time people had very little knowledge about the universe or solar system. 1. He thought the Earth was the center of the universe. 2. Copernicus/Galileo - changed what he thought based on observation. They thought the sun was the center of the universe. When he looked through his simple telescope he could tell the Earth wasn't the center of solar system. 3. Kepler - third person to change ideas in 1600s. He came up with three laws that guided the movement of the planets, called Kepler's Laws. When these people first thought the sun had planets circling around the sun. Kepler said those circles are actually ovals. 4. ellipses = oval with two points called foci. He said that the orbit of each planet is an ellipse.

T Why are they elliptical in shape?

S Gravitation.

T First, why are they orbiting at all?

S Gravitation.

T What is gravitation?

S A pull.

T A pull. Say I was holding a big sheet and we all had a corner and pulled it very taut. If space was represented by the sheet and we put a heavy ball in center of sheet, the sheet would do what? It would have a dent. What if I threw a little ping pong ball in.

S It would roll down to the ball.

T Right, roll down.

T Second law. 2. A planet moves faster when it's closer to the sun. If you look at your planet handout. We move a lot faster than the ones out here. They also move more slowly, the ones out here.

T 3. The third thing he said is: The greater the diameter of a planets orbit, the greater the revolution.

S Is the gravity from the center of the planet or is it on the outside?

T I don't understand. Does everybody have the laws written down?
Spend a minute looking at them. *(goes out to deal with student who was asked to leave)*

S Are the inner planets near the sun cuz the gravity pulls them?

T I believe the reason is that when the sun was forming, the planets that had heavier materials (lots of stuff was burned off) those were able to form near the sun, because they're more compacted, not because they're smaller.

T Three definitions: What is solar system.

T Sun, planets and all objects that revolve around sun.

T Orbit is a path an object takes when moving around another object.

T What's the difference. between revolving and rotation?

T What's a rotation?

S Spinning.

T Spinning on an axis. Do all the planets rotate?

S No.

T Yes, they do; all planets rotate like we do. What's revolution?

T Time it takes to move around the sun.

S 365 days.

T That's what it takes us, but it takes other planets different times.

May 23, 1995
Transcription

T *Had students make a Data Table on back of paper (Trial 1-4 for distance between. tacks, length across ellipse, eccentricity D/L).*

T One thing we know the planets do is rotate around the sun an revolve. Well why is the earth moving around the sun anyway? How fast?

S Fast.

T How fast?

S 2 million.

T 100,000 km per hour.

T Looking at this we were looking at the Earth it's year is 365.6 days. Mercury's year is much shorter because it is moving faster. Here we have Pluto, it's year is 247 of our years to get around the sun.
What is the sun moving around?

T The sun is moving around the galaxy. It takes the sun 246 million years to make a trip around the galaxy. We learned that the solar system is ? billion years old and it has made it's way around the solar system a couple times.

T We're going to be looking at the elliptical orbits and they have their own shape of orbit, called eccentricity. Some are like this (oval) and some are more circular. If it's circular, it equals 0. Earth's eccentricity is: when you draw some today, Earth is more like this or like this because you will do some models. So why is the Earth moving anyway?

S We're rotating.

T Because of what Newton called entree. Because something moves unless something else stops it. Once these planets started motion, there was nothing to stop them. Gravity holds it in it's orbit. Inertia keeps it moving. Objects in motion continue to be in motion and gravity keeps it in an orbit. The faster they move the smaller their orbit is.

T Your activity today. Read it over. (*Cynthia reads aloud*)

T Describes activity. Has students figure eccentricity for two lengths and distances. Then gives the eccentricity for Earth, Mars and Pluto (0.017, 0.093, 0.250) and has them change their string to produce an eccentricity similar to Earth and Mars (one was done that was similar to Pluto's as demonstration).

T These guys here have some good data. They have some too. I want someone from your group to put some data up here. *Has kids put their distance, length, ecccen figures on board. Only a couple kids completed measurement activity, however everyone at least made and measured one ellipse.*

T What happened when the tacks were further apart.

S It was more oval.

T Longer. The string was longer.

T When the tacks were further apart.

T I have two questions. I want you to think about what happened in your lab.

S Are we graded on this?

T Work quietly.

T First one. *Cynthia reads question.* You know what you did, write what you observed and why it changed.

T If the earth's orbit changed what planetary conditions might change? What are planetary conditions?

S Seasons.

T Weather, seasons, longer years, make a prediction. *Teacher draws a longer ellipse on board.* Tell what might happen if the ellipse were like this instead of like this (less elliptical).

May 30, 1995

(First period completed mid-unit essay, but not activity.) Teacher mentioned three rules prior to task.

<u>3rd Period</u>

Discussion re: papers from last unit.

Review:

T As I'm reviewing I will ask questions.

S Reads first rule.

S Reads second rule.

T What is gravitational pull?

T Tell another student what it is first.
(causes a lot of disruption)

S It's like how big something is and it pulls in stuff.

T It has to do with how big something is. Gravity is a force. I used the idea of a sheet (holding it tight and throw ball in center). Objects would roll toward dent in center. That's like the gravitational pull.

T What is an atmosphere?

T Does Earth have an atmosphere?

S The sky.

S A gaseous mass around a planet or a star.

T How is it held there?

S By gravitational pull.

T Right, by gravitational pull.

T Here it says planets w/greater mass have greater gravitational. pull thus greater atmosphere.

T Reads third rule. Planets with larger mass have more moons. Remember what I read about moons and rings and how they stay on. Scientists had different theories. Some thought the moon came from outer space, others thought it was a piece that broke off. Reads fourth rule re: temperature. If you have thick atmosphere you have greenhouse effect. The final thing is on surface features. You looked at the video last week, it showed the planets that don't have atmosphere and lots of things in space fall to those planets and hit them, and those that have atmospheres, the things burn up.

T Shows planet overhead. What are these four [inner] planets?

S Terrestrial planets.

T Right. How are they different from these five?

S Bigger.

T What else?

S The outer ones are more gaseous, the inner are less.

T *(Looking at overhead of planets)* Inner planets, terrestrial, outer planets, asteroid belt in middle. Which ones have moons?

S All of them.

T The ones that are larger have more moons. Which ones have atmospheres? Does Venus have an atmosphere?

S No.

T How about Mercury?

S It has some but not enough to do anything.

T Well right, atmospheres are different. Earth has a perfect atmosphere for our life. They all have some atmosphere, but some have more than others.

T Planetary influences overhead. Sun which determines temperature of planets and their revolution. Mass and gravity which determines atmosphere and the number of moons. When you get your quiz let me tell you what to do. Let me read it out loud first, then I'll tell what I want you to do. *Teacher reads prompt.*

I don't have a right or wrong answer, but you have to defend itself. You can say it develops its own orbit or it has a moon of its own, or what it's atmosphere is like. You have to defend your answer in terms of the rules. Tell what the conditions might be like and tell why. You have a copy of the planetary rules you have other notes you've taken, so write the best answer you can. I have a lab activity on distance which you can pick up when you're done. I want it nicely done. You can cut them out or draw them free hand. The distances can be determined from that chart you have, so get started.

Tells students they have five minutes, where first period had no time limit. Walks around room twice picking up papers.

Distance Activity:

	Avg. dist. to Sun	AU	1 cm = 1 au
Mercury	.387	.4	4mm
Venus	.723	.7	7mm
Earth	1.0	1	1cm
Mars	1.524	1.5	cm
Jupiter	5.203	5.2	cm
Saturn	9.529	9.529	cm
Uranus	19.191	19	cm
Neptune	30.061	30	cm
Pluto	39.529 3	9.5	cm

May 31, 1995
3rd Period

T Yesterday you had to move apart because you're too noisy. I'm happy to let you sit...before we start on our projects, I have some good examples of some that look very nice in pencil. The nicer it looks the better grade you get. This one is coming along. These little planes are clustered near the sun and Pluto is way our here. We put the pictures of the planets on the computer screen so you could make the colors more authentic.

Those who were absent were given mid-unit essay to take outside of classroom.

Someone in the morning class said they didn't tell why. That's true he didn't. What did it mean it might get stuck in a ring? What are the rings?

S Orbits.

T Here was Mars, it could become a moon of Mars or have a new orbit. How many had an answer like that? Why would that happen?

S Gravity.

T Gravitational pull, right.

T When you say some thing that says tell why, you should say something about the planetary rules. Tell what the atmos., temp, gravity is like now. Some of you told what the atmos. might be like. He said the closer to the sun the smaller it is, that's one of the rules. The atmosphere would be less because the mass is smaller therefore the grav. pull is less.

"It would probably go into the asteroids, they'd pull it in. The gravity and atmos. would be less." What is he lacking here, although good?

He doesn't say why. *Reads the rest of task.* You know folks you need to work on handwriting. Handwriting used to be taught, but papers that look like this it's legible, but if it looks like this it's hard to read.

Crashing planets response: I like this one because they're actually could be a chain reaction that would cause planets to be pushed out of orbits. New planet would create a second Earth. Had some ideas about polar caps melting because it was closer to the sun and providing necessary water. *Reads response re: small mass, less gravity, thus less atmosphere.* Again she used one of the planetary rules (gravity and atmos.). Smaller planet therefore closer to the sun. Do you have a good idea of what would be a good paper?

You've been good listening today. There is a review packet for you to do. Finish your planets drawing and then I'll give you your packet.

June 2, 1995
3rd Period

T Get out your inner/outer planet worksheets. We're going to go over them together and have a review. Finish them and the drawings and we're done for the day.

T Your test will include a essay that will require you know the planetary rules: mass. Mass is the amount of matter of substance. Which has more mass if they're the same size, the sponge or rock?

S Rock.

T What's density? The amount of mass in a certain volume. If I take two substances with the same volume but they have different masses. Say this is one cubic foot of concrete and this is one cubic foot of marshmallow, which has more mass?

S Concrete.

T Concrete, but the volume would be the same. Density would be higher. Density is a ratio comparing mass to volume.

S But if the marsh. were melted wouldn't they be the same?

T Spare me.

T Gravity is not an object. Gravity is a force between two objects. If something has more mass does it have more gravitational pull or less?

S More.

T Right, the more mass, the more gravity.

T How does gravity AFFECT ATMOSPHERE?

T WHAT DOES IT SAY, ATMOSPHERE IS WHAT?

T So if a planet has more gravity how does it affect atmosphere?

S Thicker atmosphere.

T The more dense and mass a planet has, the more atmosphere.

T Why does the earth have a warm temperature?

T We're close to the sun and what else?

S An atmosphere.

T Right, the atmosphere traps the heat.

T Mercury is close to the sun, what does it tell you about temperature?

S Hotter.

T Given Mars' relation to the sun, what does it tell you about size?

S Smaller.

T Given size and mass does Mercury have moons?

S No.

T How does that compare to the outer planets?

T Knowing about atmosphere, would Venus have surface features?

S No.

T Why?

S The atmosphere stops it.

T Knowing about Earth's size and mass, explain the one moon?

S It wouldn't have enough gravity to hold more than one.

T That could be, we really don't know. Maybe only one came into it's orbit. Mars is further from the sun than Earth; what is the temperature of Mars?

S Colder.

T When you say cold on one size and hot on another, remember these planets all rotate like ours. At some times they're cold when away from the sun.

T Mars has a low mass, does it have many moons?

S Just two.

T Right, but we don't know where they came from anyway.

T If it is solid rock, it has a lot of density. So it has a lot of gravity. The outer planets are so huge and have such a large mass, that they have a thicker atmosphere.

T Outer planets. More mass means more gravity.

T Why does Saturn have a thicker atmosphere than Mars?

S The surface gravitational of the larger are more, so they have thicker atmospheres.

T Good, but don't even say surface gravity, just say more gravity.

T Why is Neptune's revolution longer?

S Because it's so far from the sun and far out so it takes years and years to get around the sun.

T Why do you think they have a strong gravitational attraction?

T The closer planets are also feeling more pull from the sun. What happens to the force of gravity with distance?

S Stronger.

T Weaker, it gets weaker with distance. The farther a planet away from the sun, the gravitational pull gets weaker.

T Outer planet has greater gravitational force than inner planets.

T More mass.

T Get these done and the picture and turn in.

What Do You Think About Astronomy?

The following questions have been designed to find out what you feel about the subject of Astronomy and what you already know. This is not a test and will not be graded. Just answer the questions as best you can.

Using a scale of 1 through 5, rate the following.

1 = lowest
5 = highest

1. How well do you like school? 1 2 3 4 5

2. How well are you doing in science? 1 2 3 4 5

3. How well do you like astronomy? 1 2 3 4 5

4. What planetary conditions do you think are necessary for life, as we know it, to exist?

____

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2. Tell why you think the two planets closest to the earth (Mars and Venus) are not thought to be able to support life.

PLANETARY CONDITIONS

(Mid-Unit Essay Task)

Given the planetary rules and laws you have been learning about *density, mass, gravity, temperature, atmosphere, motion,* and *revolution,* respond to the following questions.

Imagine that an asteroid of terrific size and force collided with Mars. This collision caused a portion of Mars (about the size of Pluto) to break off and be thrust into a new orbit of its own within our solar system. Use what you know about planets to answer the following:

1. Where might the planet orbit now? Tell why.
2. What might the conditions of temperature, gravity, and atmosphere be like now? Tell why.

1. ______________________________

____

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2. ______________________________

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SCORING CRITERIA
Mid-Unit Essay Task

Question 1

All answers will differ and will be accepted as long as rationale is supported in terms of the planetary rules. The new planet should assume a new orbit somewhere in our solar system and revolve around the sun. Since it is very small (Mars is a small, cold planet with little atmosphere), it should assume a position near the sun, however since exceptions do occur, locations can vary.

Question 2

The planetary conditions of temperature, gravity, and atmosphere should be predicted and explained using the planetary rules.

temperature - related to distance from the sun (planets nearest the sun generally have higher temperatures and those furthest away have coldest temperatures), and thick atmospheres can trap heat and raise temperature of the planet.

gravity - planets with greater mass have greater gravitational pull, therefore this small piece of a planet would have a small mass and little gravitational pull (therefore thin atmosphere and no moons or rings).

atmosphere - due to small mass and little gravitational pull, the atmosphere will be thin, therefore temperature will be hot if near the sun and cold if away from the sun. Thin atmosphere will allow surface features to occur because objects from space will not be burned away.

Score as a count of rules (no range) or negative use of rules.

IN SEARCH OF GREENER GRASS

Imagine you are an astronaut aboard a space exploration craft from the planet Earth. This craft has been designed to explore and gather information on the different types of planets that exist in other galaxies. Scientists hope to find a planet with conditions similar to Earth and suitable for life as we know it.

Your most recent discovery is a solar system in the distant galaxy of Stellarius. The first solar system you encounter is made up of four planets that revolve around one sun. Initial studies indicate that each planet is different and only one has conditions suitable for life. A number of satellites (moons) appear to revolve around at least some of the planets. Since your goal is to explore planets that have conditions similar to those on Earth, you must decide which planet to land on for this purpose.

1. On the third sheet of paper draw your hypothetical solar system. Give each planet a hypothetical name and label the following:

a. *the TEMPERATURE from coldest to hottest*	T1 › coldest	T2 ›	T3 ›	T4 hottest
b. *the MASS from least to most*	M1 › least	M2 ›	M3 ›	M4 most
c. *amount of GRAVITY from least to most*	G1 › least	G2 ›	G3 ›	G4 most
d. *the DENSITY from least to most*	D1 › least	D2 ›	D3 ›	D4 most

e. *use light and dark shading to indicate thickness of ATMOSPHERE and label GASES*

f. *draw any SURFACE FEATURES that would be visible*

g. *draw the planets' MOONS*

2. On the fourth sheet of paper tell which planet you will land on and **WHY** you decided to land on and explore that planet and not the others. (Use as much information about planetary rules as you can to explain why you made your choice.)

Draw Your Solar System Here

1. What is the order of the inner planets, starting with the planet nearest the sun?
   a. Venus, Mars, Earth, Mercury
   b. Mars, Mercury, Earth, Venus
   c. Mercury, Venus, Earth, Mars
   d. Venus, Earth, Mercury, Mars

2. Do Jupiter and Saturn, the two largest planets in the solar system, have *thin* or *thick* atmospheres?
   Tell why.

3. Planets with ___________________ mass have greater gravitational pull.

4. Which planets have the most moons?
   a. Venus, Mercury, Mars
   b. Pluto, Neptune, Uranus
   c. Jupiter, Saturn, Uranus

5. Which planet has a longer period of revolution?
   a. Saturn
   b. Earth
   c. Neptune
   d. Jupiter

6. Are the inner planets generally *colder* or *hotter* than the outer planets?

7. Why do planets with thick atmospheres have fewer surface features?

SCORING CRITERIA
Astronomy Final Task

Graphic Depiction of Hypothetical Solar System

Looked for accuracy designing a hypothetical solar system of four planets and one sun based on planetary rules and 8 specific areas:

- **temperature** (hotter planets are nearer the sun)
- **mass** (larger planets have greater mass and thus more gravitational pull)
- **gravity** (more massive and dense planets have more gravity)
- **density** (greater density with greater mass produced greater gravity)
- **atmosphere** (planets with greater mass and gravity had thicker atmospheres depicted by darker shading; gases listed)
- **surface features** (drawn on planets with little or no atmosphere)
- **moons** (planets with greater mass and gravity have more moons)

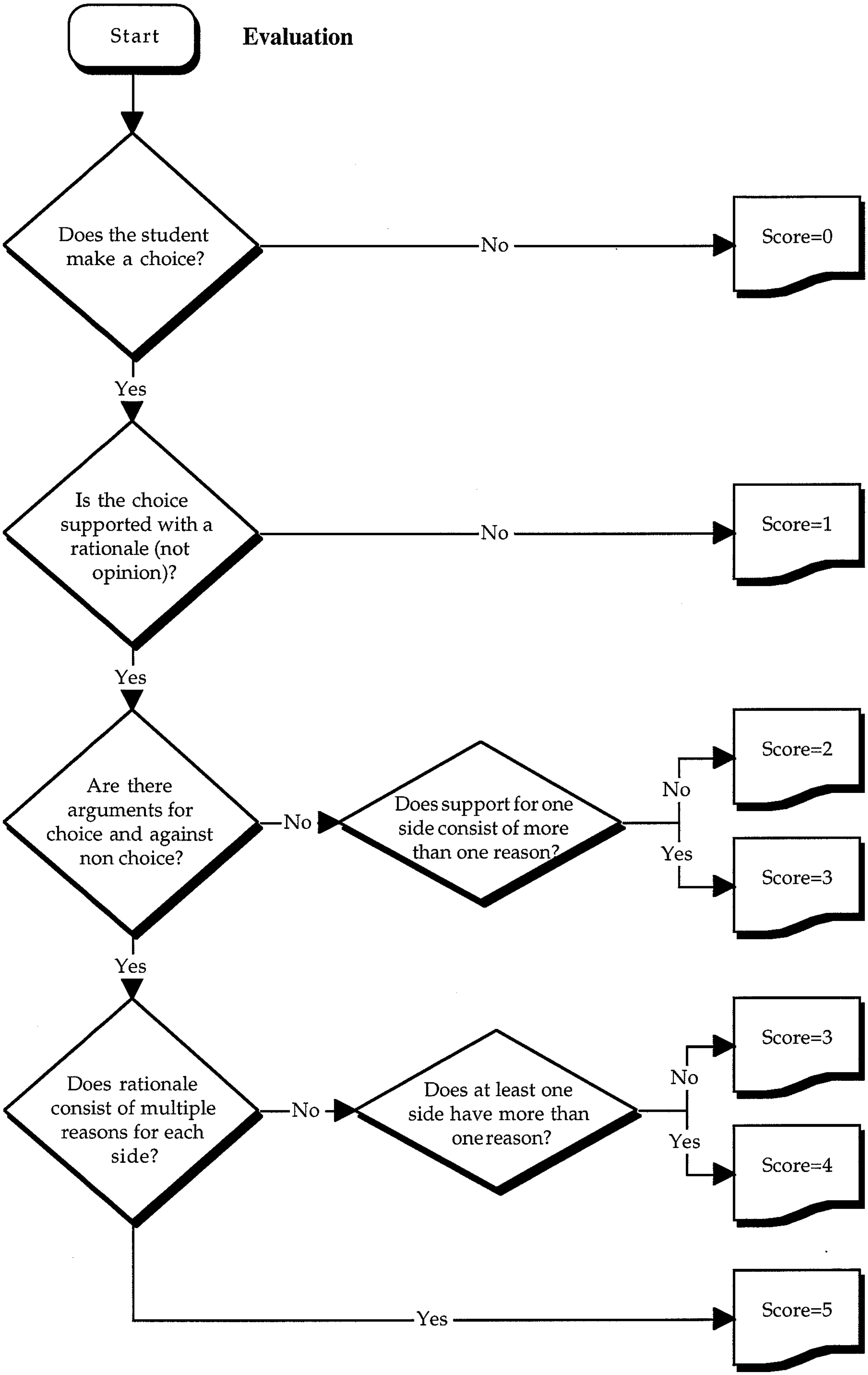
Essay Task

Used evaluation flowchart, however after student makes choice, next requirement of rationale must consist of planetary rule-based rationale.All arguments for choice or against nonchoice must contain reasoning based on rules.

Fact Test

Answers:

1. c
2. thick
   due to large mass and gravitational pull
3. greater/more
4. c
5. c
6. hotter
7. thick atmospheres burn incoming asteroids before they can reach planet surface


Start
Evaluation
Does the student make a choice?
No
Score=0
Yes
Is the choice supported with a rationale (not opinion)?
No
Score=1
Yes
Are there arguments for choice and against non choice?
No
Does support for one side consist of more than one reason?
No
Score=2
Yes
Score=3
Yes
Does rationale consist of multiple reasons for each side?
No
Does at least one side have more than one reason?
No
Score=3
Yes
Score=4
Yes
Score=5

SC8-17SC-1004

Pre-Assessment

Well Mars has a atmosphear But the oxygen is too thin to breath and venus is too hot and has no atmosphear.

Mid-Unit Task

The prtion of mars might orbit around mars like a moon. It might of not had enough motion to break throw marses gravety so it orbits around mars tell it dase have enough motion to break free

Sins the portion orbits it must not have a atmosphere or gravity wich might make temperature extremly cold

Final Problem-Solving Essay

I would land on the third planet it is very much like earth not only being the third Rock from the sun, there seems to be vegatation and animal life like birds fish Bears and alot more some we don't have on Earth.

SC8-17SC-1024

Pre-Assessment

Mars of Venus does not have oxygen, plants, animals, or water and food, and I belive that that we should not even try because if we were ment to be up there we would allready be there.

Mid-Unit Task

I belive the new planet was thrown above mars sitting between Earth and Mars. Since the asteroid hit Mars in such a way that it took a new orbit behind Earth.

The new planets temperature would most likely be hotter since now it is closer to the sun. The new planets atmosphere would probably be thiner. The new planet would now be the 4th planet from the sun.

Final Problem-Solving Essay

I belive The planet Onyx could hold life. Since Temp is not cold or hot, enough gravity for everthing on the planet to stay stable, because there is so much mass. It also has a medium density. The gasses on Onyx are, Oxygen, Co^2, nitrogen, Water vapor, and Helium which makes it a livible planet. Unio could no be explored because it is a gaseos planet - sulfer - Methane - CO2 which make it hard to explore. Zoil has the most density, Gravity and Mass is the lowest. And its temp is medium cold. Zoil also has gas storms. Cordo has a very thin atomosphere but Onyx has a thick but also thin enough to let Ultra Violet rays in. Cordo's gases are Methane, Water vaper, and Co2. So out of all these planets I belive Onyx is the only one that could hold life.

SC8 - 17SC - 4002

Pre-Assessment

(student left blank)

Mid-Unit Task

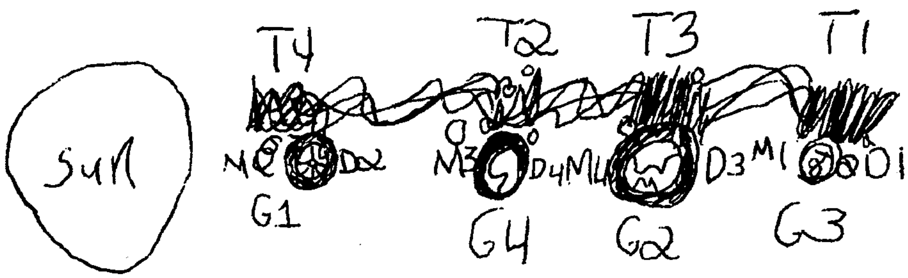
I think it will orbit in bettwen mars and Asteroids. Because it would not be able to go eany where eals.

Hight temperaturs large gravity pull. it would have an atmosphere a little smaller than our atmosphere.

Final Problem-Solving Essay

I chose to land on smith Because It is a good distance away from the sun, and it has 2 moons. I also explaned it Because it is the same size as our earth.

SC8-17SC-1004



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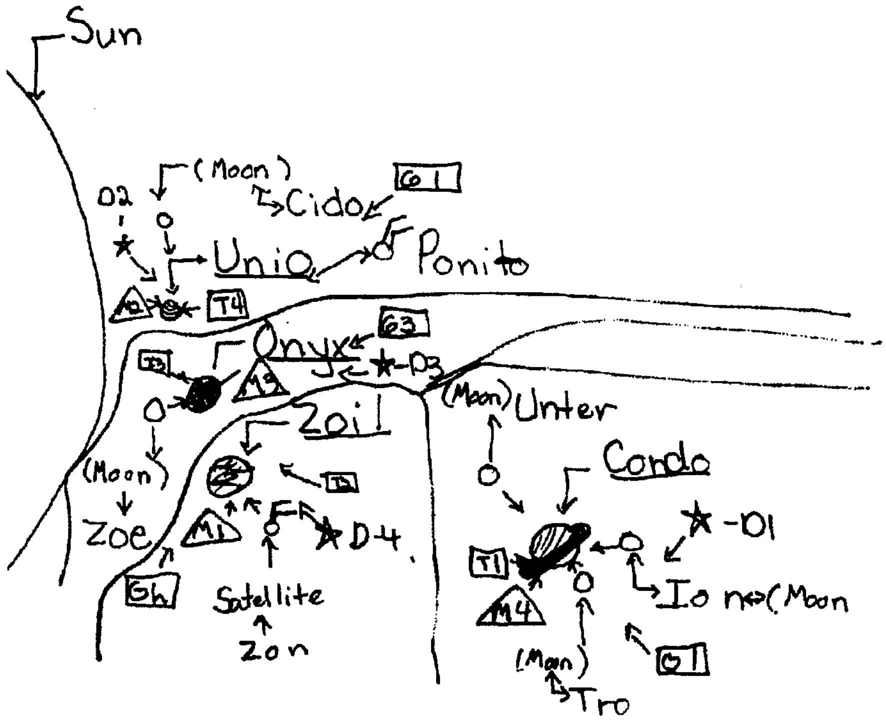


Unio-Gases

Sulfur - Methane - CO_2

Onyx-Gases

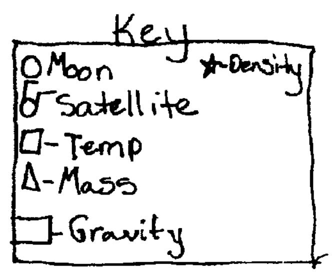
Oxygen CO_2 - nitrogen - water vapor Helium

Zoil-Gases

nitrogen - Sulfer - helium

Cordo-Gases

Methane - Water Vapor CO_2



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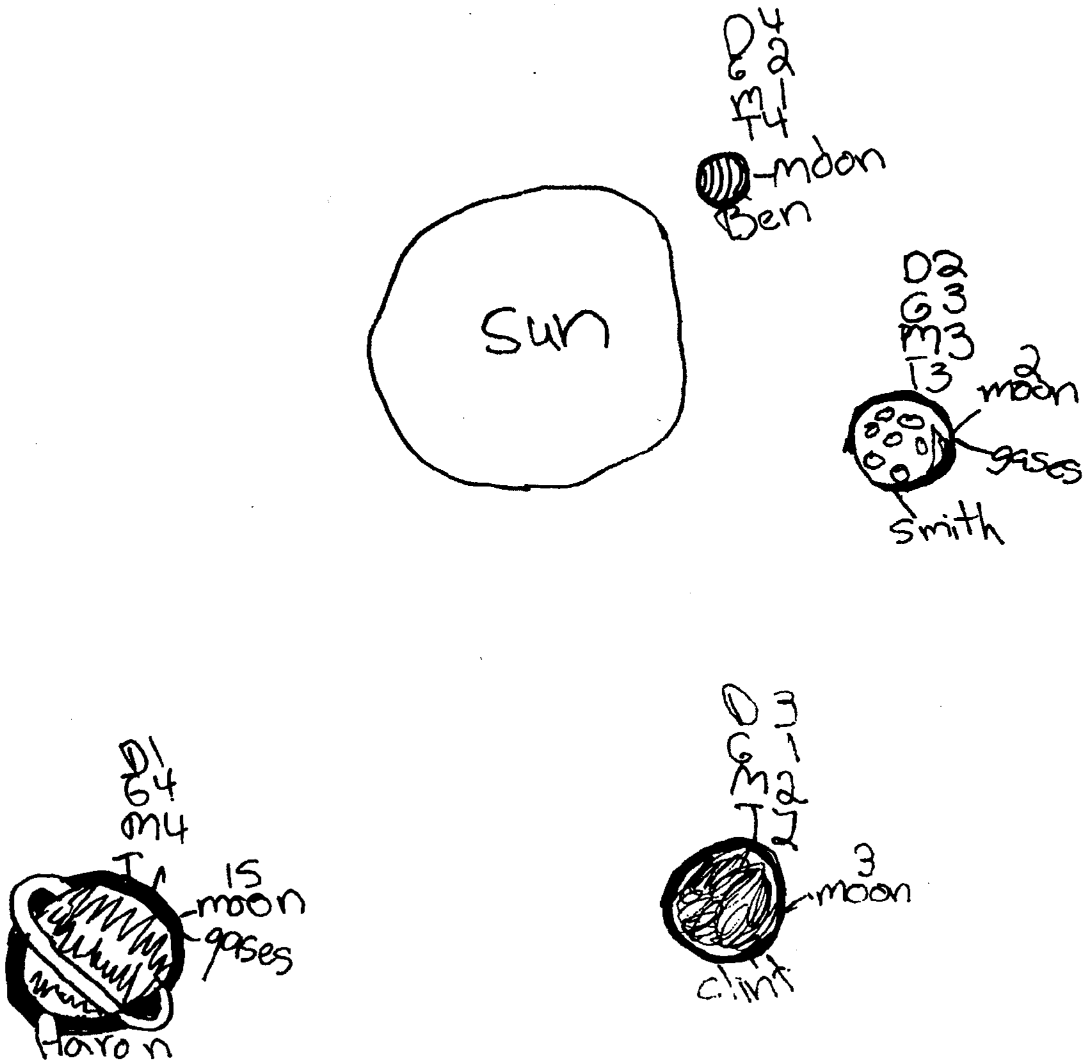

Control Student Sample Outcome on Final Test

1. What is the order of the inner planets, starting with the planet nearest the sun?

   a. Venus, Mars, Earth, Mercury

   b. Mars, Mercury, Earth, Venus

   c. Mercury, Venus, Earth, Mars

   d. Venus, Earth, Mercury, Mars

2. Do Jupiter and Saturn, the two largest planets in the solar system, have *thin* or ***thick*** atmospheres?

   Tell why.

Jupiter has a thick atmosphere because there is a lot of gases. Saturn has a thin atmosphere because of all the mineralls in the ring surrounding the planet.

3. Planets with **high** mass have greater gravitational pull.

4. Which planets have the most moons?

   a. Venus, Mercury, Mars

   b. Pluto, Neptune, Uranus

   c. Jupiter, Saturn, Uranus

5. Which planet has a longer period of revolution?

   a. Saturn

   b. Earth

   c. Neptune

   d. Jupiter

6. The inner planets are generally *colder* or ***hotter*** than the outer planets.

7. Why do planets with thick atmospheres have fewer surface features?

to much presure will cause the astroid to blow up.

I belive The planet Onyx could hold life. Since Temp is not cold or hot, enough gravity for everything on the planet to stay stable, because there is so much mass. It also has a medium density. The gasses on Onyx are, Oxygen, Co2, nitrogen, water vapor, and Helium which makes it a livible planet, Unio could no be explored becaus it is a gaseos planet- sulfer- Methane- ans Co2 which make it hard to explore. Zoil has the most density, Gravity and Mass is the lowest. And its temp is medium cold. Zoil also has gas storms. Cordo has a very thin atmosphere but onyx has a thick but also thin enough to let Ultra violet rays in. Cordo's gases are Methane, Water vapor, and Co2. So out of all these planets I belive Onyx is the only one that could hold life.

Treatment Student Sample Outcome on Final Test

1. What is the order of the inner planets, starting with the planet nearest the sun?
   a. Venus, Mars, Earth, Mercury
   b. Mars, Mercury, Earth, Venus
   c. Mercury, Venus, Earth, Mars
   d. Venus, Earth, Mercury, Mars

2. Do Jupiter and Saturn, the two largest planets in the solar system, have *thin* or *thick* atmospheres?
   Tell why.

they hav thick atmospheres Because the are fare from the sun.

3. Planets with __**less**__ mass have greater gravitational pull.

4. Which planets have the most moons?
   a. Venus, Mercury, Mars
   b. Pluto, Neptune, Uranus
   c. Jupiter, Saturn, Uranus

5. Which planet has a longer period of revolution?
   a. Saturn
   b. Earth
   c. Neptune
   d. Jupiter

6. The inner planets are generally *colder* or *hotter* than the outer planets.

they are generally hotter than the outer planets.

7. Why do planets with thick atmospheres have fewer surface features?

Because they are under the thick atmosphere.

I chose to land on Smith Because It is a good distance away from the sun, and it has 2 moons. I also explored it Because it is the same size as our earth.