Assessing Student Learning in a 6th – 8th Grade Space Science Curriculum

Prepared by:

Kristin Nagy-Catz, Ph.D.
and
Ann Barter, M.A

Center for Research, Evaluation, and Assessment

Lawrence Hall of Science

University of California, Berkeley

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Executive Summary

The Great Explorations in Math and Science's *Space Science Sequence* for sixth to eighth grade curriculum was field tested in the winter and spring of the 2006 academic year. The *Space Science Sequence* builds upon a solid body of research-based and classroom-tested astronomy/space science units from the GEMS Series, including several units developed with NASA support. The sixth – eighth grade *Space Science Sequence* is 32 class sessions in length. It is made up of four units that build key concepts in Earth and Space Science, related to our place in the Solar System, our Galaxy, and the Universe. The sequence focuses on helping students develop two important scientific skills: using evidence and understanding models. Pretest to posttest student learning gains were statistically significant for all units. Breaking down the items by type found that multiple choice and short answer gains were statistically significant across all units for short answer items and for three of the four units for the multiple-choice items. Reliability estimates for the pre/post measures range from .75 to .84. Effect sizes were statistically significant for all units and ranged from .33 to .59 indicating a moderate effect size for Unit 2 and smaller effects for Units 1, 3, and 4. Grade level comparisons (6^{th}, 7^{th}, and 8^{th}) found statistically significant gains for all units across all grade levels. Limitations of the study are that results are formative as units were revised based on both student learning results and teacher feedback collected during the national field test year. Recommendations for future research include collection of curriculum calendars including CD use and analyses of embedded student work. Results suggest consistent evidence of the effectiveness of the curriculum.

Introduction

The current project examines student learning, as shown by unit pre/post assessment change, in the Space Science Sequence (SSS) sixth to eighth grade science curriculum developed by Great Explorations in Math and Science (GEMS) at Lawrence Hall of Science (LHS), University of California, Berkeley.

Center for Research, Evaluation, and Assessment (REA)

The Center, based at Lawrence Hall of Science, conducts both internal and external evaluation and research in the fields of mathematics and science education. In addition to evaluation of in-house projects, REA provides professional consultation for the evaluation of science and mathematics education programs for clients nationwide.

For the current study, REA had the responsibility for scoring and conducting data analyses for the Space Science Sequence sixth through eighth grade curriculum 2005-2006 national field test. REA also worked with the Space Science curriculum team developing the assessment items and scoring rubrics. The REA evaluation associates directing this study were familiar with both the SSS curriculum and the assessment system developed for assessing student growth. Both formative and summative results for this study were shared with the SSS curriculum team and the funders of the project.

Evaluation Questions

Evaluation questions for this project took into consideration concerns and interests of curriculum funders, the curriculum development team, and potential users of the curriculum. Evidence of student learning is of primary interest to all stakeholders and is therefore the overarching question for this evaluation.

Student Learning Questions

- As evidenced by pre/post analyses do students make significant gains in understanding for each unit?
- Are the gains made by students at different grade levels similar?
- Do students make greater gains in some units?

Stakeholders

Those interested in the results of this project are numerous. Funders of science curriculum development, in this case NASA, are primary stakeholders along with district science teachers and science resource personnel. Additionally the curriculum development team at LHS is interested in both formative and summative information concerning student learning to inform their work. Curriculum marketing personnel

require evidence of successful student learning outcomes for their work with district curriculum decision-makers.

Space Science Sequence

The *Space Science Sequence* builds upon a solid body of research-based and classroom-tested astronomy/space science units from the GEMS Series, including several units developed with NASA support. The units were sequenced, revised, and refashioned into a curricular core for Grades 3–5 and Grades 6–8. Revisions were made in light of updated science content, current theories of learning, national standards and benchmarks, key research findings in astronomy education, and the just-now-developing NASA space science education framework. In addition, the *Space Science Sequence* integrates related content about NASA missions and scientists through student readings, guided website navigation, and open inquiry investigations and environments. The Beyond the Solar System unit is brand new and deals with our solar system, galaxies, and the universe in relation to planet detection and the current on-going Kepler mission. The new unit and redesign process for the entire *Space Science Sequence* placed priority on careful selection of essential understandings and essential questions to frame major student learning goals. This outcomes-driven process in turn provided the basis and alignment for an assessment system with student progress variables, guided decisions on unit revision and sequencing, and provided the framework and content criteria for the inquiry-driven technology component.

The 6^{th} – 8^{th} grade portion of the *Space Science Sequence* is 32 class sessions in length. It is made up of four units that build key concepts in Earth and Space Science, related to our place in the Solar System, our Galaxy, and the Universe. The sequence focuses on helping students develop two important scientific skills: using evidence and understanding models.

Table 1. Primary Science Content by Unit and Estimated Instructional Time

Unit	Primary Science Content	Estimated Instructional Time
How Does The Sun Affect The Earth? (Unit 1)	Energies that a star can produce including electromagnetic energy.	8 sessions
Why Are There Seasons? (Unit 2)	Causes of earth's seasons.	6 sessions
The Solar System (Unit 3)	Diverse objects in the Solar System and big ideas about how the Solar System is organized	11 sessions
Beyond The Solar System (Unit 4)	Solar System, Galaxy, and Universe	7 sessions

Method

Participants

A call for applications to participate in the 2006 national field test was sent to GEMS associates that had previously participated in research related to GEMS curriculum and/or sites with GEMS centers. The application was also posted on the GEMS website. Requirements for selection were that each teacher have a 6^{th} – 8^{th} grade science class, each teacher would teach between one and four of the curriculum units as specified by the GEMS curriculum team, and teachers with computer access were offered the technology component (CD) that was designed with the curriculum.

In order to answer the evaluation question regarding possible differences in student learning over grade levels a stratified sample was chosen in order to have similar number of student papers for scoring and data analyses. Table 2 contains the overall number for each unit analyses as well as the number in each grade level category by unit. Units 3 and 4 did not have any 7^{th} grade papers as very few were returned. As a result, a conscious decision was made to focus on sixth and eighth grade student achievement.

Table 2. Number of Papers Used in Data Analyses

Unit	N
How Does the Sun Affect The Earth? (Unit 1)	361
Sixth Grade	134
Seventh Grade	119
Eighth Grade	108
Why Are There Seasons? (Unit 2)	351
Sixth Grade	121
Seventh Grade	93
Eighth Grade	137
The Solar System (Unit 3)	459
Sixth Grade	241
Seventh Grade	n/a
Eighth Grade	218
Beyond The Solar System (Unit 4)	360
Sixth Grade	195
Seventh Grade	n/a
Eighth Grade	165

As there were a large number of pre/posttest returned, a stratified sample of papers were chosen for scoring and data analyses. In order to represent a wide variety of papers, across sites and grade level, random sample papers were chosen from each teacher and class for the analyses.

Pre/Post Assessment Measure Development

Items used for the pretest/posttest assessments were developed by the SSS curriculum team and REA assessment specialist at LHS. Tests were constructed to include multiple-choice and short answer items. Key science concepts presented in each unit guided the development of items. Multiple-choice items included content considered essential to students' ability to communicate space science information. Short answer items provided students with the opportunity to develop and present their own thinking. Table 3 shows test item type (multiple-choice and short answer) frequency by unit.

Table 3. Item Type by Unit

Unit	Multiple Choice Items	Short Answer Items
How Does The Sun Affect The Earth? (Unit 1)	1	4
Why Are There Seasons? (Unit 2)	4	2
The Solar System (Unit 3)	2	4
Beyond The Solar System (Unit 4)	4	2

Pre/post assessment items were developed from items in previously published GEMS curriculum and then adapted to the SSS curriculum as well as new items specifically designed for the 6^{th} – 8^{th} grade sequence. All items were piloted in classrooms and revised for the field test by the SSS curriculum development team after reviewing comments/recommendations received from teachers and analyzing student pre/post-tests. The assessment specialist in the REA conducted final review of the items.

Pre/Post Administration

Forms of pre/posttests were sent to participating teachers. Teachers were asked to administer the pre/posttests for each unit taught. Pretests were to be administered just before the unit was taught and posttests were to be administered as indicated in the curriculum at the end of the unit.

Teachers were asked to return the pre/posttests for all of their students. Pre/posttests were matched prior to scoring for all of the units. For the current study, only matched pre/posttest were scored and analyzed.

Scoring

Scoring of each of the questions was based on a rubric designed to assess students' understanding of science concepts. Comparisons were made across four levels of understanding of science concept in order to an accurate profile of students' understanding. By using this approach, misconceptions and key concepts can be identified. Description of the general rationale for each scoring level is shown in Table 4 below.

Table 4. Scoring Rubric Rationale

Score	Level	Level Description
0	Missing, illegible, irrelevant, off topic	Blank or response is not scoreable
1	Inaccurate Information	Response is based on at least some inaccurate information.
2	Insufficient Information	Response does not provide enough information to demonstrate an understanding of the science concepts.
3	Partial Understanding	Response provides accurate information that demonstrates a partial understanding of the science concepts.
4	Complete Understanding	Response provides accurate and sufficient information that demonstrates a complete understanding of the science concepts.

Scoring of matched pretests/posttests was conducted by REA using undergraduate science major students at the University of California, Berkeley. The REA assessment specialist trained scorers. Ten posttest papers, not being used for analyses, for each unit were chosen for use in scorer training. Reliability tests were performed with all of the scorers after they received training. All scorers had a 90% or higher reliability score for each of the unit measures. Matched pre/post assessments were scored and analyzed for all each of the four units. The REA assessment specialist to ensure scorer consistency

completed a 10% read-behind of the pre/post assessments. The scores were recorded on a scantron form in order to facilitate reliable data entry.

Data Analyses

Analyses focused on mean pretest/posttest/gain percent correct comparisons for total score percent correct gain, multiple-choice item percent correct gain, and short answer percent correct gain by unit. Paired sample t-tests were conducted for all pretest posttest gains. Reliability and effect size estimates were calculated for each unit as well.

Individual item pretest/posttest/gain percent correct were calculated in order to provide curriculum development team with specific feedback on the concept learning contained in each item. For those items that had qualitative notations made during scoring, frequencies of the various response categories were provided as well. This individual item feedback allowed the development team to review the assessment items to learn how much previous knowledge students had prior to instruction as well as discovering any misconceptions students may have had about the unit concepts. Appendix A contains both the quantitative and qualitative data for each item.

Results

Descriptive statistics were calculated for pretest/posttest data to review the distribution of scores for each unit. Pretest scores for all units were approximately normally distributed with a slight skew to the left. Posttest scores were also normally distributed with a slight skew to the right.

Reliability and Effect Sizes

Reliability (Cronbach's alpha) for unit pretest/posttest measures ranged from .75 to .84. The How Does The Sun Affect The Earth? unit pretest/posttest assessment had the lowest reliability. Given the relatively small number of items for each unit the reliability estimates are acceptable. Table 5 contains reliability estimates by unit.

Table 5. Reliability Estimates by Unit

Unit	Reliability
How Does The Sun Affect The Earth? (Unit 1)	.75
Why Are There Seasons? (Unit 2)	.77
The Solar System (Unit 3)	.84
Beyond The Solar System (Unit 4)	.77

Overall, unit effect sizes (Table 6) for the pretest to posttest gains ranged from .33 to .59. Using Cohen's (1988) general guidelines for interpreting effect sizes (.20 — .50 = small effect size; .50 – .80 = moderate effect size; > .80 = large effect size) Units 1, 3, and 4 had the smallest effect sizes at .33, .36, and .36 respectively. Unit 2 had a moderate effect size of .59. These effect sizes are respectable given the relatively short instructional time of the units (see Table 1).

Table 6. Effect Size Statistics Overall by Unit

Unit	Effect Size
How Does The Sun Affect The Earth? (Unit 1)	.33*
Why Are There Seasons? (Unit 2)	.59*
The Solar System (Unit 3)	.36*
Beyond The Solar System (Unit 4)	.36*

*Statistically significant p < .000

Overall Results

Total score mean pretest/posttest gains, multiple-choice mean pretest/posttest gains, and short answer mean pretest/posttest gains were statistically significant for all units and item types with Unit 2, Why Are There Seasons?, having the largest gain overall (22%) and Unit 1, How Does The Sun Affect The Earth? having the smallest gain overall (11%). Table 7 shows the total score pretest/posttest/gain mean percent correct for each unit.

Table 7. Total Score Mean Percent Correct by Unit

Unit	**Total Score Pretest** ***Mean % Correct***	**Total Score Posttest** ***Mean % Correct***	**Total Score Gain** ***Mean % Correct***
How Does The Sun Affect The Earth? (Unit 1)	59	70	11*
Why Are There Seasons? (Unit 2)	44	66	22*
The Solar System (Unit 3)	60	73	13*
Beyond The Solar System (Unit 4)	54	71	17*

*Statistically significant p < .000

Multiple-choice item gains by unit (Table 8) ranged from 0% gain (How Does the Sun Affect The Earth?) to 27% gain (Why Are There Seasons?). The surprising result of 0% gain in Unit 1 may be due to that unit having only one multiple-choice item in the pre/post assessment and/or to a problem with the item itself. Review of the curriculum found that the concepts were not covered as well as they could be and the development team enhanced the concepts in the curriculum and the assessment item was revised accordingly.

Short answer item gains (Table 9) were more consistent across units ranging from 11% - 17% with the greatest gain in the Beyond The Solar System unit.

Table 8. Multiple Choice Mean Percent Correct by Unit

Unit	Multiple Choice Pretest *Mean % Correct*	Multiple Choice Posttest *Mean % Correct*	Multiple Choice Gain *Mean % Correct*
How Does The Sun Affect The Earth? (Unit 1)	31	31	0
Why Are There Seasons? (Unit 2)	41	68	27*
The Solar System (Unit 3)	70	84	14*
Beyond The Solar System (Unit 4)	51	67	16*

*Statistically significant $p < .000$

Table 9. Short Answer Mean Percent Correct by Unit

Unit	Short Answer Pretest *Mean % Correct*	Short Answer Posttest *Mean % Correct*	Short Answer Gain *Mean % Correct*
How Does The Sun Affect The Earth? (Unit 1)	66	79	13*
Why Are There Seasons? (Unit 2)	50	65	15*
The Solar System (Unit 3)	56	67	11*
Beyond The Solar System (Unit 4)	57	74	17*

*Statistically significant $p < .000$

Figure 1 shows the pattern of overall score gains across units and item type. The largest gains are seen in Unit 2, Why Are There Seasons?, and the smallest gains are found in Unit 1, How Does The Sun Affect The Earth? Units 3 and 4, The Solar System and Beyond The Solar System, respectively have similar gains.

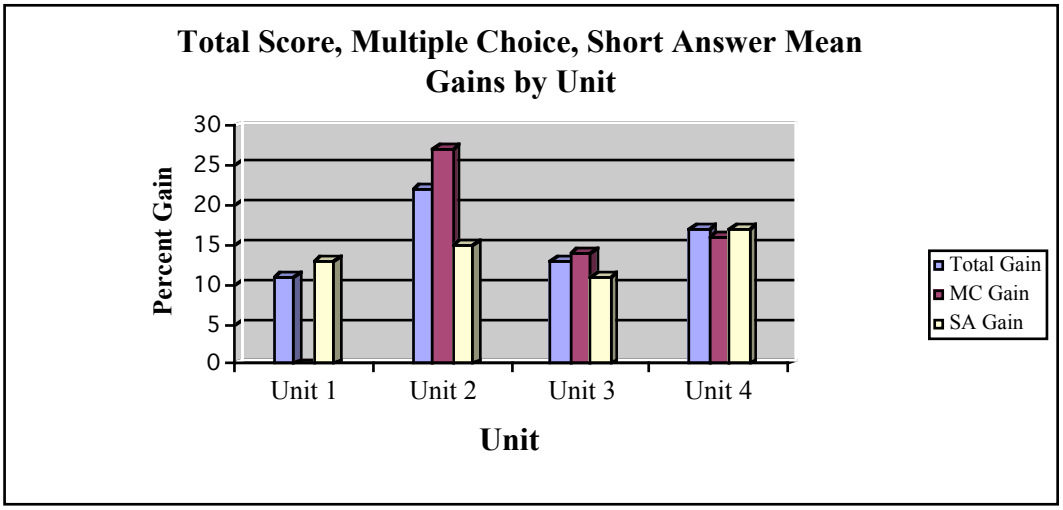

Figure 1. Mean percent correct gains by unit and assessment item type.

Grade Level Comparisons

Unit pretest/posttest/gain mean percent correct comparisons were made across grade levels. Grade-level effect sizes (Table 10) for the pretest to posttest gains are statistically significant for all grade levels and units.

Differences in effect sizes across grade levels are significant. Seventh grade effect sizes for How The Sun Affects The Earth? and Why Are There Seasons? units were the smallest at .16 and .43 respectively. In three of the four units (Why Are There Seasons?, The Solar System, and Beyond the Solar System) eighth grade effect sizes are the larger than sixth grade by an average of 12%. Unit 1, How Does The Sun Affect The Earth? had the largest effect size for sixth grade students.

Table 10. Grade Level Effect Size Statistics by Unit

Unit	Effect Size
How Does The Sun Affect The Earth? (Unit 1)	
Sixth	.45*
Seventh	.16*
Eighth	.40*
Why Are There Seasons? (Unit 2)	
Sixth	.52*
Seventh	.43*
Eighth	.65*
The Solar System (Unit 3)	
Sixth	.25*
Eighth	.37*
Beyond The Solar System (Unit 4)	
Sixth	.36*
Eighth	.46*

*Statistically significant $p < .000$

Total score mean pretest and/posttest gains by grade level are statistically significant for all units and grade levels with the greatest overall gains for all grade levels in Unit 2, Why Are There Seasons?, with an average gain of 20%. The smallest gains for all grade levels were in Unit 1, How Does The Sun Affect The Earth?, with an average gain of only 10% (Table 11).

Tables 12 and 13 contain the percent correct pre to post and gain percentages for multiple choice and short answer items. Multiple choice item gains are statistically significant for Units 2, 3, and 4 for all grades. Unit 1 multiple-choice item results are not significant as noted in the overall gain results discussion earlier. Short answer item gains are statistically significant across all grade levels

Table 11. Total Score Mean Percent Correct by Unit and Grade Level

Unit	Total Score Pretest *Mean % Correct*	Total Score Posttest *Mean % Correct*	Total Score Gain *Mean % Correct*
How Does the Sun Affect The Earth? (Unit 1)			
Sixth	59	72	13*
Seventh	58	66	8*
Eighth	60	71	11*
Why Are There Seasons? (Unit 2)			
Sixth	42	63	21*
Seventh	40	59	19*
Eighth	48	72	24*
The Solar System (Unit 3)			
Sixth	58	70	12*
Eighth	63	75	12*
Beyond The Solar System (Unit 4)			
Sixth	50	54	17*
Eighth	54	75	21*

*Statistically significant $p < .000$

Table 12. Multiple Choice Mean Percent Correct by Unit and Grade Level

Unit	Multiple Choice Pretest *Mean % Correct*	Multiple Choice Posttest *Mean % Correct*	Multiple Choice Gain *Mean % Correct*
How Does the Sun Affect The Earth? (Unit 1)			
Sixth	29	31	2
Seventh	32	29	-2
Eighth	32	34	2
Why Are There Seasons? (Unit 2)			
Sixth	38	65	27*
Seventh	37	57	20*
Eighth	45	73	28*
The Solar System (Unit 3)			
Sixth	66	83	17*
Eighth	74	85	11*
Beyond The Solar System (Unit 4)			
Sixth	50	67	17*
Eighth	53	71	18*

*Statistically significant $p < .000$

Table 13. Short Answer Mean Percent Correct by Unit and Grade Level

Unit	**Short Answer Pretest** ***Mean % Correct***	**Short Answer Posttest** ***Mean % Correct***	**Short Answer Gain** ***Mean % Correct***
How Does the Sun Affect the Earth? (Unit 1)			
Sixth	67	82	15*
Seventh	65	74	8*
Eighth	67	80	13*
Why Are There Seasons? (Unit 2)			
Sixth	49	60	11*
Seventh	46	63	17*
Eighth	53	68	15*
The Solar System (Unit 3)			
Sixth	54	63	9*
Eighth	58	71	13*
Beyond The Solar System (Unit 4)			
Sixth	54	70	16*
Eighth	58	78	20*

*Statistically significant $p < .000$

Figures 2, 3, and 4 show the mean percent change by unit and grade level for overall gain, multiple-choice, and short answer gains. These show the similarity in the pattern of gains for the SSS units over grade levels. This is important as it indicates a similar effect of the curriculum for sixth, seventh, and eighth grade which allows districts to place these units in the grade levels most appropriate for their individual standards/benchmark requirements.

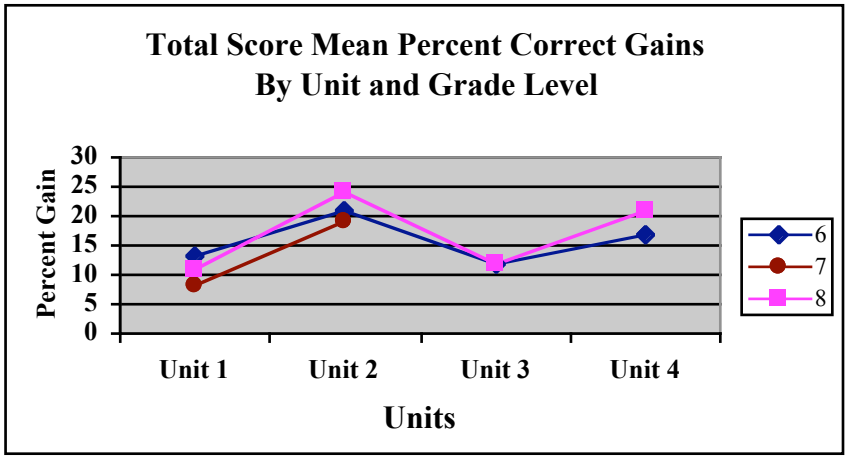

Figure 2. Total score mean percent correct gains by unit and grade level.

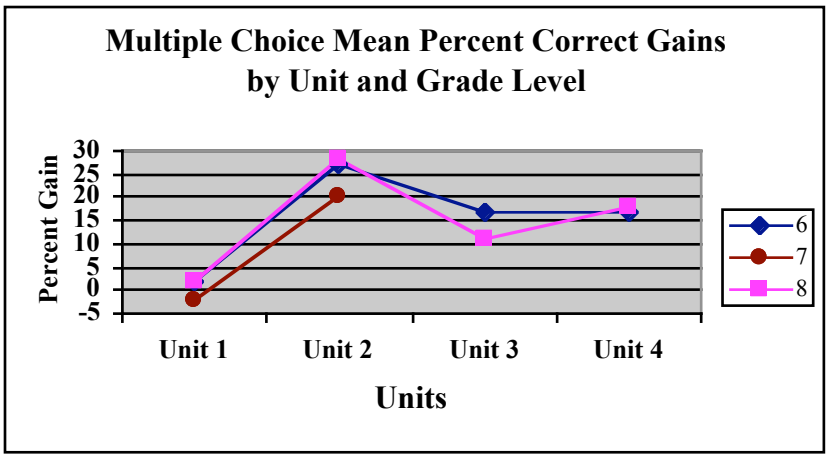

Figure 3. Multiple-choice mean percent correct gains by unit and grade level.

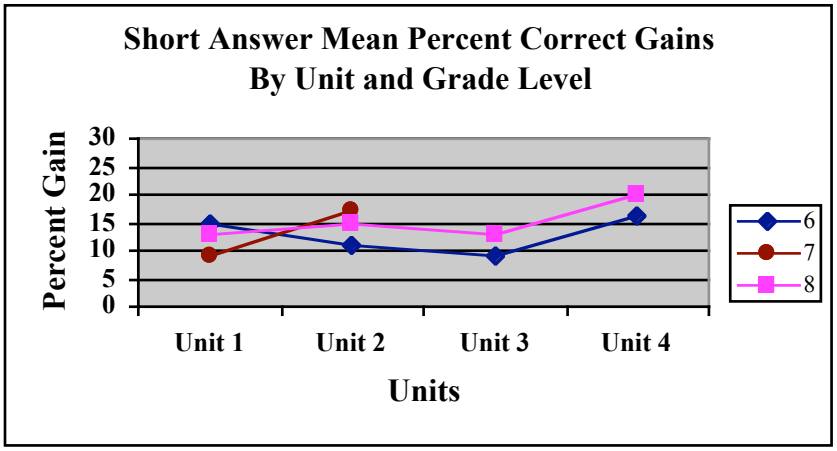

Figure 4. Short answer mean percent correct gains by unit and grade level.

Individual item results by unit were shared with curriculum developers giving them information about the results for specific content included in each item and recommendations were given for revision of items, graphics, or content coverage in the curriculum. Curriculum developers when revising the curriculum for final publication used this information. Appendix A contains the individual item results by unit. The text for each item is provided but the graphics are not.

Discussion

The results of this study found statistically significant learning gains in total pre to post scores for all units in the *Space Science Sequence Sixth – Eighth Grade* curriculum. Why Are There Seasons? (Unit 2) had the largest gain at 22%. The smallest gain, 11% was for How Does The Sun Affect The Earth? (Unit 1). Total score gains for the two remaining units, The Solar System (Unit 3) and Beyond The Solar System (Unit 4), were 13% - 17% respectively.

An interesting finding in the Why Are There Seasons? unit (Unit 2) is that this unit has the greatest gains for total score, multiple-choice score, and short answer scores and has the shortest instructional time of only six sessions. This unit had undergone a major revision prior to the national field test. Previous research on the unit identified common concept misconceptions held by many students. The revision concentrated on addressing these misconceptions and providing additional scientific information related to those misconceptions in student understanding.

Another finding of interest was for the Beyond the Solar System unit. The results for this unit are promising in that the concepts covered in this unit have traditionally been thought of as too difficult for middle school students and as a result are most often taught only in high school. Student gains for this unit, in the current study, are significant and suggest that these concepts can be taught and understood in middle school with an expectation of respectable student concept learning gains.

Effect sizes of pretest/posttest gains per unit ranged from .33 to .59 indicating moderate effect size for the Why Are There Seasons unit and smaller effect sizes for How Does The Sun Affect The Earth?, The Solar System, and Beyond The Solar System units. These effect sizes are respectable given the relatively short instructional length of the units. However, it is important to remember that these assessments and analyses were formative, not summative, as all units were revised based on both student scores on pre/post assessment measures and feedback from teachers. Interpretation of these gains must be tempered by this fact. These gains may not be representative of student learning for the final curriculum. With revision of curriculum based on the feedback data collected, it is anticipated that student learning would be enhanced in the published curriculum.

The grade level finding of statistically significant total score gains across all units is important for a number of reasons. The curriculum sequence was designed to be taught both longitudinally and/or vertically. In this way districts can choose how the curriculum is implemented in their classrooms by allowing them to make informed decisions about curriculum placement in order to more closely match their curriculum to their local and state science standards.

Recommendations for future studies include collection of curriculum calendars of instructional time spent on each unit/activity as well as information about how the CD component designed for the unit is used and how much time the students spend using the CD component and its features. Having this information would allow for additional interpretation of gains across classrooms using the CD and classrooms that do not use the CD, across units and grade levels. For instance, these additional analyses have the potentially indicate a positive effect of CD use with the curriculum.

Another recommendation is that analysis of embedded assessments in the curriculum be done. By looking at student work across the unit, it may be possible to track growth in student understanding or skill development within a content area. In addition, exemplars for embedded assessments illustrating differing levels of student achievement could be included in the published curriculum.

Even though student learning gains in this study are formative the results can be viewed with a level of confidence. Reliability estimates and effect sizes are good and the similar pattern of gains across sites and units suggest consistent evidence of the effectiveness of the curriculum.

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Appendix A

Assessment Item Results by Unit

Unit 1 – How Does The Sun Affect The Earth?

Items:

1. What things are coming toward the Earth from the Sun? List as many things as you can, and be as specific as possible. Next to each thing you list, write if it is harmful or helpful to us and how.

1. How do people protect themselves from harmful effects of the Sun? List at least two ways.

1. Is the energy that comes from the Sun always the same? Explain how the energy is the same or different.

1. What does the Earth and Sun system look like? Draw the Earth and Sun system on the page. You must include the Sun and the Earth, and label each of them. You may include:
    A. Labels that show sizes or distances.
    A. Arrows to show how the Sun and Earth move.
    A. Anything else to show how the Sun and Earth affect each other.

5. What protects us from the harmful effects of the Sun? Circle all the correct answers. There may be more than one.
    A. The atmosphere of the Earth protects us from harmful energies.
    A. Ozone in Earth's atmosphere protects us from harmful particles
    A. Sunscreen protects us from harmful particles.
    A. The magnetic field of the Earth protects us from harmful particles.

Unit 1 – How Does The Sun Affect The Earth?

Item 1 - Short Answer

What things are coming toward the Earth from the Sun? List as many things as you can, and be as specific as possible. Next to each thing you list, write if it is harmful or helpful to us and how.

Table 14. Unit 1 – Item 1 – Score Frequencies

Scores	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	3	.5
Inaccurate Information (Score 1)	3	.3
Insufficient Information (Score 2)	75	39
Partial Understanding (Score 3)	12	21
Complete Understanding (Score 4)	6	39

Table 15. Unit 1 – Item 1 – Ray Response

Category	Pretest Percent	Posttest Percent
Mentioned Rays		
General	58	20
Specific	23	77
None	19	3

Unit 1 – How Does The Sun Affect The Earth?

Table 16. Unit 1 – Item 1 – Responses

Category	Pretest Percent	Posttest Percent
Mentioned Light	66	52
Mentioned Heat	67	41
Mentioned Rays	25	29
Mentioned Solar Particles	10	24

Table 17. Unit 1 – Item 1 – Responses – Infrared and X-Rays

Category	Pretest Percent		Posttest Percent	
	Yes	No	Yes	No
Mentioned Infrared and Harmful		36	4	48
Mentioned X-Rays and Helpful	1	36	24	37

Unit 1- How Does The Sun Affect The Earth?

Item 2 – Short Answer

How do people protect themselves from harmful effects of the Sun? List at least two ways.

Table 18. Unit 1 – Item 2 – Score Frequencies

Scores	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	1	1
Inaccurate Information (Score 1)	1	1
Insufficient Information (Score 2)	1	1
Partial Understanding (Score 3)	6	3
Complete Understanding (Score 4)	91	94

Unit 1 – How Does The Sun Affect The Earth?

Item 3 – Short Answer

Is the energy that comes from the Sun always the same? Explain how the energy is the same or different.

Table 19. Unit 1 – Item 3 – Score Frequencies

Scores	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	4	3
Inaccurate Information (Score 1)	18	7
Insufficient Information (Score 2)	48	41
Partial Understanding (Score 3)	19	16
Complete Understanding (Score 4)	11	33

Table 20. Unit 1 – Item 3 – Responses

Category	Pretest Percent		Posttest Percent	
	Yes	No	Yes	No
Mentioned Seasons	9	88	2	95
Mentioned Day or Night	2	95	1	95

Unit 1 – How Does The Sun Affect The Earth?

Item 4 – Short Answer

What does the Earth and Sun system look like? Draw the Earth and Sun system on the page. You must include the Sun and the Earth, and label each of them. You may include:

A. Labels that show sizes or distances.
A. Arrows to show how the Sun and Earth move.
A. Anything else to show how the Sun and Earth affect each other.

Table 21. Unit 1 – Item 4 – Score Frequencies

Scores	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	4	2
Inaccurate Information (Score 1)	35	15
Insufficient Information (Score 2)	6	6
Partial Understanding (Score 3)	27	21
Complete Understanding (Score 4)	28	53

Table 22. Item 4 – Does the drawing show these elements?

Category	Pretest Percent		Posttest Percent	
	Yes	No	Yes	No
Shows Correct Orbit of Earth Around the Sun	61	39	58	40
Shows Spinning of the Earth	25	75	18	82
Shows Correct Distance Between the Earth and Sun	4	96	44	56
Shows Relative Size of Earth to Sun	61	39	80	20
Shows Energy from the Sun	35	64	39	61
Shows Spherical Shape of Earth and Sun	94	6	97	3
Shows Shields Protecting the Earth	9	91	17	83

Unit 1 – How Does The Sun Affect The Earth?

Item 5 – Multiple Choice

What protects us from the harmful effects of the Sun? Circle all the correct answers. There may be more than one.

A. The atmosphere of the Earth protects us from harmful energies.
A. Ozone in Earth's atmosphere protects us from harmful particles
A. Sunscreen protects us from harmful particles.
A. The magnetic field of the Earth protects us from harmful particles.

Table 23. Unit 1 – Item 5 – Score Frequencies

Scores	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	1	2
Inaccurate Information (Score 1)	89	88
Insufficient Information (Score 2)	n/a	n/a
Partial Understanding (Score 3)	8	2
Complete Understanding (Score 4)	2	8

Table 24. Unit 1 – Item 5 – Responses

Category	Pretest Percent	Posttest Percent
A (Correct)	68	75
B (Incorrect)	29	77
C (Incorrect)	53	71
D (Correct)	68	64

Unit 2 – Why Are There Seasons?

Items:

1. These two pictures show the same tree on two different days at noon. Why do the Sun's rays come in at different angles? Explain why this occurs.

1. Imagine there where two Earths. One Earth is where our Earth is. The other Earth is 8000 miles closer to the Sun. Which place on these two Earths would be hotter, A or B. Explain why you think so.

1. Why do you think it is hotter in the United States in June than in December? Circle all that are correct.
    A. Because the United States is tilted more toward the Sun in June and away from the Sun in December.
    A. Because in the United States there are more hours of daylight in June than in December.
    A. Because the Earth is closer to the Sun in June and farther away from the Sun in December.
    A. Because the Sun gives off more heat and energy in June and less in December.
    A. Because the Sun appears higher in the sky in June and its rays are more intense.
    A. Because the United States is closer to the Sun in June and farther away from the Sun in December.

4. When the Earth is closest to the Sun which of the following is true? Circle the letter of the best answer.
    A. The distance to the Sun causes summer in the Northern hemisphere.
    A. It is summer everywhere on Earth.
    A. The distance to the Sun has nothing to do with the reasons for seasons.
    A. It is winter everywhere on Earth.

5. In the Sun-Earth drawing along the right side of this page, which picture of the Earth best shows its size and distance from the Sun? Circle the letter of the best answer.

5. Which of the four drawings do you think best shows the shape of the Earth's orbit around the Sun? Circle the correct letter.

Unit 2 – Why Are There Seasons?

Item 1 – Short Answer

These two pictures show the same tree on two different days at noon. Why do the Sun's rays come in at different angles? Explain why this occurs.

Table 25. Unit 2 – Item 1 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	6	2
Inaccurate Information (Score 1)	26	13
Insufficient Information (Score 2)	30	16
Partial Understanding (Score 3)	27	37
Complete Understanding (Score 4)	11	32

Table 26. Unit 2 – Item 1 – Responses

Category	Pretest Percent	Posttest Percent
Mentions intensity of light/angle of rays from Sun	21	38
Mentions location of Earth in its orbit	11	11
Mentions seasons but NOT tilt	7	14
Mentions Sun in a different location at noon	9	14
Mentions tilt/angle related to seasons	16	35
Pictures are labeled wrong, but explanation is correct.	1	3

Unit 2 – Why Are There Seasons?

Item 2 – Short Answer

Imagine there where two Earths. One Earth is where our Earth is. The other Earth is 8000 miles closer to the Sun. Which place on these two Earths would be hotter, A or B. Explain why you think so.

Table 27. Unit 2 – Item 2 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	4	2
Inaccurate Information (Score 1)	47	27
Insufficient Information (Score 2)	12	13
Partial Understanding (Score 3)	34	50
Complete Understanding (Score 4)	3	8

Table 28. Unit 2 – Item 2 – Responses

Category	Pretest Percent	Posttest Percent
Mentions intensity of light/angle of rays from Sun	24	50
Location A is negligibly closer to Sun	4	11
Makes geographic reference.	16	11

Unit 2 – Why Are There Seasons?

Item 3 – Multiple Choice

Why do you think it is hotter in the United States in June than in December? Circle all that are correct.

A. Because the United States is tilted more toward the Sun in June and away from the Sun in December.
A. Because in the United States there are more hours of daylight in June than in December.
A. Because the Earth is closer to the Sun in June and farther away from the Sun in December.
A. Because the Sun gives off more heat and energy in June and less in December.
A. Because the Sun appears higher in the sky in June and its rays are more intense.
A. Because the United States is closer to the Sun in June and farther away from the Sun in December.

Table 29. Unit 2 – Item 3 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	2	1
Inaccurate Information (Score 1)	78	35
Insufficient Information (Score 2)	16	26
Partial Understanding (Score 3)	3	17
Complete Understanding (Score 4)	1	21

Unit 2 – Why Are There Seasons?

Table 30. Unit 2 – Item 3 – Responses

Category	Pretest Percent	Posttest Percent
Because the United States is tilted more toward the Sun in June and away from the Sun in December. (Correct)	44	83
Because in the United States there are more hours of daylight in June than in December. (Correct)	24	53
Because the Earth is closer to the Sun in June and farther away from the Sun in December (Incorrect)	47	86
Because the Sun itself gives off more heat and energy in June and less in December. (Incorrect)	84	84
Because the Sun appears higher in the sky in June and its rays are more intense. (Correct)	15	38
Because the United States is closer to the sun in June and farther away from the sun in December. (Incorrect)	57	80

Unit 2 – Why Are There Seasons?

Item 4 – Multiple Choice

When the Earth is closest to the Sun which of the following is true? Circle the letter of the best answer.

A. The distance to the Sun causes summer in the Northern hemisphere.
A. It is summer everywhere on Earth.
A. The distance to the Sun has nothing to do with the reasons for seasons.
A. It is winter everywhere on Earth.

Table 31. Unit 2 – Item 4 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	1	4
Inaccurate Information (Score 1)	80	28
Insufficient Information (Score 2)	an	an
Partial Understanding (Score 3)	an	an
Complete Understanding (Score 4)	19	68

Table 32. Unit 2 – Item 4 – Responses

Category	Pretest Percent	Posttest Percent
The distance to the Sun causes summer in the Northern hemisphere. (Incorrect)	67	23
It is summer everywhere on Earth. (Incorrect)	12	3
The distance to the Sun has nothing to do with the reasons for seasons. (Correct)	19	69
It is winter everywhere on Earth. (Incorrect)	1	1

Unit 2 – Why Are There Seasons?

Item 5 – Multiple Choice

In the Sun-Earth drawing along the right side of this page which picture of the Earth best shows its size and distance from the Sun? Circle the letter of the best answer.

Table 33. Unit 2 – Item 5 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	5	3
Inaccurate Information (Score 1)	60	35
Insufficient Information (Score 2)	an	an
Partial Understanding (Score 3)	an	an
Complete Understanding (Score 4)	35	62

Table 34. Unit 2 – Item 5 – Responses

Category	Pretest Percent Correct	Posttest Percent Correct
A	41	26
B	13	9
C - Correct	37	62

Unit 2 – Why Are There Seasons?

Item 6 – Multiple Choice

Which of the four drawings do you think best shows the shape of the Earth's orbit around the Sun? Circle the correct letter.

Table 35. Unit 2 – Item 6 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	4	3
Inaccurate Information (Score 1)	67	36
Insufficient Information (Score 2)	an	an
Partial Understanding (Score 3)	an	an
Complete Understanding (Score 4)	29	61

Table 36. Unit 2 – Item 6 – Responses

Category	Pretest Percent Correct	Posttest Percent Correct
A	20	6
B	16	13
C	30	17
D - Correct	30	62

Unit 3 – The Solar System

Items:

1. Circle True or False for each statement below.
   A. Earth is in orbit around Saturn.
   A. As a planet orbits the Sun, it takes about the same amount of time to go around the sun each time it orbits.
   A. Moons orbit around planets
   A. Everything in the Solar System orbits around the Earth.
   A. A planet close to the Sun takes less time to orbit the Sun than a planet that is far from the Sun.
   A. Some planets in the Solar System don't orbit the Sun.

2. What description in the chart below best describes the Solar System object listed on the Left? Circle the correct descriptions.

Solar System Object	**Temperature**		**Size**		**Distance from Sun**		**Composition**			**Atmosphere**	
Jupiter	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere
Venus	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere
Neptune	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere
Mars	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere
Pluto	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere
Ceres (Asteroid)	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere

Unit 3 – The Solar System

3. Choose a planet or moon in the Solar System (other Than Earth) that might be suitable for life. What are at least three reasons why it might be suitable for life? Explain your answer.

3. What are the different objects on the diagram? Label as many objects as you can.

3. What are at least two accurate and two inaccurate things about the diagram as a model of the Solar System? List as many as possible.

3. How would you make a more scientifically accurate model of the Solar System?

Unit 3 – The Solar System

Item 1 – Multiple Choice

Circle True or False for each statement below.

A. Earth is in orbit around Saturn. (False)
A. As a planet orbits the Sun, it takes about the same amount of time to go around the sun each time it orbits. (True)
A. Moons orbit around planets. (True)
A. Everything in the Solar System orbits around the Earth. (False)
A. A planet close to the Sun takes less time to orbit the Sun than a planet that is far from the Sun. (True)
A. Some planets in the Solar System don't orbit the Sun. (False)

Table 37. Unit 3 – Item 1 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	8	1
Inaccurate Information (Score 1)	7	2
Insufficient Information (Score 2)	18	10
Partial Understanding (Score 3)	23	27
Complete Understanding (Score 4)	44	60

Unit 3 – The Solar System

Table 38. Unit 3 – Item 1 – Responses – Percent of Students Choosing *Correctly*

Category	Pretest Percent	Posttest Percent
Earth is in orbit around Saturn. (False)	78	91
As a planet orbits the Sun, it takes about the same amount of time to go around the sun each time it orbits. (True)	74	83
Moons orbit around planets. (True)	74	89
Everything in the Solar System orbits around the Earth. (False)	81	92
A planet close to the Sun takes less time to orbit the Sun than a planet that is far from the Sun. (True)	73	84
Some planets in the Solar System don't orbit the Sun. (False)	76	88

Unit 3 - The Solar System

Item 2 – Multiple Choice

What description in the chart below best describes the Solar System object listed on the Left? Circle the correct descriptions.

Solar System Object	Temperature		Size		Distance from Sun		Composition			Atmosphere	
Jupiter	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere
Venus	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere
Neptune	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere
Mars	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere
Pluto	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere
Ceres (Asteroid)	Hotter than Earth	Colder than Earth	Bigger than Earth	Smaller than Earth	Closer to the Sun than Earth	Farther to the Sun than Earth	Mostly Gas	Mostly Rock	Mostly Ice	Has Atmos-phere	Has no Atmos-phere

Table 39. Unit 3 – Item 2 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	6	1
Inaccurate Information (Score 1)	5	1
Insufficient Information (Score 2)	20	11
Partial Understanding (Score 3)	49	43
Complete Understanding (Score 4)	20	44

Table 40. Unit 3 – Item 2 – Jupiter Responses

Category	Pretest Percent Correct	Posttest Percent Correct
Temperature	66	66
Size	83	91
Distance from Sun	84	91
Composition	55	71
Atmosphere	39	64

Table 41. Unit 3 – Item 2 – Venus Responses

Category	Pretest Percent Correct	Posttest Percent Correct
Temperature	69	81
Size	66	72
Distance from Sun	66	84
Composition	41	58
Atmosphere	39	64

Table 42. Unit 3 – Item 2 – Neptune Responses

Category	Pretest Percent Correct	Posttest Percent Correct
Temperature	79	85
Size	64	72
Distance from Sun	79	89
Composition	30	44
Atmosphere	36	53

Table 43. Unit 3 – Item 2 – Mars Responses

Category	Pretest Percent Correct	Posttest Percent Correct
Temperature	47	53
Size	62	66
Distance from Sun	62	77
Composition	52	73
Atmosphere	48	74

Table 44. Unit 3 – Item 2 – Pluto Responses

Category	Pretest Percent Correct	Posttest Percent Correct
Temperature	84	92
Size	81	92
Distance from Sun	83	65
Composition	61	61
Atmosphere	63	74

Table 45. Unit 3 – Item 2 – Ceres Responses

Category	Pretest Percent Correct	Posttest Percent Correct
Temperature	51	81
Size	62	83
Distance from Sun	61	75
Composition	59	87
Atmosphere	72	92

Table 46. Unit 3 – Item 2 – Temperature Responses

Object	Pretest Percent Correct	Posttest Percent Correct
Jupiter	66	66
Venus	69	81
Neptune	79	85
Mars	47	53
Pluto	84	92
Ceres	51	84

Table 47. Unit 3 – Item 2 – Size Responses

Object	Pretest Percent Correct	Posttest Percent Correct
Jupiter	83	91
Venus	66	72
Neptune	64	72
Mars	62	66
Pluto	81	92
Ceres	62	83

Table 48. Unit 3 – Item 2 – Distance from Sun Responses

Object	Pretest Percent Correct	Posttest Percent Correct
Jupiter	84	91
Venus	66	84
Neptune	79	89
Mars	62	77
Pluto	83	65
Ceres	61	75

Table 49. Unit 3 – Item 2 – Composition Responses

Object	Pretest Percent Correct	Posttest Percent Correct
Jupiter	55	71
Venus	41	58
Neptune	30	44
Mars	52	73
Pluto	61	61
Ceres	59	87

Table 50. Unit 3 – Item 2 – Atmosphere Responses

Object	Pretest Percent Correct	Posttest Percent Correct
Jupiter	39	64
Venus	39	64
Neptune	36	53
Mars	48	74
Pluto	63	74
Ceres	72	92

Unit 3 – The Solar System

Item 3 – Short Answer

Choose a planet or moon in the Solar System (other Than Earth) that might be suitable for life. What are at least three reasons why it might be suitable for life? Explain your answer.

Table 51. Unit 3 – Item 3 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	13	5
Inaccurate Information (Score 1)	17	7
Insufficient Information (Score 2)	25	27
Partial Understanding (Score 3)	35	37
Complete Understanding (Score 4)	10	24

Table 52. Unit 3 –Item 3 – Responses – Planets/Moons

Planet Chosen	Pretest Percent	Posttest Percent
Mars	50	51
Earth	1	1
Mercury	1	3
Saturn	2	2
Europa	1	12
Earth's Moon	11	8
Venus	7	8
Uranus	1	1
Titan	1	1
Other Moons	1	1
Jupiter	4	4
Neptune	2	1
Pluto	3	3

Table 53. Unit 3 – Item 3 – Responses

Category	Pretest Percent	Posttest Percent
Atmosphere	27	53
Water	34	47
Rocky Surface	11	22
Temperature	34	46

Unit 3 – The Solar System

Item 4 – Short Answer

What are the different objects on the diagram? Label as many objects as you can.

Table 54. Unit 3 – Item 4 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	9	8
Inaccurate Information (Score 1)	28	14
Insufficient Information (Score 2)	21	24
Partial Understanding (Score 3)	30	24
Complete Understanding (Score 4)	12	30

Table 55. Unit 3 – Item 4 – Responses

Category	Pretest Percent Labeled	Posttest Percent Labeled
Sun	74	70
Earth	59	72
Jupiter	56	71
Neptune	44	62
Mercury	51	67
Mars	49	65
Saturn	64	77
Pluto	69	79
Venus	48	67
Asteroid Belt	20	43
Uranus	40	59

Unit 3 – The Solar System

Item 5 – Short Answer

What are at least two accurate and two inaccurate things about the diagram as a model of the Solar System? List as many as possible.

Table 56. Unit 3 – Item 5 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	7	7
Inaccurate Information (Score 1)	27	14
Insufficient Information (Score 2)	27	20
Partial Understanding (Score 3)	2	2
Complete Understanding (Score 4)	37	57

Unit 3 – The Solar System

Item 6 - Short Answer

How would you make a more scientifically accurate model of the Solar System?

Table 57. Unit 3 – Item 6 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	12	10
Inaccurate Information (Score 1)	9	5
Insufficient Information (Score 2)	30	24
Partial Understanding (Score 3)	32	37
Complete Understanding (Score 4)	17	24

Table 58. Unit 3 – Item 6 – Responses

Category	Pretest Percent	Posttest Percent
Relative Size	26	31
Orbit	15	12
Spacing/Distance	13	14
Scale	8	15

Unit 4 – Beyond The Solar System

Items

1. Why is detecting planets around other starts difficult? Explain at least two reasons.

1. What is the order of things from smallest to largest? Fill in the blanks below with the following

    The Universe
    The Sun
    The Milky Way Galaxy
    The Solar System
    The Earth

3. Which is true?
    A. There are galaxies in the Solar System.
    A. There are more galaxies than stars.
    A. There are more than a billion galaxies.
    A. No galaxies can be viewed as a whole through a telescope.

3. What stars can we see with the unaided eye in the night sky?
    A. Stars in our Solar System
    A. Most of the stars in the galaxy.
    A. Most of the stars in the Universe.
    A. A small portion of the stars in the galaxy.

3. Which is the best description of how stars are arranged in the Universe?
    A. They occur in clumps called galaxies that are many different sizes and shapes.
    A. They are spread out fairly evenly throughout the Universe.
    A. There is no apparent order to the arrangement of stars in the Universe.
    A. They occur in clumps called galaxies, which are all about the same size and shape.

3. How have astronomers explored the stars beyond our solar system? Circle all the are true.
    A. By studying our own Sun and comparing it to other stars.
    A. By sending astronauts to other stars.
    A. By sending spacecraft to fly by other stars.
    A. By studying the light that comes to Earth from stars.

Unit 4 – Beyond The Solar System

Item 1 – Short Answer

Why is detecting planets around other starts difficult? Explain at least two reasons.

Table 59. Unit 4 – Item 1 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	19	6
Inaccurate Information (Score 1)	14	7
Insufficient Information (Score 2)	47	42
Partial Understanding (Score 3)	18	38
Complete Understanding (Score 4)	2	8

Table 60. Unit 4 – Item 1 – Responses

Category	Pretest Percent	Posttest Percent
Distance	31	42
Size	18	16
Light	12	40
Telescope	4	4

Unit 4 – Beyond The Solar System

Item 2 – Short Answer

What is the order of things from smallest to largest? Fill in the blanks below with the following

The Universe
The Sun
The Milky Way Galaxy
The Solar System
The Earth

Table 61. Unit 4 – Item 2 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	0	0
Inaccurate Information (Score 1)	22	5
Insufficient Information (Score 2)	25	16
Partial Understanding (Score 3)	NA	NA
Complete Understanding (Score 4)	53	79

Unit 4 – Beyond The Solar System

Table 62. Unit 4 – Item 2 – Percent Choosing Categories

Score	Pretest Percent	Posttest Percent
Smallest		
Universe	1	0
Sun	3	2
Milky Way	5	1
Solar System	1	1
Earth	**90**	**98**
Second		
Universe	2	0
Sun	**78**	**95**
Milky Way	10	1
Solar System	6	3
Earth	4	1
Third		
Universe	3	1
Sun	11	1
Milky Way	27	17
Solar System	**57**	**81**
Earth	2	0
Fourth		
Universe	7	2
Sun	5	1
Milky Way	**54**	**81**
Solar System	33	15
Earth	2	1
Largest		
Universe	**87**	**96**
Sun	4	1
Milky Way	4	2
Solar System	4	1
Earth	1	0

Table 63. Unit 4 – Item 2 – Percent Choosing Correct Responses Pre/Post

Smallest	Second	Third	Fourth	Largest
90 / 98	78 / 95	56 / 81	54 / 81	87 / 96
Earth	Sun	Solar System	Milky Way	Universe

Unit 4 – Beyond The Solar System

Item 3 – Multiple Choice

Which is true?

A. There are galaxies in the Solar System.
A. There are more galaxies than stars.
A. There are more than a billion galaxies.
A. No galaxies can be viewed as a whole through a telescope.

Table 64. Unit 4 – Item 3 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	1	5
Inaccurate Information (Score 1)	73	40
Insufficient Information (Score 2)	NA	NA
Partial Understanding (Score 3)	NA	NA
Complete Understanding (Score 4)	26	55

Table 65. Unit 4 – Item 3 – Responses

Answer	Pretest Percent	Posttest Percent
There are galaxies in the Solar System. (Incorrect)	26	11
There are more galaxies than stars. (Incorrect)	3	3
There are more than a billion galaxies. (Correct)	28	55
No galaxies can be viewed as a whole through a telescope. (Incorrect)	41	22

Unit 4 – Beyond The Solar System

Item 4 – Multiple Choice

What stars can we see with the unaided eye in the night sky?

A. Stars in our Solar System
A. Most of the stars in the galaxy.
A. Most of the stars in the Universe.
A. A small portion of the stars in the galaxy.

Table 66. Unit 4 – Item 4 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	0	1
Inaccurate Information (Score 1)	49	35
Insufficient Information (Score 2)	NA	NA
Partial Understanding (Score 3)	NA	NA
Complete Understanding (Score 4)	51	64

Table 67. Unit 4 – Item 4 – Responses Chosen

Answer	Pretest Percent	Posttest Percent
Stars in our Solar System. (Incorrect)	32	18
Most of the stars in the galaxy. (Incorrect)	11	9
Most of the stars in the universe. (Incorrect)	5	5
A small portion of the stars in the galaxy. (Correct)	52	63

Unit 4 – Beyond the Solar System

Item 5 – Multiple Choice

Which is the best description of how stars are arranged in the Universe?

A. They occur in clumps called galaxies that are many different sizes and shapes.
A. They are spread out fairly evenly throughout the Universe.
A. There is no apparent order to the arrangement of stars in the Universe.
D. They occur in clumps called galaxies, which are all about the same size and shape.

Table 68. Unit 4 – Item 5 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	1	2
Inaccurate Information (Score 1)	70	41
Insufficient Information (Score 2)	NA	NA
Partial Understanding (Score 3)	NA	NA
Complete Understanding (Score 4)	29	57

Table 69. Unit 4 – Item 5 – Responses

Answer	Pretest Percent	Posttest Percent
They occur in clumps called galaxies that are many different sizes and shapes. (Correct)	30	55
They are spread out fairly evenly throughout the universe. (Incorrect)	11	6
There is no apparent order to the arrangement of stars in the Universe. (Incorrect)	50	31
They occur in clumps called galaxies, which are all about the same size and shape. (Incorrect)	8	6

Unit 4 – Beyond The Solar System

Item 6 – Multiple Choice

How have astronomers explored the stars beyond our solar system? Circle all that are true.

A. By studying our own Sun and comparing it to other stars.
B. By sending astronauts to other stars.
C. By sending spacecraft to fly by other stars.
D. By studying the light that comes to Earth from stars.

Table 70. Unit 4 – Item 6 – Score Frequencies

Score	Pretest Percent	Posttest Percent
Missing/Wrong (Score 0)	1	0
Inaccurate Information (Score 1)	60	44
Insufficient Information (Score 2)	NA	NA
Partial Understanding (Score 3)	19	21
Complete Understanding (Score 4)	20	35

Table 71. Unit 4 – Item 6 – Responses – Percent of Students that Chose *Correctly*

Answer	Pretest Percent	Posttest Percent
By studying our own Sun and comparing it to other stars. (True)	59	68
By sending astronauts to other stars. (False)	80	89
By sending spacecraft to fly by other stars. (False)	47	61
By studying the light that comes to Earth from stars. (True)	60	71