

MISCONCEPTION BASED CURRICULUM RESTRUCTURING FOR FRESHMEN  
EARTH SCIENCE STUDENTS VIA MOON JOURNAL PROJECTS

by

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## ABSTRACT

This project had the goal of taking the first earth science student project of the year, a journal of one lunar cycle, and modifying its curriculum to achieve higher student participation and scores. In addition a major aim was to improve the mastery of astronomy themed concepts within that thematic unit, especially as measured with common misconceptions related to its content. The treatment incorporated new or redesigned activities, use of models, labs, and unit assignments, assessment strategies, and measured academic growth using a newly implemented pretest and posttest. These results were compared to a pretest and posttest given on the subsequent thematic unit where curriculum was not modified. Data gathered showed that the curriculum that was reworked enabled greater test score growth despite challenges in student moon journal participation and scoring.

## INTRODUCTION AND BACKGROUND

### Background and Demographics

This school year marked the fourth year that I have taught at the high school that I graduated from, Hellgate High School in Missoula, Montana. Grade nine earth science engaged most of my instructional time there, and this course is a graduation requirement so it hosted a wide array of students. My four sections this academic year ranged in size from 15 to 27 students. Classes included up to five Individualized Education Plan (IEP) or 504 plan students, as many as four sophomores mixed in with the freshmen, and had gender ratios that ranged from 69% male to 70% female. A broad range of socio-economic and even geographic ranges were represented as well, given that as many as seven direct feeder schools (and many more potentially as we are in an open enrollment school) bring students by bus, on foot, and driving themselves to school. Hellgate's free and reduced lunch rate is 36% and the science education staff that I work with includes a total of nine full-time and one half time instructor, including myself. The syllabus adopted by the earth science department puts astronomy as the first thematic unit of the school year after reviewing general science skills, and freshmen enjoy learning the concepts and material, often expressing disappointment when the unit ends and we move on to meteorology.

### Project Origin

My action research project focused on an extended student project that I have done on several separate occasions, usually during the first quarter of school. The moon journal project has the observation and better understanding of the lunar cycle as its main learning goals. Having first studied the idea of keeping a moon journal in a college

writing course, I eagerly did my first moon journal activity during my student teaching ten years ago. The assignment basics have students observe the moon, noting the time of viewing, its position in the sky, and its shape (what the brightest part looks like.) Journal entries also had students write a few sentences on a lunar-themed prompt such as “How does lunar gravity compare to earth gravity?” or “What would you do on the moon?” Having conducted the project four other times since then, I found some areas of concern with the assignment as far as its structure, and how motivated students were to actively participate in and learn from the process and project.

I found that my last two iterations of the moon journal project garnered a fair amount of feedback from students suggesting changes to the project itself which would make for greater success on their part. I also found that some of my learning targets and the take away messages that I intended to impart upon students were not being fully realized. Fundamental concept questions related to the moon’s cycle, the earth’s seasons, and eclipses (all taught within the moon journal itself or within its thematic section) were being missed by students on the unit exam. After observing this, I began to investigate potential ways to upgrade the project to increase student engagement and to improve concept mastery within the unit. Student suggestions on how to positively modify the moon journals focused largely on requests for format changes for the weekend, fewer entries overall, and on the idea of more hands-on activities. In addition to trying some of those changes I also looked to incorporate different teaching materials, methods, and activities in order to make the moon journal experience more approachable and to make the unit a more effective way to teach stubborn astronomical concepts.

The encompassing issue of student engagement and incomplete learning that

underlies the moon journal struggles of certain students was a key area where reflection and data gathering could be of great benefit to my teaching. The fact that it was ninth graders who I taught this upgraded unit to was of particular value as far as engagement was concerned. Each year these students are challenged by the transition out of middle school to a larger, more demanding, less insulated school setting, and are at the greatest risk when it comes to dropping out. Therefore finding information about how to improve their learning and engagement can be of huge importance to my teaching success and to the success of our school in general. Uncovering strategies that can improve student participation and concept mastery at this critical juncture in their academic careers would be a great addition to my skill set as a teacher, and will maximize the effectiveness of a large curricular unit whose position early in the school year could set a positive tone for the entire academic year. I also hoped that finding ways to overcome student misconceptions would be of use to the other three teachers in my department that teach the same class to other young people, and that our resource and idea sharing would benefit our professional learning community.

My study looked to chiefly address the following questions:

1. How did a moon journal project redesign affect student performance, as measured by mastery of astronomy learning targets / loss of astronomy misconceptions?
2. How did a moon journal project redesign affect student involvement, opinion, and performance, as measured by scores (my own and those from survey data) on the assignment?
3. What additional strategies, tools, and lesson elements did this project and process bring to mind so that I can continue to be of the greatest utility in affecting student

learning target growth and moon journal satisfaction?

### CONCEPTUAL FRAMEWORK

In my literature search to gain footing on my moon journal redesign strategy I initially looked for works specifically addressing the idea of moon journals, but found little to work with other than references to the Joni Chaucer book “Moon Journals: Writing, Art, and Inquiry Through Focused Nature Study” (1997). This resource was where my moon journal exposure began in the undergraduate setting mentioned earlier. That book is excellent, although chiefly focused on elementary language arts study, which limited its applicability to my teaching setting. After sifting through many unusable or unconnected citations and sources I broadened my search to look in general deeper into lunar misconceptions. The number of high quality articles, resources, and internet citations attached to science misconceptions, especially astronomy misconceptions gave me a huge number of ideas on how to modify instruction, craft assessments, and target instruction with the goal of knocking misconceptions out.

One of the first articles that initially caught my eye lead with the fact that understanding the phases of the moon is an eighth grade standard, but is often unmet even among adults and graduates from some of the most reputable colleges (Kavanagh, Agan, & Sneider, 2005). The article’s emphasis on constructivist learning where project based and hands-on learning were key to successful learning about the moon really stuck with me. The authors did a fantastic job of laying out a number of teaching suggestions at many different age / ability levels from elementary to adult learners. Strategies that the article suggested that I pay special attention to including the use of models rather than diagrams, active determination of content weaknesses and lesson plans incorporating

direct observations and classroom discussions. I also really appreciated the reference to Lillian McDermott's *Physics by Inquiry*, touted as “a highly regarded and well-researched curriculum based on constructivist learning theory” (Kavanagh et al, 2005, p. 42). That resource was a big inspiration in my choice of this action research direction, where learning new models for determining and teaching the phases of the moon challenged me academically and professionally.

Another useful article I found was that of another action researcher that also encountered the pervasive misconception of the Earth's shadow as the cause for the moon's phases and stated that the seeds for that error often start before students enter school (Olson, 2007). It also had some good suggestions on how to break misconceptions, with interventions beginning best before the age level that I see students, but giving me lead-ins from unsophisticated materials, such as lesson starters using cartoons or children's literature illustrations where my students could spot the inaccuracies, and begin taking apart moon mistruths. Oversimplifying the moon's phases using two dimensional, space based pictures (as I have done in class) was referenced as problematic and should be replaced with models utilizing spheres, or globes and lamps. The article also made reference to inquiry style discussions which made me think about how I could open up my lunar unit so that data and dynamic models would be interpreted by students and not presented by myself. I especially took away from the article the need for focused use of manipulatives to replace the stubborn shadow explanation, and that giving students enough class time with lamps, globes and moon models, they will abandon the Earth shadow explanation on their own once they see its inaccuracy.

Another resource I found looked at “alternative conceptions” for lunar astronomy

concepts, finding that middle schoolers still wrestled with the centuries old idea of the moon and/or sun orbiting the Earth, or of the new moon being too small to cause a solar eclipse (Danaia & McKinnon, 2007). The study's focus on muddy learning areas including the movement of the sun, moon phases / eclipses, seasons, and the explanation of day and night cycles showed me where the core of my astronomy curriculum redesign should focus. I was somewhat surprised by their conclusion that teaching out of the curricular area of expertise was a major cause of student misconceptions, and felt good that my educational pursuit was taking me opposite of that direction. In addition I found it insightful that the maintaining of astronomy misconceptions was connected by Danaia and McKinnon in part to "the overcrowded nature of the science curriculum" (2007, p. 9) which is an issue I have often wrestled with in my job generally and in the implementation of this project specifically.

The lesson of having students individually write their explanation for why the moon goes through phases, then having them test different ideas using a ball and floor lamp is key to starting the intelligible, plausible, and fruitful idea change in students with lunar concept errors, wherein students must understand the concept, see how it replaces the misconception, and see how that idea applies elsewhere (Brunsell & Marcks, 2007). The article lent me good ideas for my moon journal revamping with the suggestion that students should be presented with "discrepant events" or "anomalous data" in order to challenge and ultimately bust their misconceptions. I think that a lesson mentioned above where students were challenged to recreate the different moon phases using a lamp, globe, and baseball with directions to make the Earth's shadow cause the phase changes would be one such discrepant event scenario. Their ideas on how to more effectively

teach the concept of the Earth / moon scale and example assessment questions were also helpful. For sure I would like more of my students to be “cognitively dissatisfied” with their tired and annoying lunar misconceptions after unsuccessfully attempting to model those misconceptions.

The short article “Found in the Phases of the Moon” had a highly useful addition to my curricular redesign quest when it comes to keeping the halves of the moon month straight. The author’s simple “a” and “b” manual pneumonic for recognizing the moon’s current phase (after or before full) was a real treat for me and definitely earned a place in a future moon journal setting (Currin, 2007). The longer article entitled “Moon Misconceptions” laid out a structured and well researched strategy to break misconceptions that involved a three step process. Developing lessons that identify, overturn, and then replace misconceptions was the key to their effective confrontation and elimination, according to the piece (Hermann & Lewis, 2003). It also presented a brief pretest example that assessed student understanding of the moon phases before and after instruction that served as a good template for the pretest I eventually crafted.

The literature review that I did was most useful when it came to identifying the most stubborn astronomical misconceptions, so I that I could come to know exactly where to target my curricular changes. They also allowed me to choose key elements, themes, and even some specific questions to place into my pre and post instruction assessment. As detailed above I had extensive resources to draw on as far as designing misconception and mastery assessments based on activities, open ended and multiple choice questions, surveys, interviews, and other techniques. The literature review I used included studies, many of them extensive, on students from middle school to high school and beyond, and

students in the United States and abroad, so I feel certain that their credibility and transferability into my teaching situation are legitimate.

The running theme of lunar misconceptions being stubborn in my literature sweep made me all the more resolute about continuing with the undertaking of reconstructing my moon journal unit. I wanted students to really have more to show from the unit than some have in the past, and I spun into my design common threads like the incorporation of dynamic physical models, repeated exposure to misconception replacing concepts, and incorporating more activities instead of direct instruction. In addition, I came to have the study data to verify that the careful design and implementation of those pieces could yield meaningful results that improve learning and invigorate instruction.

My research into meteorology misconceptions was much less detailed, largely because my intent for this portion of my project was to leave the content and delivery untouched from its previous usage carried forward to the 2013-2014 school year. Using that curriculum as a comparison unit meant that my greatest research need was developing a pretest / posttest instrument with the same format and similar rigor and pervasiveness of misconceptions in its questions. In working with my subject professional learning committee, I discussed the scope of this project with my colleagues, and found another earth science teacher that was interested in utilizing and developing pre and post assessment tools, and also was gifted with a good misconception source from a separate colleague.

The misconception resource is the Science Assessment Website established by American Association for the Advancement of Science with funding by the National Science Foundation to display data as it relates to misconceptions in many science areas

such as life science, physical science, and earth science (including meteorology but unfortunately not astronomy). Misconception headings and sub-ideas are shared along with field tested materials and data showing the percentage of students who correctly responded to test questions using that prompt. An example: only 32% of high school test takers correctly responded that “Clouds form anywhere there is moist air that cools to form tiny water droplets” (AAAS Science Assessment, 2013).

The end result of my research was the facilitated creation of a pair of tests that were given before and after instruction in my earth science astronomy and meteorology subject units, the first two of the school year. They were designed with seven open response questions followed by eighteen true and false questions. The American Association for the Advancement of Science website was set up to generate multiple choice questions, but I took their topic areas and derived true and false questions to maintain the format that I began with. My departure from the educational standard of a multiple choice exam was deliberate, in that I wanted an instrument that could show clearly whether students grasped concepts or not and at the same time discouraged students from simply guessing.

My literature review also supported the use of this type of test, at least indirectly. My colleague and I looked into pre and posttest development as a means of not just assessing student learning, but also for supporting student confidence that they were making educational progress as the thematic units progressed. To have students show positive growth before and after instruction and struggle less with concept questions after content delivery would be a positive experience that could encourage learning and participation. The doctoral dissertation of misconceptions in earth science and astronomy that I uncovered utilized multiple choice instruments with researched preconceptions

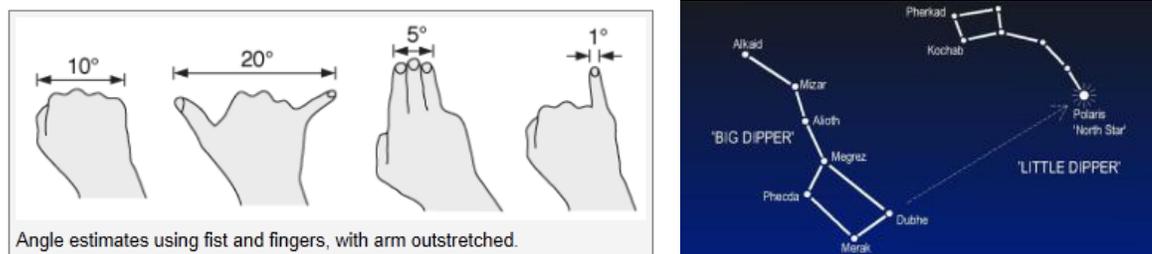
and/or misconceptions supplied as distractors within each question. That project showed an average student misconception test score of only 34 percent, and recommended the adjustment of grading policies to reflect these anticipated low scores (Sadler, 1992). Since my intent was to share student results with them and praise their satisfactory scores and marked pre to posttest growth, I went with a majority of easier true / false questions as my assessment constituents.

### METHODOLOGY

The moon journal project that I completed the last four school years usually began with the first new moon that occurs around September 15<sup>th</sup>, and would run through to the ensuing new moon. Earlier iterations consisted of daily entries wherein students observed, noted the time of, and sketched a drawing of the moon's shape, while also writing four sentences recording the details of their observation and/or reflections on a daily lunar writing prompt. This year's treatment kept that general outline, but incorporated a more scientific observation element in addition to the written reflections, while reducing the overall number of entries. The required number of entries was cut back due to the large number of survey respondents at the previous school year's project conclusion who complained of the project length, suggesting that they would score better if they were asked to do fewer entries, especially avoiding weekends.

My redesigned moon journal unit began with a data collection activity over the course of a week, prior to the official moon journal kick-off. Students were instructed to conduct two independent moon observations using the same template that would later appear in the moon journal. The goal of those observations, which were modeled in

class for the first time this year, was to witness how and contemplate why the moon's appearance and position changes. In doing this, students would learn, practice, and receive feedback regarding measurement and documentation of moon position and appearance prior to the penning of actual moon journal entries. Inaccurate drawings of the moon, often with the illuminated and dark portions of the moon reversed, were a place where students had lost points in earlier moon journal iterations, and this practice assignment was designed to minimize those errors. Measurement techniques for finding the moon's compass position and altitude were also modeled and assigned here as a means of restoring some of the rigor sacrificed by cutting the overall number of entries. I also wanted to emphasize the feeling of being a true scientist gathering field data as a student hook. The images below are among those used with students during this new preliminary exercise.



*Figure 1.* Moon Observation / Data Gathering Diagrams. (Image sources: left is from <http://physics.weber.edu/schroeder/ua/StarMotion.html>, right is from <http://misfitsandheroes.wordpress.com/tag/big-dipper/>)

The official kick off of the moon journal project carried the modified assignment of 15 moon observations and 15 writing prompts (rather than 29 of each) which could be done at the students' discretion over the course of the 29 day cycle. Another new piece added to this year's moon journal delivery was the use of moon cycle information sheets distributed to students with detailed information about the moon including its time of

rising, setting, and highest ascent in the sky. Writing prompts were also listed here, and with this extra resource at hand I thought that students would be better prepared to make high quality journal entries. The first of the four of these information pages handed out to students can be found in Appendix A. The individual entries on those hand-outs mirrored the slides shown to students at the beginning of each class period as we progressed through the moon journal unit as well. The image below indicates one such assignment detail shown to students:

**Friday, October 4, 2013**  
**Observation:**

Date month	Clock Time	Phase Sketch	Altitude of the moon above the horizon (feet)	Compass direction of the moon's position
		○		

**NEW MOON**  
**Moonrise: 7:20 am**  
**Moonset: 6:51 pm**



**Writing topic:**  
**How does gravity differ  
on the moon compared to  
the Earth?**

**Complete entry =  
observation sequence and  
4 sentence topic response  
(15 times this lunar  
"month")**

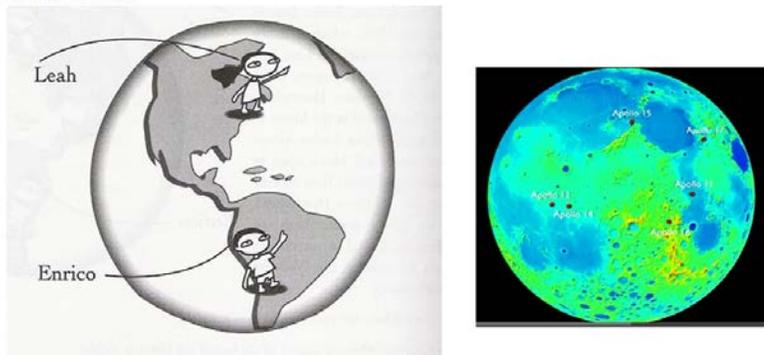
*Figure 2.* Moon Journal Instructions Sample. (Moon image source: <http://www.die.net/moon/>)

As the moon journal unit progressed instructional elements within the moon journal and the broader astronomy unit was further modified to more actively identify, confront, and hopefully replace student misconceptions. More accurate explanations of fundamental astronomy principles like the phases of the moon, the cause of earth's seasons, and the nature of eclipses were taught, modeled, and practiced with more detail, diligence to kinesthetic design, and repetition than in earlier years. Evaluation of what worked well, what students struggled with, and what was most engaging honed this unit

into something much stronger than it was in the first year's implementation. Since I was concerned about further improving the effectiveness of the moon journal as a tool for teaching astronomy content, I elected to make a number of alterations to the project as far as how it was scored, presented, reinforced, and how concepts within it were modeled, conducted, and assessed.

Daily delivery of moon journal topics was modified from previous presentations in an effort to make the material more engaging and to incorporate more visual models and thorough explanation. I carefully searched through and previewed short instructional videos on topics that students were writing about, and used new warm-up questions to incite greater connection with lunar themes. Pictures of two of those pieces, including a screen shot from a YouTube video on lunar topography are shown below.

Gazing at the Moon



**\*1. Enrico and Leah live in opposite hemispheres. Enrico lives in Santiago, Chile, which is in the Southern Hemisphere. Leah lives in Boston, Massachusetts, which is in the Northern Hemisphere. They both gazed at the Moon on the same evening. Enrico noticed there was a full Moon when he looked up at the sky from his location (the Southern Hemisphere). What do you predict Leah saw when she looked up in the sky from her location (the Northern Hemisphere)?**

- A. New Moon (no part of the Moon is visible)
- B. Crescent Moon (a quarter of the face of the Moon is visible)
- C. Half Moon (half of the face of the Moon is visible)
- D. Gibbous Moon (three-quarters of the face of the Moon is visible)
- E. Full Moon (the entire face of the Moon is visible)

Provide an explanation for your answer. How did you decide what the Moon would look like in the opposite hemisphere?

*Figure 3.* Moon Journal Topic Presentation Aides (Image sources: left is from <http://www.surveymonkey.com/s/6JLJZBN>, right is from <http://www.youtube.com/watch?v=N1osIxwSFgk>)

Changes in the moon journal delivery process were designed to stimulate greater learning and organization using the tools outlined above, but also sought to boost participation. One such strategy that I endeavored to push at that time was a heightened interest in conducting the actual moon observations. Having witnessed earlier moon journaling students relying on internet images of the moon, I tried to stress how fun it can be to get outside and capture a moon moment, and offered extra credit for student submissions. Examples of this process are shown below:



*Figure 4.* Moon Observation Photography Samples. (Image source: top left is from <http://www.butterfunk.com/image-128/parachuting.htm>, all others are from the author)

Moon journal scoring was done largely the same as I had during previous school years. Observations were scored for accuracy of time (AM or PM and between a little after moonrise and a little before moonset), presence of correctly drawn moon, and for the presence of compass and altitude measures. Writing topics were scored by the number of complete sentences up to four. Students were coached as shown earlier to do fifteen complete entries (written response and observation) and also to do a longer final entry (project response / survey) to get full marks. Extra credit was offered to those students who did additional entries beyond the 15 required. My thought was that this

format would make the journaling process easier to complete and less boring as greater variation in moon appearance could be observed if entries were made every other day instead of every single day.

Curricular redesigns around the moon journal also embellished content beyond a modified journal assignment and delivery. New lab activities that I used for a more robust teaching of lunar and astronomy concepts within the unit included the following:

- \* modeling the orbit and scale of the moon around the Earth using tennis balls, globes, and

- central lights

- \* conducting a proportional measure lab that can estimate the moon's diameter

- \* constellation study and/or creation activity using regional star maps

- \* modeling the seasons using globes and an incandescent bulb at each lab station

- \* stellar fingerprint and exoplanet habitability analysis activity

- \* practicing solar system distances and body diameters using common objects and classroom

- scale measurements

- \* galaxy number and classification lesson using the Hubble Deep Field Academy website

New labs, different assessments, new moon journal topic introductions, and new modeling activities were developed with the intent of removing common misconceptions, as measured by a pretest / posttest assessment scheme. My pretest used questions that my literature review uncovered as common astronomy misconception areas for sampled students. Since the foundational problem that sparked this research topic was the fact that students were retaining erroneous explanations for phenomena like why the moon

goes through phases or why the earth has seasons, then a pretest and posttest was perfectly suited. It would see what student strengths and weaknesses are at the unit outset, and measure how much growth they had made regarding those concepts after focused instruction. Designing a test without the pressure of a grade book score and without an onerous number of difficult questions, I would have an accurate view of student concept mastery before and after, with sufficient data to make measured conclusions.

In contemplating what my data collection instruments would look like, I began by inspecting my action research proposal: moon journal project enhancement using more hands-on activities to raise student engagement and success, as measured by topic related misconceptions. Within that proposal were a huge number of potential data collection scenarios, and among those that I chose to consider and utilize were an informal teacher journal, student surveys, moon journal project scores, and assessment scores for astronomy themed assignments. The matrix below summarizes my methodology.

Table 1  
*Project Data Collection Strategies Matrix*

	<b>Data Sources</b>			
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
<b>Research Questions:</b>	Pre-test/ Post-test and unit exams	Moon Journal / assignment & lab scores	Student Surveys	Teacher Journal
1. How will a moon journal project redesign affect student performance, as measured by mastery of astronomy learning targets / loss of astronomy misconceptions?	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>

2. How will a moon journal project redesign affect student involvement, opinion, and performance, as measured by scores (mine + survey data) on the assignment?		X	X	X
3. What additional strategies, tools, and lesson elements did this project and process bring to mind so that I can continue to be of the greatest utility in affecting student learning target growth and moon journal satisfaction?	X	X	X	X

Next I narrowed my attention to the two sources of data that I believed would give me the most concrete data when it comes to assessing what degree of change my action research has affected. I felt that the most useful and substantive instruments would be the pre and post test results and the student surveys. The astronomy pre/posttest can be found in Appendix B, and the meteorology pre/posttest can be found in Appendix C. When substantiated with moon journal score data and astronomy unit exam scores, the survey data and pre/posttest numbers really gave a complete picture of how students felt about the moon journal project while also illuminating how well they learned from it. The combination of hard data in numerical scores was balanced by softer data by way of surveys. Astronomy unit tests, pre and post test data, and moon journal scores gave the project analysis a variety of perspectives. In that same way survey questions, interviews, and comparisons between astronomy and meteorology unit exams, across two different years of students, and between two different unit pretest / posttest data sets also gave a greater breadth of view as to project results.

The survey question design process began by referencing and utilizing the “How did

the project go?” style survey question response set from all of my earth science students the year before my official treatment. The moon journal completion survey can be found in Appendix D. That data would serve as a baseline for comparison of the same questions administered to this year’s students. The newest treatment survey was expanded to also include other questions that would allow me to more fully measure student response and satisfaction with the moon journal process. In considering whether or not I should conduct individual student interviews, I was more in favor of a brief survey to all students as it would provide more data and a definitive measure of what students thought of the moon journal project. Boiling my survey down to the most salient points was my goal, because I felt that a long survey would not greatly improve the scope of perspective I hoped to gain.

In addition to pre and posttest numbers and survey data, I also measured students by way of their moon journal assignment and astronomy / meteorology unit test scores. The astronomy curricular redesign and its effect on the pretest / posttest growth and scoring average were also contrasted to an unchanged curriculum presentation to students. The unit following astronomy in my syllabus is meteorology, and its content was also gauged with a pretest and posttest.

Since my intention was to redesign the curriculum for the entire Earth Science moon journal unit and because I had four sections of this class the last two school years, I had choices when it came to whom I would sample. My intent was to gather data from all four of the sections of my earth science students. The more data I collected the stronger my conclusions would be as far as statistical significance and overall project integrity and up to 93 sets of current student data would give me much to work with. The survey and

score data that I had available from the previous school year was collected from all four of my sections, and my preference was to continue that trend and collect at least moon journal score and survey / reflection comments from all of my sections again. While comparisons between the two different student groups (2012-13 and 2013-14 freshmen) would yield interesting data, their comparison was troublesome as far as being valid and fair. For that reason the analysis of pretest / posttest results and survey data was my research design's chief area of focus. Copies of the instruments utilized are included in the appendices at the end of this document.

My data analysis plan for the pretest was to collect detailed information about the accuracy of responses to each question, cataloging the data in an Excel spreadsheet. The open-ended questions were assessed on a pass/fail rubric looking for key terms, explanations, or details that illustrate mastery of the concept. Positive responses to these questions and to the true / false questions will earn a score of "1" while negative responses to all questions will earn a "0". Each test taker's responses were entered into Excel by the student identification number. One day short of seven weeks later, upon concluding the moon journal project and the astronomy unit, the same test retitled as "posttest" was administered a second time with the same scoring rules. A second set of pretest and posttest data from the non-treatment curricular unit (meteorology) would provide a comparison group so that my astronomy conclusions were put into proper context.

My data analysis plan for the student surveys was to again compile the answers, chiefly using an Excel spreadsheet to quantify my results. The first three survey questions were not readily quantifiable, but included the question that I asked of students

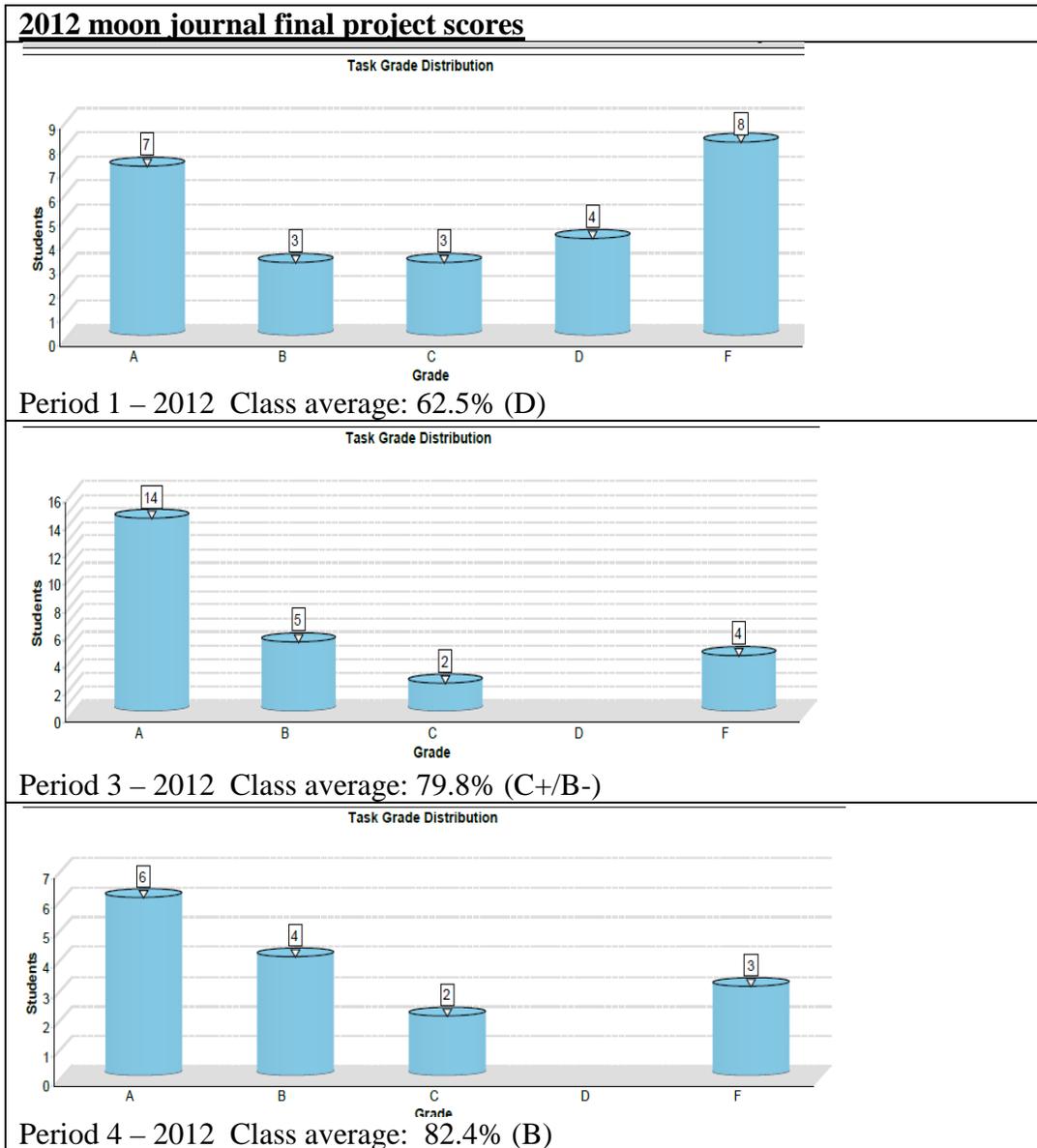
last school year (before this action research project was fully developed) and were used again so that qualitative data analysis could be conducted with an entire second years' worth of case study information and valued feedback. The additional Likert scale questions were scored with the negative responses, disagree strongly and disagree, scoring zero and one points respectively. The positive responses, agree and agree strongly, will be scored as two and or three points respectively, and were again logged into an Excel table by class and student id number. The most illuminating question responses (two questions 4-6) were then averaged, allowing comparisons by student and section.

In an effort to increase the validity of my work I looked to analyze the effect of my curriculum intervention from three perspectives: by looking at assignment scores, unit and pre/post exam scores, and survey data. It was my hope that if all three areas showed the same data trend (positive or negative) that my results would be more reliable. In addition, notes in the informal teacher journal, unit assignments scores and reflections, and the bouncing of ideas off of colleagues provided qualitative data to add body to the research results and conclusions.

The research that I conducted was approved by the Montana State University Institutional Review Board on November 3, 2013. The IRB exemption application can be found in Appendix F. My research was conducted in established and commonly accepted educational surroundings, involving standard classroom practices such as research on the effectiveness or instructional methods, materials, and techniques. Data and survey response information is presented without identifying individual subjects and without academic or other risk.

DATA AND ANALYSIS

The analysis of data results that I collected began with the baseline data that I collected from two separate years' worth of students. In comparing the 2012-13 freshmen earth science student moon journal scores to the 2013-14 freshmen earth science student moon journal scores the data I accumulated appeared as follows:



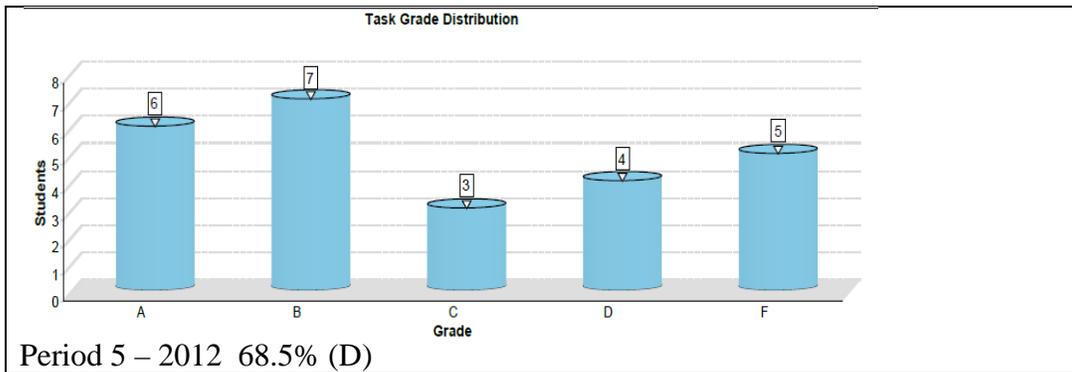
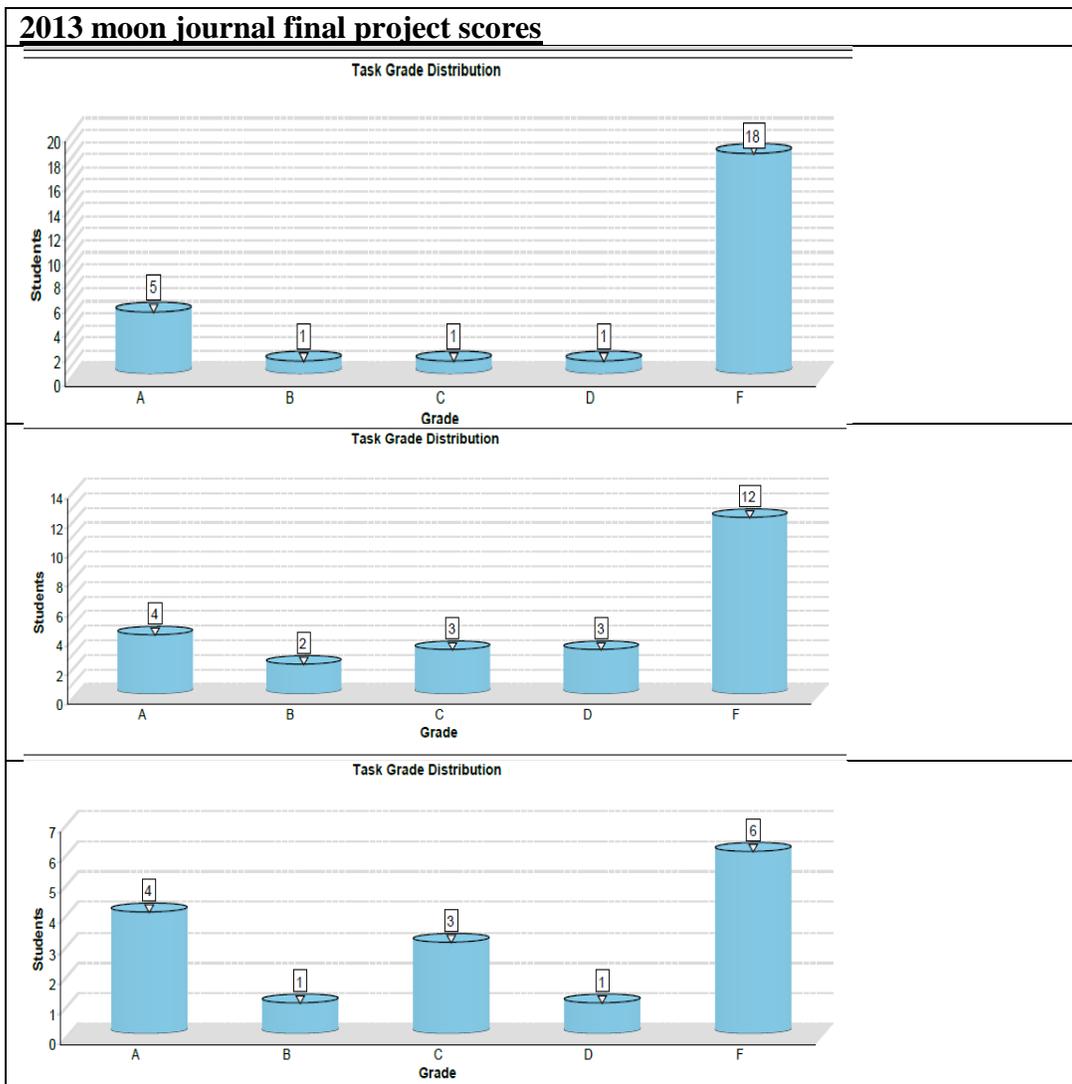


Figure 5. Moon Journal Project Scores for 2012 - 2013 school year



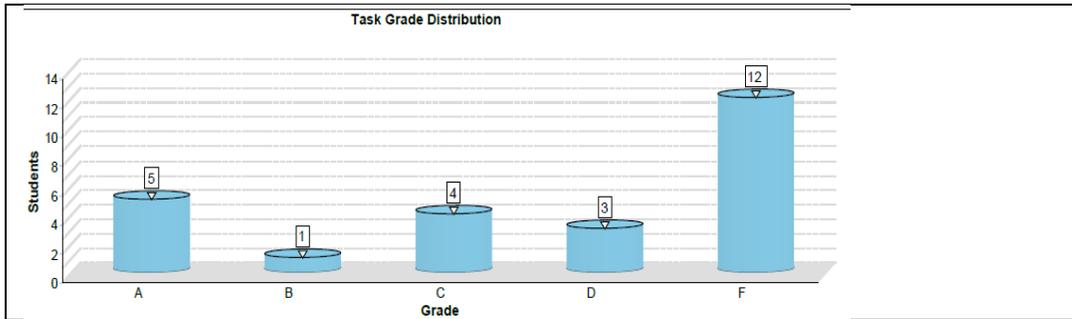


Figure 6. Moon Journal Project Scores for 2013 – 2014 school year.

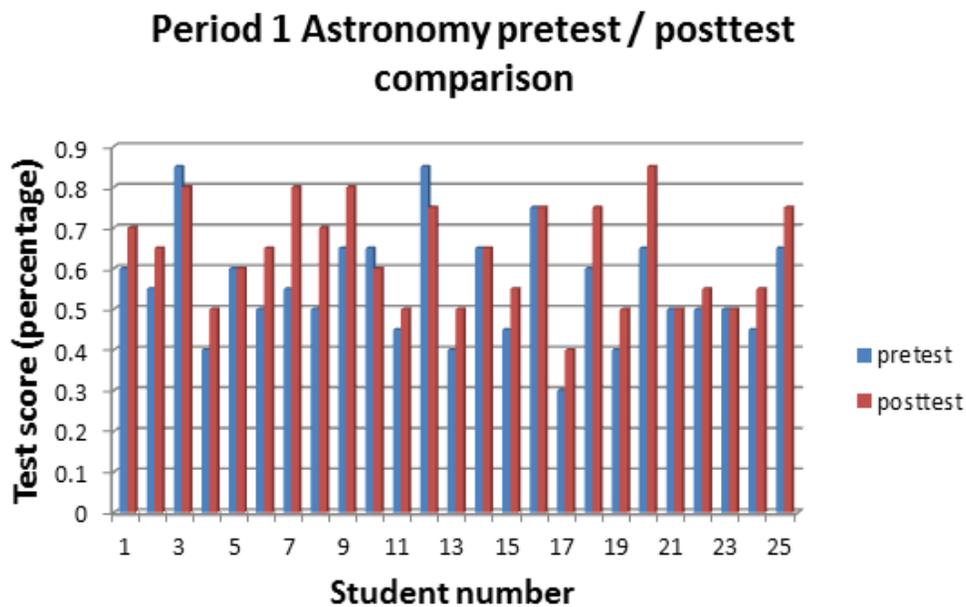
Class averages were calculated to be:

2012 STUDENT MOON JOURNAL AVERAGE SCORE: <u>73.3%</u>	2013 STUDENT MOON JOURNAL AVERAGE SCORE: <u>67.9%</u>
2012 STUDENT SEMESTER ONE AVERAGE GRADE: <u>77.8%</u>	2013 STUDENT SEMESTER ONE AVERAGE GRADE: <u>74.3%</u>

Analysis of these variant data groups suggests that earlier students with a more demanding moon journal assignment actually scored higher than later students with a less demanding set of requirements. This anomaly makes more sense when considering that the earlier year of students had a higher average grade for the first semester (where moon journals were scored) than the later year. This indicated that the second group of students was overall less academically proficient, so a dip in moon journal scores from the first year to the second is not out of line. The variation in this data may also have been due to differences in the student populations or due to assignment differences, but in actuality was probably related to both, so strong cause and effect determination was not possible. Initial analysis suggested that my curricular redesign may not have had the desired effect of improving student participation and success. The data indicated that a less rigorous assignment did not translate into improved scores and future project modifications should look at maintaining or raising, not lowering the expected student work load. It would seem that student feedback as to the main challenges or issues with the moon journals

may not show the primary places to restructure it to improve student scoring and learning from the project.

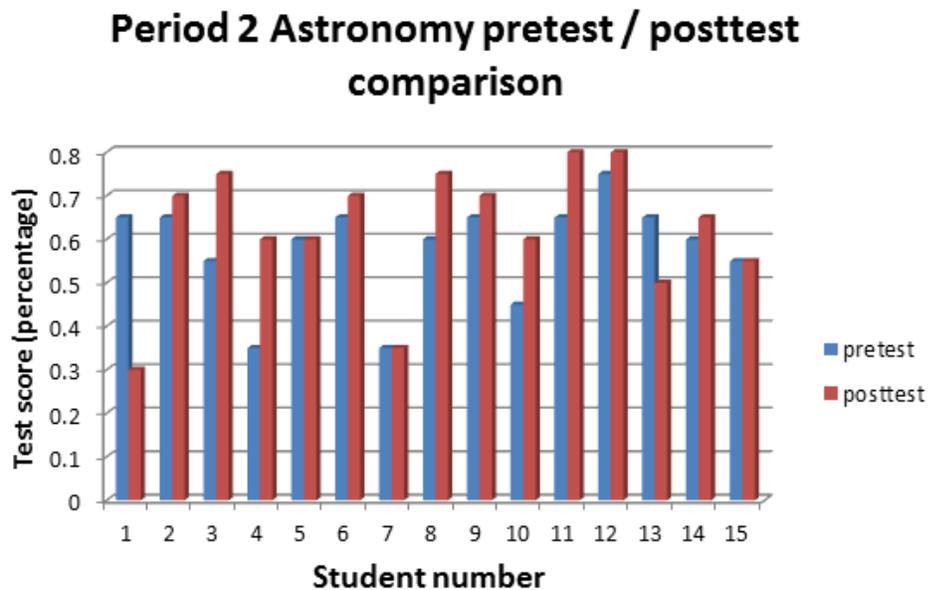
In comparing my treatment students to themselves before and after the thematic unit completion I was able to achieve more reliable and valid data than in comparing two separate student groups with many obfuscating variables. Analysis and comparison of treatment group pretest and posttest data for the astronomy thematic unit yielded the following results (presented in class section order):



*Figure 7.* Astronomy Pretest and Posttest Score Comparison (Section 1).

The results for this student group, consisting of eight females and seventeen males with all but three freshmen, had a pretest average score of 55.80% and a posttest average score of 63.40%. That means that this group showed a fairly robust growth in scores of 7.60% on the same exam administered before and after astronomy instruction. A paired-samples t-test was conducted to compare the astronomy pretest and posttest conditions. There was a significant difference in the scores for the pretest ( $M=55.8\%$ ,  $SD=13.7\%$ )

and posttest ( $M=63.4\%$ ,  $SD=12.6\%$ ) conditions;  $t(24) = 0.0017$ ,  $p = 0.05$ . (For this and all subsequent t-tests I utilized paired t-test calculations within Microsoft Excel.) These results suggest that the curricular modifications and student learning during the astronomy unit are effective in raising student astronomy assessment scores for first period students utilizing the testing instrument employed. Only two students in this generally strong and awake at the beginning of the day (when I am most effective as well) group did not exhibit pre to posttest growth, a result that I would have predicted going in.



*Figure 8.* Astronomy Pretest and Posttest Score Comparison (Section 2).

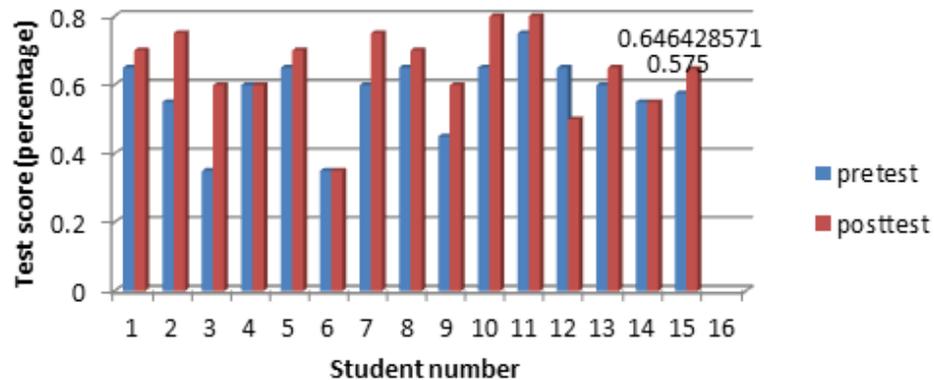
The results for this student group, consisting of six females and ten males with all but four freshmen, had a pretest average score of 58.00% and a posttest average score of 62.33%. That means that this group showed a more modest growth in scores of 4.33% on the same exam administered prior to and following astronomy instruction. A paired-samples t-test was conducted to compare the astronomy pretest and posttest conditions.

There was not a statistically significant difference in the scores for the pretest ( $M=58.0\%$ ,  $SD=11.1\%$ ) and posttest ( $M=62.3\%$ ,  $SD=14.5\%$ ) conditions;  $t(14) = 0.2703$ ,  $p = 0.05$ .

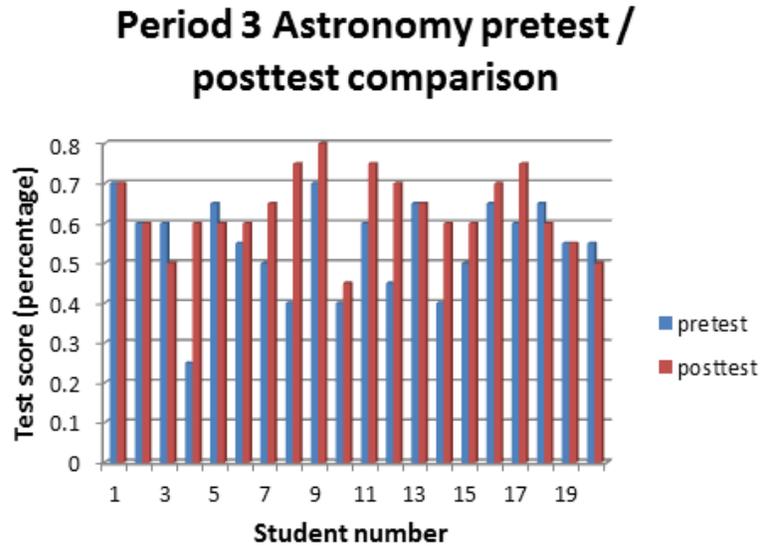
The t-test and validity results may have gone the way that they did due to a single student (#1) not taking the posttest seriously and showing a 35% drop posttest versus pretest score. Only one other student in this section showed a pre to post decline in score and that was only a 15% drop. Overall these results suggest that the curricular changes and/or student growth during the astronomy unit were ineffective in raising astronomy assessment scores for second period students utilizing the testing instrument employed. The disparity of these numbers led to me performing further analysis of a combined data set of all students for whom I collected astronomy exam pre and posttest data, which will be presented below. In general I was relieved to have chosen such a large data collection routine, because as I had supposed more data would be preferable to less, as the t-test results above indicated.

An analysis of this set with student #1 removed and averages recalculated looked as follows:

## Period 2 Astronomy pretest / posttest comparison (amended)



*Figure 9.* Astronomy Pretest and Posttest Score Comparison (section 2 amended). This modified data set, with the new averages displayed in lieu of the omitted student, showed a pre to posttest growth in scores of 7.14% (versus the 4.33% value with one additional student above). A new paired-samples t-test reversed the statistical significance difference in the scores for the pretest ( $M=57.5\%$ ,  $SD=11.7\%$ ) and posttest ( $M=64.6\%$ ,  $SD=12.5\%$ ) conditions;  $t(13) = 0.0205$ ,  $p = 0.05$ . Omitting a single student allowed me to rule that the curriculum modifications were effective in raising posttest scores for the majority of this section's students with the instrument utilized.



*Figure 10.* Astronomy Pretest and Posttest Score Comparison (Section 3).

The results for this student section, consisting of twelve females and twelve males with all but two freshmen, had a pretest average score of 54.75% and a posttest average score of 63.25%. That means that this group showed a respectable growth in scores of 8.50% on the same exam given at the beginning and end of astronomy instruction. A paired-samples t-test was conducted to compare the astronomy pretest and posttest conditions. There was a statistically significant difference in the scores for the pretest ( $M=54.8\%$ ,  $SD=11.9\%$ ) and posttest ( $M=63.3\%$ ,  $SD=9.4\%$ ) conditions;  $t(20) = 0.0082$ ,  $p = 0.05$ . These results suggest that the changes in curriculum presentation and/or student growth during the astronomy unit were effective in building astronomy assessment scores for third period students given the testing instrument I used. This is highly consistent with the fact that this was my strongest academic performance class throughout the school year.

### Period 5 Astronomy pretest / posttest comparison

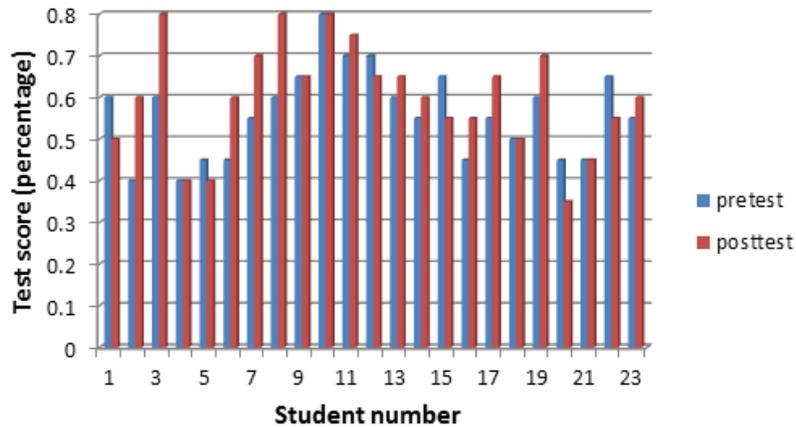


Figure 11. Astronomy Pretest and Posttest Score Comparison (Section 5).

The results for this student section, consisting of seventeen females and eight males with all but one freshman, had a pretest average score of 56.09% and a posttest average score of 60.00%. That means that this group showed a slight growth in scores of 3.91% on the same exam before and following astronomy instruction. A paired-samples t-test was conducted to compare the astronomy pretest and posttest conditions. There was a difference just beyond statistical significance in the scores for the pretest ( $M=56.1\%$ ,  $SD=10.5\%$ ) and posttest ( $M=60.0\%$ ,  $SD=12.9\%$ ) conditions;  $t(22) = 0.0707$ ,  $p = 0.05$ . These results suggest that the changes in curriculum and/or student learning during the astronomy unit were not quite effective in building astronomy test scores for fifth period students given the pre/post test I used.

Since these results were so close to significant, I elected to again rework this data set after having omitted the results for outlier students, in this case one of the lowest academic performing student in all four sections, and one who struggled to stay awake in class as the year went on. Both of these individuals showed a pre to post test score drop

of 10%, and their omission rendered the following results:

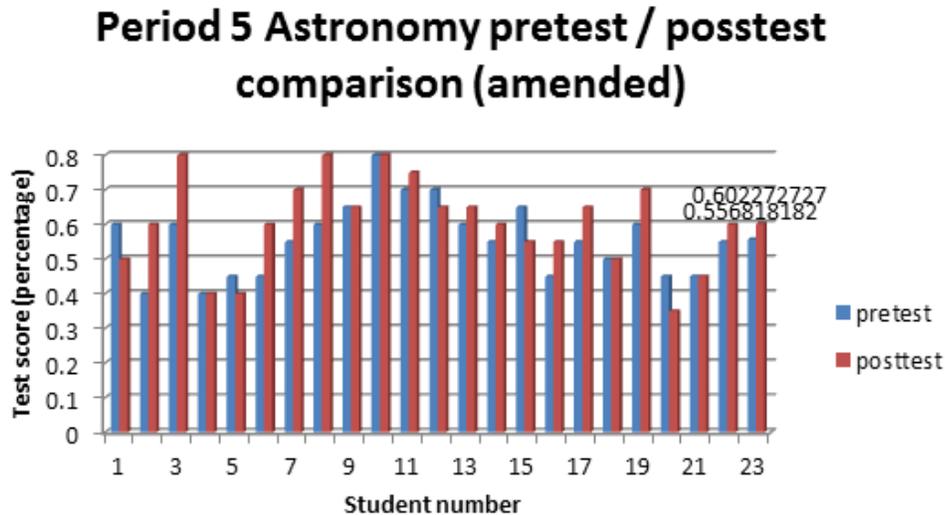
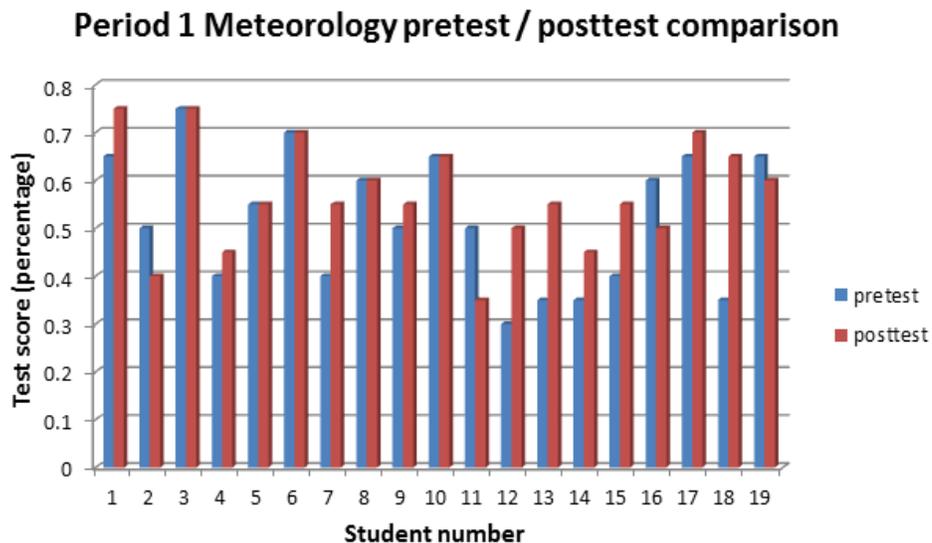


Figure 12. Astronomy Pretest and Posttest Score Comparison (Section 5 amended).

This adjusted data set, with the new means displayed in lieu of the removed students, showed a pre to posttest growth in scores of 4.55% (versus the 3.91% value with two additional students shown earlier). A new paired-samples t-test again reversed the statistical significance difference in the scores for the pretest ( $M=55.7\%$ ,  $SD=10.6\%$ ) and posttest ( $M=60.2\%$ ,  $SD=13.1\%$ ) conditions;  $t(21) = 0.0379$ ,  $p = 0.05$ . Omitting just two students made possible the conclusion that the curriculum modifications *were* valuable in raising posttest scores for the majority of this section's students with the instrument utilized.

Overall it was encouraging to see that all students averaged positive growth from the astronomy pretest to its posttest and the range of growth was clearly measurable, from a 3.91% minimum up to an 8.50% maximum. This growth swing from class to class could have been due to several factors including motivation or instruction or attendance or demographic differences from section to section. To more thoroughly

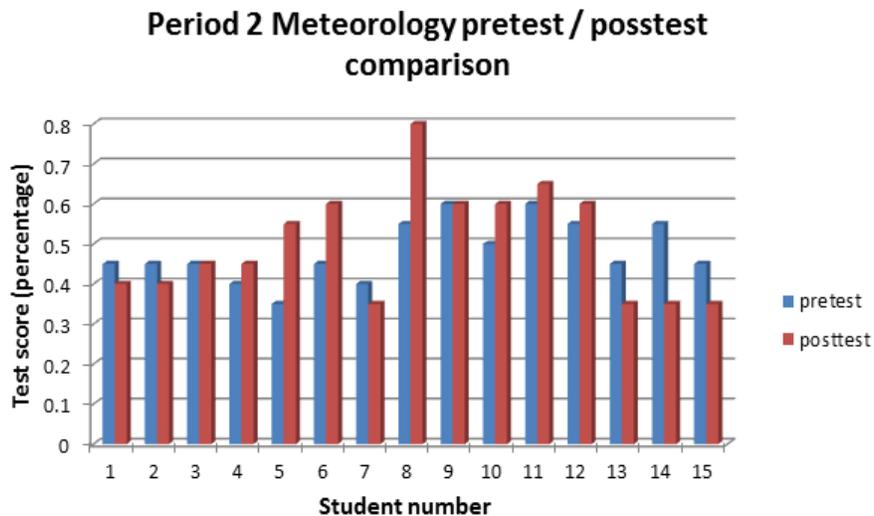
analyze this treatment a paired-samples t-test was conducted to compare the entire astronomy pretest and posttest data set (83 pre and posttests for astronomy) not split out by class section. There was a significant difference in the scores for the pretest (M=56.0%, SD=11.9%) and posttest (M=62.2%, SD=12.3%) conditions;  $t(82) = 0.00000291$ ,  $p = 0.05$ . The average overall growth of 6.2%, or approaching a full letter grade equivalent improvement, suggests significant academic growth, but the fairly wide range of growth suggests that results were somewhat mixed. The upward trending of the scores was overall highly encouraging, especially when contrasted to the lower pretest to posttest score growth for the subsequent thematic unit (meteorology) that are displayed below.



*Figure 13.* Meteorology Pretest and Posttest Score Comparison (Section 1).

The results for this student group, consisting of eight females and seventeen males with all but three freshmen, had a pretest average score of 51.84% and a posttest average score of 56.84%. That means that this group showed a growth in scores of 5.00% on the same exam administered before and after meteorology instruction. (By comparison this

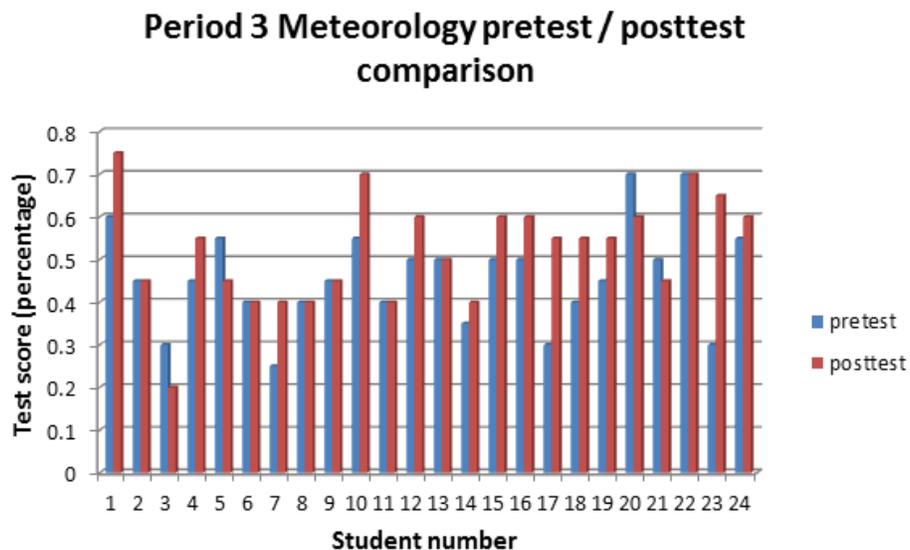
period showed a 7.40% growth during the treatment phase.) A paired-samples t-test was conducted to compare the meteorology pretest and posttest conditions. There was a not significant difference in the scores for the pretest ( $M=51.8\%$ ,  $SD=13.9\%$ ) and posttest ( $M=56.8\%$ ,  $SD=11.3\%$ ) conditions;  $t(18) = 0.0753$ ,  $p = 0.05$ . These results suggest that the curriculum and student learning during the meteorology unit were ineffective in raising student meteorology assessment scores for first period students as measured by the testing instrument employed. The fact that seven students showed static or lower pre to posttest scores further tells me that they were not sound in their grasping of meteorology.



*Figure 14.* Meteorology Pretest and Posttest Score Comparison (Section 2).

The results for this student group, consisting of six females and ten males with all but four freshmen, had a pretest average score of 48.00% and a posttest average score of 50.00%. That means that this group showed a growth in scores of 2.00% on the same exam administered prior to and following meteorology instruction. (By comparison this group showed a 4.33% growth during the treatment phase.) A paired-samples t-test was

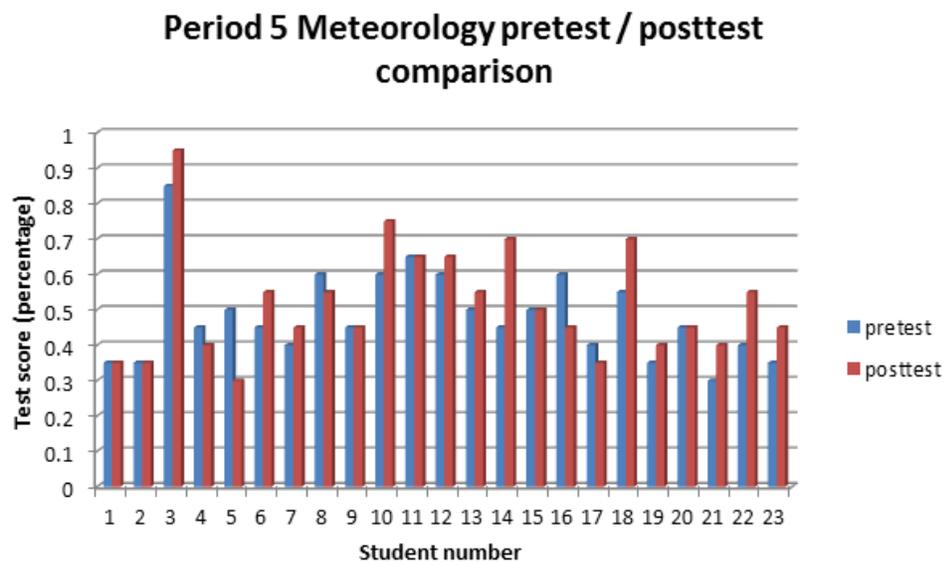
conducted to compare the meteorology pretest and posttest conditions. There was not a statistically significant difference in the scores for the pretest ( $M=48.0\%$ ,  $SD=7.51\%$ ) and posttest ( $M=50.0\%$ ,  $SD=13.9\%$ ) conditions;  $t(14) = 0.5314$ ,  $p = 0.05$ . These results suggest that the curriculum and/or student growth during the meteorology unit were ineffective in raising meteorology assessment scores for second period students utilizing the testing instrument employed. This, as my smallest student section, showed one of the poorest test growth trends with eight students showing no or reverse growth.



*Figure 15.* Meteorology Pretest and Posttest Score Comparison (Section 3).

The results for this student section, consisting of twelve females and twelve males with all but two freshmen, had a pretest average score of 46.04% and a posttest average score of 52.08%. That means that this group showed a growth in scores of 6.04% on the same exam given at the beginning and end of meteorology instruction. (By comparison this section showed an 8.50% growth during the treatment phase, so their results were not as good here as before.) A paired-samples t-test was conducted to compare the meteorology pretest and posttest conditions. There was a statistically significant

difference in the scores for the pretest ( $M=46.0\%$ ,  $SD=11.7\%$ ) and posttest ( $M=52.1\%$ ,  $SD=12.6\%$ ) conditions;  $t(23) = 0.01257$ ,  $p = 0.05$ . These results suggest that the curriculum and/or student growth during the meteorology unit were effective in building meteorology assessment scores for third period students given the testing instrument I used. Again I would attribute the gains in meteorology test scores for this student group in part to the fact that they are my highest academic output section, and their study and work habits were in all very sound all year.



*Figure 16.* Meteorology Pretest and Posttest Score Comparison (Section 5).

The results for this student section, consisting of seventeen females and eight males with all but one freshman, had a pretest average score of 48.26% and a posttest average score of 51.74%. That means that this group showed a growth in scores of 3.48% on the same exam before and following meteorology instruction. (By comparison this student section showed a 3.91% growth during the treatment phase.) A paired-samples t-test was conducted to compare the meteorology pretest and posttest conditions. There was a difference beyond statistical significance in the scores for the pretest ( $M=48.3\%$ ,

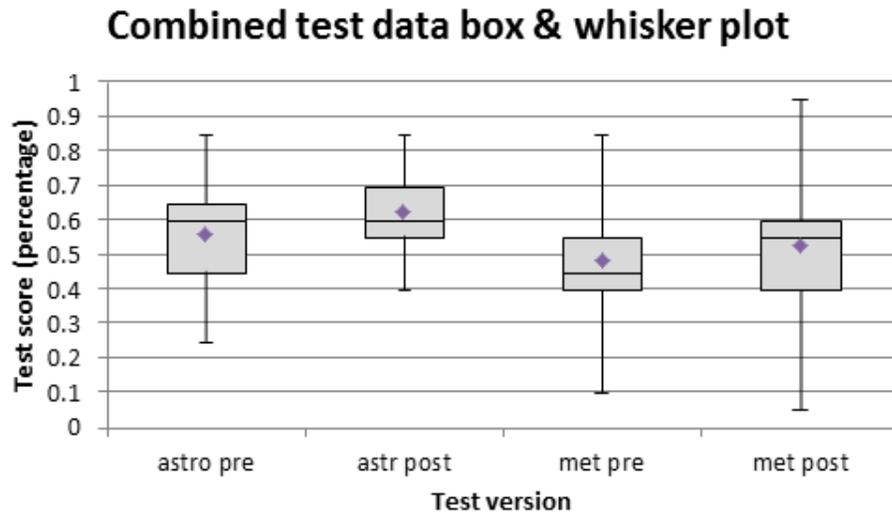
SD=12.7%) and posttest (M=51.7%, SD=15.7%) conditions;  $t(22) = 0.1111$ ,  $p = 0.05$ .

These results suggest that the curriculum and/or student learning during the meteorology unit were not quite effective in building meteorology test scores for fifth period students given the pre/post test I used. This mediocre test improvement level could be attributed in part to the fact that this section is after lunch (the only of my four) and student behavior and focus are often inferior to those of morning sections.

The results for the meteorology unit with three of four sections not displaying statistical significance again suggested the need to process the collective data set rather than that of individual class sections. The t-test analysis of this combined data set consisting of 81 pre and posttests for meteorology displayed a statistically significant difference in the scores for the pretest (M=48.4%, SD=11.9%) and posttest (M=52.7%, SD=13.5%) conditions;  $t(80) = 0.000644$ ,  $p = 0.05$ . Comparison of the aggregate astronomy and meteorology assessment data show an average growth of 6.2% in the treatment phase versus an average growth of 4.3% in the non-treatment phase. Although that difference is modest, its relevance is boosted by the fact that astronomy is a longer thematic unit over which students must remember concepts and comes earlier in the school year when students are less familiar with my teaching and testing methods. The astronomy test growth can also be favorably reported as 143.5% of the growth in the meteorology test data.

The more reliable nature of the combined data sets when it came to making statistically valid conclusions led me to take the analysis of the collective figures one step

further with a box and whisker plot. That deeper inspection yielded this data:



*Figure 17.* Box and Whisker Plot for Aggregate Pre/Posttest Data, ( $N = 81$ ).

When interpreting this data summation tool there were a number of evaluations that came to light in short order. First I observed that median shift between the pre and post test for the treatment (astro) was not only approximately two percent larger than that of the non-treatment condition (met), but the astro test data was closer to a passing score overall. This suggested to me that students were generally less knowledgeable about meteorology going in than they were about astronomy, which could imply that there was more room for improvement in their knowledge and skill base for meteorology in general. However the curriculum for meteorology without the renovations utilized in the earlier astronomy unit was not able to take advantage of that greater potential growth space. These two academic units have some operational differences that my earth science teaching group agreed to be small enough to still make their comparison significant, and their placement back to back serves to discount the maturation and intellectual growth that could be expected as the school year goes on.

However, the test results for the later meteorology unit did not reflect a predicted trend of more mature and skilled students coming to task with my expectations. In truth, the range of test data also indicated *less* student struggle in the astronomy unit as the interquartile range in the astronomy data went down from the pretest to posttest conditions (0.20 to 0.15) whereas in the same area for the meteorology data the interquartile range *rose* (from 0.15 to 0.20). The range of the entire unit data sets for each of the conditions also showed less academic comfort in the meteorology region where the overall range raised pre to post as opposed to the astronomy unit where the overall range dropped between the pre and posttest.

Other data that I collected or observed less formally seemed to support the fact that students had less academic growth in the meteorology unit as compared to the astronomy unit. When observing the number of questions left blank in the pretest and posttest conditions for each unit I found that in the astronomy test conditions the blank questions before and after went from 99 to 55, a drop of 44.44%. The same item for meteorology showed a pretest value of 122 and a posttest number of 72, a drop of 40.98%. At the same time that students were making smaller strides on the misconception pre and posttests from treatment to non-treatment I was able to compare the traditional unit exam scores that went into my gradebook as well. For the astronomy unit students scored an average of 68.8% while in meteorology that score was 71.4%. Again, this highlights the fact to me that because the meteorology unit was of shorter duration (21 days versus 29 days of astronomy). The notion that shorter academic units (with less time to forget important concepts and fewer overall concepts to master) will produce higher scores was confirmed by the unit exam but not supported by the misconceptions pretest / posttest. I

took this to mean that there was still room for much improvement within the meteorology unit and less stability than was shown in the astronomy unit.

The final analysis that I completed looked at student satisfaction, learning outcome, and buy-in or participation with the entire moon journal project. These survey questions from the final moon journal entry were scored as 0 = strongly disagree, 1 = disagree, 2 = agree, and 3 = strongly agree, then the three question scores were added so that 0, 3, 6 and 9 would be the aggregate scores if a student had the same three responses for all three. With that, the highest score possible (9) would indicate a student that had a very positive moon journal experience where activities in the unit taught them well, and wherein they were an active participant. A score of 0 would be the complete opposite. The results are shown here:

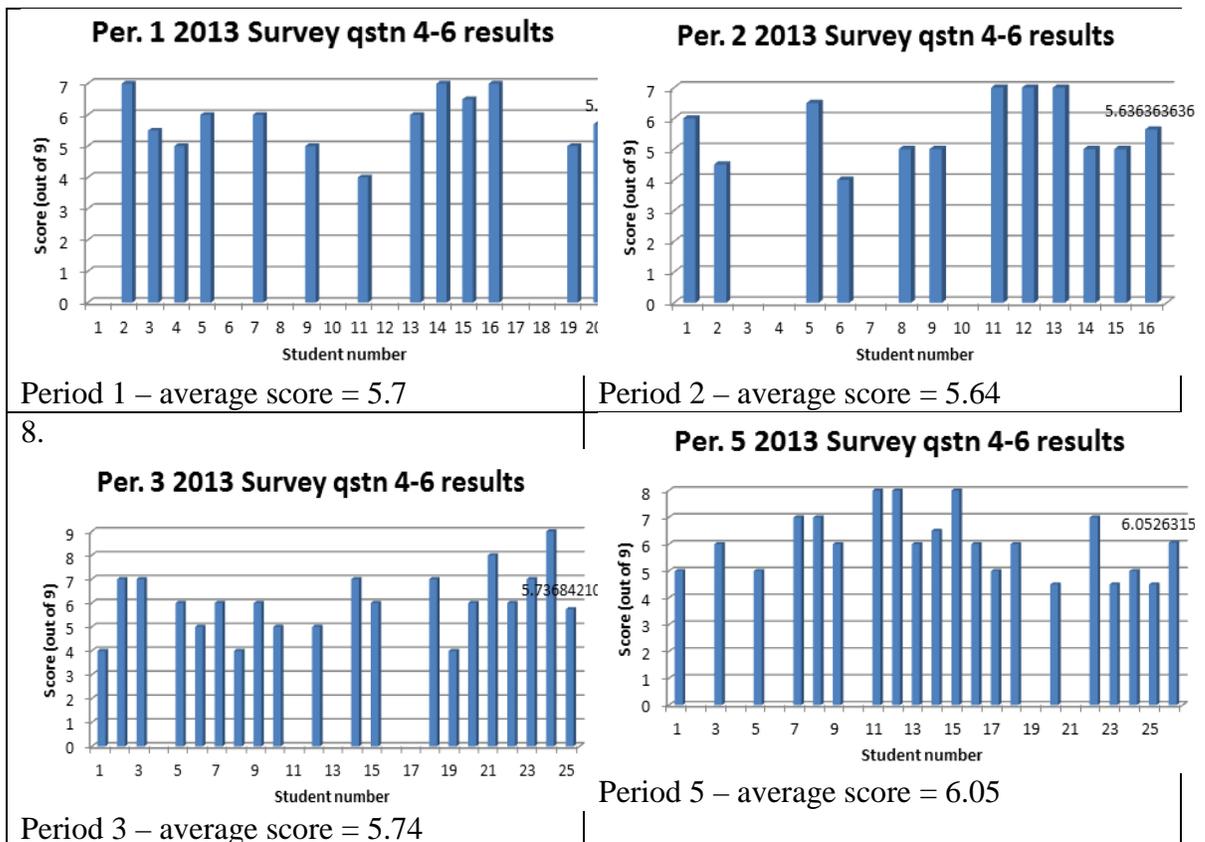


Figure 18. Moon Journal Survey Results.

An average score of 6.0 would indicate that the survey respondent agreed that the moon journal project was positive, increased their understanding of important space science concepts, and was one that they were active participants in. To see that the average student score was 5.78 on these three questions indicated that on average students essentially agreed that the project was positive, informative, and worthy of active participation. The first (“How did it go?”) survey question gave a mixed bag of feedback that gave me much to think about in moving forward with the moon journal project. Notable negative student responses (which were outnumbered by positive summations at a 2.26:1 ratio) included the following word for word selections:

*“I thought it was hard to find the moon everynight. Because I couldn’t find the moon most of the time when I went outside. I always had to have someone help me find the*

*moon.*” (from a student who scored 72.3% on the moon journal vs. the student average of 67.9%)

*“I didn’t like doing moon journals. I’m usually very busy so it’s hard for me to go out and do it. I usually go home late and forget about it.”* (from a student who scored 69.2% on the moon journal vs. the average of 67.9%)

*“I thought that the moon Journal was boring and inaccurate.”* (from a student who scored 19.2% on the moon journal vs. the average of 67.9%)

*“The process is very tedious and boring and I didn’t find it very fun. I didn’t have a fun memory this assignment sucked a lot.”* (from a student who scored 47.7% on the moon journal vs. the average of 67.9%)

Many of the negative comments focused on the length of the assignment, that is, the overly long duration of time we spent observing the moon, and others bemoaned the entry length. Students that were not strong writers or ones that did not do well with long-term assignments voiced their disapproval. The weather was another common complaint, but having focused on the part that I could control (the demands as far as number and nature of entries) I was surprised. Complaints about students being too busy to complete observation portions of the assignment, being insufficiently stimulated, or being overtaxed by the amount of writing were things that I had consciously tried to address. Apparently my curriculum changes and halving the number of entries required still left some students wanting. Some of the positive comments follow:

*“I think moon journaling is a pretty good idea from an educational standpoint, I definitely know a lot more about the moon than before. However it was really hard to remember to observe the moon so much especially cause it often rose or set super early or super late. As well cloud cover sometimes made observing it physically impossible.”* (from a student who scored 91.5% on the moon journal vs. the student average of 67.9%)

*“It was a good experience. I actually learned a lot about the moon and its cycles. It was a good project and I wouldn’t change the project. It was a good learning experience.”* (from a student who scored 53.8% on the moon journal vs. the average of 67.9%)

*“Next year make your class do this moon journal thing, its not very fun but it really helps peoples understanding the moon :) and the stars to.”* (from a student who scored 19.6% on the moon journal vs. the average of 67.9%)

*“The moon journal was very helpful in order to see the cycle that the moon goes through each month. I also feel like I have a lot more backround knowledge on the moon & why it appears the way it does.”* (from a student who scored 90.8% on the moon journal vs. the average of 67.9%)

*“I really like the moon journal idea. We learned so much every day we had something new to learn every day.”* (from a student who scored 100.8% on the moon journal vs. the average of 67.9%)

Comments such as these and the positive trends in the survey data tell me that the vast majority of students appreciated the potential and usually the results of the moon journal process. I was satisfied that students had more than twice as many positive things to say rather than negative in response to the journal experience exercise. Informal verbal surveying of the class at the project’s conclusion also gave some good ideas, such as condensing the journal from every other day for 29 to 30 days to every day for half of the moon cycle.

## INTERPRETATION AND CONCLUSION

My primary research question was “How will a moon journal project redesign affect student performance, as measured by mastery of astronomy learning targets / loss of astronomy misconceptions?” The pretest versus posttest data collected suggested meaningful positive growth in student astronomy learning. For example, looking within the test data to the individual question of “What causes the moon to cycle from new to full to new?” the four classes tested showed on average a 26% increase in students correctly answering. As a whole the classes improved by an average of 6.2% in

astronomy versus 4.3% in meteorology if the pre and post exams were part of the grade book.

In the future I would like to pare down the pretest to ten questions so that lesson elements could be streamlined to address a smaller number of misconceptions. Teaching the unit felt too frantic because of the dozens of misconception models and examples running through my thoughts. Students could show even greater improvement if a smaller number of learning targets were employed at greater depth.

My second research question was “How will a moon journal project redesign affect student involvement, opinion, and performance?” Survey data suggests that students were on average in complete agreement that the moon journal project was a positive experience that they actively participated in, and it gave them a better understanding of major space science concepts. An average score of 3 or lower would have indicated that they had a negative experience, passively participated, and did not learn a lot, but their average was nearly double that at 5.78. Future iterations could involve the students raising their participation level by polling the members of their household about the astronomy misconceptions present. Seeing their parents, siblings, or relatives struggling with the same concepts could motivate them to explain the concept to others, utilizing the principle that lessons taught are the ones learned most effectively.

My final research question was “What additional strategies, tools, and lesson elements did this project and process bring to mind so that I can continue to be of the greatest utility in affecting student learning target growth and moon journal satisfaction?” Answering this question will be ongoing, but the thought of reformatting the moon journal schedule from four loose weeks (with entries due every other day) into a guided

practice week, two weeks of every day independent journaling, and a final week of group work is compelling. Such a change could allow class time modeling of observation techniques outside during the waxing crescent period when all classes could see the moon which will rise early in the morning.

The two weeks sandwiching the full moon could have students apply their in class practice on their own when the moon is typically up in the afternoon after school, or in the morning before school. Then, students could research and present information on lunar themed prompts, perhaps in pairs. Opinion based writing prompts could be the ones students write about independently with daily entries that would run from first quarter to last quarter. (Students have routinely reported favoring those entry types within the survey data.) Collaborating with my colleagues about these lesson strategies and following through on other extensions that came up in support team meetings such as a star party or an outdoor scale rendering of the solar system, could continue the rewarding process begun with this action research.

#### VALUE

This action research project was about a lot more than revamping moon journals or modifying astronomy lessons and their delivery. Under the surface of curriculum restructuring was the issue of content misconceptions and how complex it can be to replace these incorrect explanations that students develop for scientific phenomena such as why the moon cycles or what causes the seasons. Deeper still this project involved the exploration of student modes of learning, applying what my literature review emphasized, which is the power of hands-on learning and the use of kinesthetic models is key. It also represented some meaningful skill building for me when it came to

redesigning or designing anew classroom activities, labs, and learning the art and value of pretest and posttest data writing and analysis. Along with that the project dipped into student motivation and the value of starting the school year with positive learning experiences. I really felt that this project allowed me to gain skill and professionally mature as an educator.

Science process skills were part of what this project developed in student participants, as far as collecting data, modeling processes, measuring, and developing valid explanations for phenomena and systems. Students also added to their writing skills as they composed moon journal entries and explained concepts on daily assignments, labs, and exams. But more than anything students taught me a great deal in this action learning process. I learned that there are concrete and measurable learning benefits to be gained from improving the curriculum and instruction that I deliver. I learned that when I am doing so it is best not to try and take on too many tasks at once: to pick and choose a handful of concepts to really drive home to students and to feature in pretests and posttests is best.

Perhaps the greatest value I found in this project was the inspiration to keep building skills and showing fearlessness when it comes to challenging how things were done in the past. A peripheral inquiry into the use of student graders that I began pursuing at the onset of this project may turn into a fantastic opportunity to redesign my gradebook systems and drastically speed up assignment scoring data entry and feedback. I am anxious to try this methodology out and to learn if it can deliver greater student learning while easing my workload outside of contract time. I also look forward to a greater use of concise pre and posttest assessments throughout the entire school year as a guide for

measuring student mastery of a handful of crucial learning targets in each content unit. If my students learned half as much as I have during this school year as I did in this action research process, then I have truly succeeded as an educator.

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APPENDICES

APPENDIX A:

MOON JOURNAL STUDENT INFORMATION SHEET #1

**Moon journal info:**

*This moon cycle runs from Friday, October 4<sup>th</sup> through Sunday, November 3<sup>rd</sup>. Your assignment, over that 31 day time period is to make 15 observations and to write 15 paragraphs ( $\geq 4$  sentences) related to provided astronomy prompts. Both tasks may be completed in a single day's entry, but entries on 15 or more different days will be needed to earn full credit. See below for further details and examples.*

Date	Moonrise	Moonset	Meridian passing time	Illuminated	Other info
Oct 4, 2013	7:20 AM	6:51 PM	1:10 PM	0.1%	New Moon: 6:35 PM
Oct 5, 2013	8:29 AM	7:22 PM	2:00 PM	0.8%	
Oct 6, 2013	9:40 AM	7:58 PM	2:52 PM	4.1%	
Oct 7, 2013	10:50 AM	8:39 PM	3:47 PM	10.0%	
Oct 8, 2013	11:58 AM	9:27 PM	4:44 PM	18.1%	
Oct 9, 2013	1:01 PM	10:23 PM	5:42 PM	28.2%	
Oct 10, 2013	1:57 PM	11:26 PM	6:40 PM	39.5%	
Oct 11, 2013	2:46 PM	-	7:38 PM	51.3%	First Quarter at 5:03 PM

**Week one topics:**

Friday, October 4, 2013 - NEW MOON: How does gravity differ on the moon compared to the Earth?

Saturday, October 5, 2013: What causes the moon to cycle?

Sunday, October 6, 2013: Where did the moon come from?

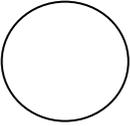
Monday, October 7, 2013: The moon is receding from the Earth at a rate of 1.5 inches a year. How do you think things were different between the Earth and Moon 4 billion years ago?

Tuesday, October 8, 2013: How long did it take in your opinion for the (Apollo mission) flights from the Earth to the moon?

Wednesday, October 9, 2013: Should we go back to the moon? Why or why not?

Thursday, October 10, 2012: What would you do if you were on the moon?

**Moon Observation format:**

Date mm/dd	Clock Time	Phase Sketch	Altitude of the moon above the horizon (fists)	Compass direction of the moon's position
				

APPENDIX B:

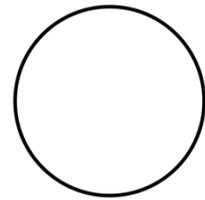
ASTRONOMY PRETEST / POSTTEST QUESTION SET

Student id # **(NO NAMES)**: \_\_\_\_\_ Per. \_\_\_\_ Date \_\_\_\_\_

**ASTRONOMY Pretest / Posttest:**

1. What causes day and night for the earth?
2. What causes the moon to cycle from new to full to new?
3. What causes the Earth to have changing seasons?
4. What does the Big Bang theory say and what does it have to do with our solar system?

5. If the earth were the size of a quarter (as shown), draw how big the moon would be.



6. Based on the scale in question 5, about how far apart would the earth and moon be?

7. List the planets in order from the sun outward, and plot the relative distances between them on the line below:



8. True / False: Everyone on the earth shares the same seasons on the same dates.
9. True / False: There are not an exact number of days in a year.
10. True / False: The moon can only be seen during the night.
11. True / False: The far side of the moon is always in darkness.
12. True / False: The moon rotates on an axis.
13. True / False: Stars do not actually twinkle.
14. True / False: The North star is not the brightest star in the sky.
15. True / False: Gas giant planets have solid surfaces.
16. True / False: Planetary orbits and the orbits of moon are not perfect circles.
17. True / False: Your personality and future are determined by the positions of the sun, moon, and planets.
18. True / False: Brighter stars must be closer or more powerful.
19. True / False: Stars change their position in the sky and their brightness over time.
20. True / False: The light year is a unit of time.

APPENDIX C:  
METEOROLOGY PRESTEST / POSTTEST QUESTION SET

Student id # (**NO NAMES**): \_\_\_\_\_ Per. \_\_\_\_ Date \_\_\_\_\_

**METEOROLOGY Pretest / Posttest:**

1. Is the earth closer to or farther away from the sun when we experience summer in the Northern hemisphere?
2. What makes Earth's winds?
3. Does warm air or cold air bring storms?
4. What is the "fuel" for Earth's weather?
5. Why do we sometimes get snow, and sometimes freezing rain and sleet?
6. What steps lead to the formation of a cloud?
7. What is the main cause of global climate change?
8. True / False: The Earth's rotation has no effect upon weather systems.
9. True / False: Temperatures uniformly go up as one goes higher up in Earth's atmospheric layers.
10. True / False: Humidity is a measure of the temperature of air.
11. True / False: The temperature of air is not affected by the surface of the earth beneath it.
12. True / False: The amount of energy sunlight can transfer to a given place on the surface of the earth is not affected by clouds blocking the sun.
13. True / False: The air around the earth is mainly warmed by energy transferred directly from sunlight, not by energy transferred from the surface of the earth.
14. True / False: The air feels colder higher on a mountain than lower on the mountain because it is windier, not because the temperature is changing.
15. True / False: The position of the sun in the sky is related to how close or far the sun is from the earth.
16. True / False: The amount of energy sunlight transfers to a place on the surface of the earth increases during the whole day (until the sun goes below the horizon).
17. True / False: 17. Sunlight feels warmer in the middle of the day than at other times of the day because the sunlight that reaches the earth does not have to travel as far in the middle of the day.
18. True / False: The humidity of air will increase whenever the air is in contact with water regardless of how humid the air already is.
19. True / False: When water evaporates, tiny droplets of water, not water vapor, are formed.
20. True / False: Clouds, fog, and rain form as air becomes warmer.

APPENDIX D:  
MOON JOURNAL POST PROJECT SURVEY QUESTIONS

Name: **LEAVE THIS BLANK / ANONYMOUS** Per. \_\_\_\_ Date \_\_\_\_\_

**Moon journal survey:**

1. Now that you have finished with your moon journals, tell me your thoughts about the moon journal process and your moon journal experience.
2. List what your least and most favorite memories about this ongoing assignment were.
  
3. Tell me what journal entry topics you liked and disliked the most.

For the questions below answer circle the answer choice that best fits your opinion:

4. The moon journal project was a positive experience for me.  
*disagree strongly      disagree      agree      agree strongly*
  
5. The moon journal hands-on activities gave me a greater understanding of key space science concepts.  
*disagree strongly      disagree      agree      agree strongly*
  
6. I actively participated in the moon journal process inside the class and out.  
*disagree strongly      disagree      agree      agree strongly*
  
7. Grading the work of my classmates during this unit was helpful in my learning process.  
*disagree strongly      disagree      agree      agree strongly*

Additional comments???

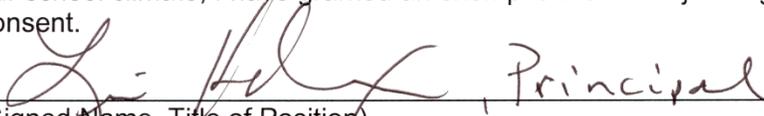
*Students were presented these tasks via projector as their final moon journal entry on the last day of the project in the following untimed format:*

<p><b>Monday, November 4, 2013</b></p> <p><b>Notes:</b> WAXING CRESCENT  <b>Moonrise:</b> 6:09 am, <b>Moonset:</b> 5:19 pm</p> <p><b>Topic (part 1):</b></p> <ol style="list-style-type: none"> <li>1. Now that you have finished with your moon journals, tell me your thoughts about the moon journal process and your moon journal experience.</li> <li>2. List what your least and most favorite memories about this ongoing assignment were.</li> <li>3. Tell me what journal entry topics you liked and disliked the most.</li> </ol>  <p><b>Complete entry = observation sequence and 4 sentence topic response (15 time this lunar "month"</b></p>	<p><b>Monday, November 4, 2013</b></p> <p><b>Notes:</b> WAXING CRESCENT  <b>Moonrise:</b> 8:43 am, <b>Moonset:</b> 6:19 pm</p> <p><b>Topic (part 2):</b></p> <p>For the questions below list the answer choice that best fits your opinion: (You may simply write <b>DS / D / A / AS</b>)</p> <ol style="list-style-type: none"> <li>4. The moon journal project was a positive experience for me.  <i>disagree strongly      disagree      agree      agree strongly</i></li> <li>5. The moon journal hands-on activities gave me a greater understanding of key space science concepts.  <i>disagree strongly      disagree      agree      agree strongly</i></li> <li>6. I actively participated in the moon journal process inside the class and out.  <i>disagree strongly      disagree      agree      agree strongly</i></li> <li>7. Grading the work of my classmates is helpful in my learning process.  <i>disagree strongly      disagree      agree      agree strongly</i></li> </ol> <p>Additional comments???</p> 
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APPENDIX E:  
ADMINISTRATOR INFORMED CONSENT LETTER

## Administrator Exemption Regarding Informed Consent

I, Lisa Hendrix, Principal of Hellgate High School, verify that the classroom research conducted by Eric Ojala is in accordance with established or commonly accepted educational settings involving normal educational practices and that I approve the project. To maintain the established culture of our school and not cause disruption to our school climate, I have granted an exemption to Eric Ojala regarding informed consent.

  
\_\_\_\_\_  
(Signed Name, Title of Position)

Lisa Hendrix  
\_\_\_\_\_  
(Printed Name)

11-1-13  
\_\_\_\_\_  
(Date)

APPENDIX F:  
IRB EXEMPTION LETTER

**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
**FWA 00000165**



960 Technology Blvd. Room 127  
 c/o Immunology & Infectious Diseases  
 Montana State University  
 Bozeman, MT 59718  
 Telephone: 406-994-6783  
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 E-mail: cherylj@montana.edu

*Chair:* Mark Quinn  
 406-994-5721  
 mquinn@montana.edu  
*Administrator:*  
 Cheryl Johnson  
 406-994-6783  
 cherylj@montana.edu

**MEMORANDUM**

**TO:** Eric Ojala and Walt Woolbaugh  
**FROM:** Mark Quinn, Chair *Mark Quinn CJ*  
**DATE:** November 5, 2013  
**RE:** *Moon Journal Project Pedagogical Changes and Their Impact on Pretest/Posttest Scoring for Grade Nine Earth Science Students* [EO110513-EX]

The above research, described in your submission of November 4, 2013, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- X (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- X (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- \_\_\_\_\_ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- \_\_\_\_\_ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- \_\_\_\_\_ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- \_\_\_\_\_ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.