

TRANSCENDING LANGUAGE: BRIDGING LANGUAGE GAPS IN SCIENCE
EDUCATION WITH DRAWING

By

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ABSTRACT

TRANSCENDING LANGUAGE: BRIDGING LANGUAGE GAPS IN SCIENCE EDUCATION WITH DRAWING

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This study seeks to find if drawing can help English Learning (EL) students better understand and retain science content. Seventh and eighth grade students were given series of presentations about Pluto. Half of the students were asked to write only written notes while the other half was asked to both draw and write down notes during the presentations. Their pre and post-test scores were compared to show the growth of the students' content knowledge. Results indicate that the group that was required to both draw and write had on average higher scores than the group that only wrote in their lecture notes. The data and previous literature was used to influence the creation of a work book to be used for educational activities and trips at the Mount Wilson Observatory in Pasadena, California. Activities were designed to support language development of both fluent English speaking students and EL students. Specific to the majority of language needs of Los Angeles students, the glossary includes both English and Spanish translations.

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INTRODUCTION

This study investigates the effectiveness of using hand drawing in the classroom to help students, both English Learners (EL) and fluent English speaking students alike, retain the content of a science lesson. It is the purpose of this study to develop the beginning of a curriculum in the form of a printable workbook to be used in conjunction with the developing education program at the Mount Wilson Observatory in Pasadena, California. The observatory is working towards building an educational outreach program that facilitates field trips for grades five through twelve as well as overnight trips for high school students in Los Angeles, Orange, and San Bernardino counties. As a middle school science teacher, I have become involved with the observatory through my employer, Magnolia Public Schools, who has partnered with them to create this program. I have taken my students on field trips and developed worksheets for the activities the scientists lead. Through more discussion with the observatory trustees, scientists, astronomers, and other involved educators along with the research compiled in this study, I have created a work to be used and built upon for future educational trips.

The following literature review provides a window into the body of research already conducted in education and will review established and supported pedagogy used in many classrooms. This chapter reviews a selection of writing that examines current instructional strategies for EL students, note taking strategies for all students, and current science education.

REVIEW OF LITERATURE

Needs of English Learner Students

In California, 53.25% of the 6,235,520 enrolled students were of Hispanic heritage during the 2014-15 school year (California Department of Education, 2015). According to the California Department of Education, more than just Hispanic students qualify as EL students and can include students from places such as Russia, Korea, China, Turkey, Pakistan, and Senegal. The top native languages of all 1,392,263 EL students are Spanish (83.7%), Vietnamese (2.34%), Filipino (1.37%), and Mandarin (1.36%) (California Department of Education, 2015). As a whole, 22.32% of all students in California, one in five, are classified as English Learners. According to a study by Waxman (2002), the majority of EL students are of Hispanic heritage who are often behind with up to 40% of students a grade level or more behind in their studies and up to 50% who don't graduate on time. The study also reported that dropout rates of Hispanic students are higher than any other ethnic population. Waxman (2002) reports that 30% of Hispanics between the ages of 16 and 24 are drop-outs. Factors such as high poverty rates, lack of English speaking skills, and little or no early childhood education contribute to the seriousness of issues that Hispanic Americans face in their education (Waxman, 2002). The Waxman study also attributes the failures of EL students to lack of teacher preparation and reported that less than 20% of teachers at the time of the study had English as a Second Language (ESL) or bilingual education certification.

The American Federation of Teachers have made many suggestions on how schools can support their EL students, including smaller class sizes, early reading instruction programs, early intervention programs, safe learning environments, and fully qualified teachers in the classroom (Teaching english-language, 2002). In smaller groups, students are often able to receive more personal attention from an educator. This might lead one to assume that the smaller the class size, the better the learning experience for EL students. California Education Code dictates maximum class size and has done so since 1964 (Gonzalez, 2014). Lower socio-economic school districts that cannot afford to lower their class size beyond the legal limit may find it more difficult to provide small class size or facilitate small groups without the assistance of additional teachers or teacher aides (Matas & Rodriguez, 2014).

Proposition 227 in California introduced legislation that eliminated much of the bilingual education in the state, where classes that had previously been taught in the students' native languages were now mandated to be taught in English: "all children in California public schools shall be taught English by being taught in English language classrooms" (Matas & Rodriguez, 2014, p. 44). This action suggests that complete immersion in English is the only option for EL students in public schools, and that their English language skills will improve by not learning content in their native language. When a student is forced to learn in a language that is foreign to them, they have to split their focus between two different learning objectives, language and content (Matas & Rodriguez, 2014). For the approximately 1.5 million EL students enrolled in California public schools, Proposition 227 cut off access to educational programs and embedded the

burden of language acquisition education in the classrooms of multiple subject and content specific teachers (Matas & Rodriguez, 2014). Matas and Rodriguez examined data in an urban California school district and found that even though students are still receiving some support, they are unable to gain understanding of the content due to denying students “access to grade-level content in the more comprehensible manner of utilizing students’ primary language as a vehicle for instruction” (p. 52). Because there are so many enrolled EL students who have lost access to government funded programs, teachers are finding it necessary to learn new strategies to support their students.

More recently however, Proposition 58 was passed in California on November 8, 2016 and it repealed the requirement from Proposition 227 that students must learn in an English-only immersion classroom (Hopkinson, 2017). The law will go into effect July 1, 2017.

Common Teaching Strategies for English Learner Students

Throughout teaching programs and professional development, there are many different suggestions as to what are considered best practice strategies in the classroom (Waxman, 2002). For example, if something has been studied and supported or used with success repeatedly in the classroom, that knowledge is shared amongst educators and used in their respective classrooms. All students, and particularly EL students, benefit from teachers sharing best practices because even though individual needs may vary, there are common mistakes made when language is a barrier to student success. Best practices for EL students have come to include the use of visual organizers, color coding,

exaggerated gestures, selective pairing, and instructional materials translated into the student's first language. The best practices for each class will vary depending on the specific needs of the enrolled students and what subject is being taught.

The Waxman study (2002) researched different teaching strategies in a mixed English only speaking and EL student classroom and reported a number of valuable strategies already in use to support EL students. Cooperative learning, learning that encourages students to collaborate and share their ideas, was found to help build language skills through social interactions. Another valuable teaching strategy suggested was for teachers to provide multiple representations. This might be something as simple as a teacher holding up a picture of a dog when saying the word dog, to something less concrete such as using graphic organizers to demonstrate a specific relationship among words. It was found that the use of pictures illustrating a written narrative helps students to decode word meanings. A third strategy is building on prior knowledge of the students. A correlation was found with students who had little prior knowledge of a subject and performed poorly on questions that required the use of what was assumed to be common knowledge. The fourth suggested teaching strategy is the use of instructional conversation that is spoken back and forth. One on one conversation allows EL students an opportunity to be understood and gives them a chance for their speech to be corrected without the fear of humiliation. Another strategy that would need to be personalized depending on the student population, provides culturally responsive instruction. Instruction should be designed to reflect the cultural heritages represented in a classroom since the practices of some home cultures may be different than the practices in a

traditional American classroom. An additional suggestion is for teachers to use cognitively guided instruction that models cognitive learning strategies so students can effectively use these strategies themselves. The last teaching strategy suggestion from the Waxman study (2002) is to enrich instruction with technology. Certain computer based programs provide a “risk-free environment for ELs that made the students feel comfortable about expressing their ideas” (p. 22). Another outcome of technology enriched lessons is the reduction of class time dedicated to direct instruction, so students might have more opportunities for interaction to practice the language.

EL students come with their own set of needs and challenges, and, if their language needs are overlaid with a learning disability, more specified strategies become necessary (Barrera, 2006). When students are behind in reading, teachers employ specific reading strategies, and for students who have an identified learning disability and are learning English, one such strategy that can assist them is Chunking and Questioning Aloud (CQA). The Barrera study describes CQA as reading part of a story, a chunk, stopping at a designated point to ask the students specific questions and check for comprehension before continuing (2006). Even though there are a variety of strategies to assist special learning groups, these strategies will also help the general population of the class and be used for whole class instruction (Carr, 2007). By discovering any new methods that can support EL students, teachers can help support all students.

Needs of Students in a Science Classroom

Science textbooks require students to not only pick up on new vocabulary terms, but also understand concepts that are being explained in what could be considered a disengaging and dry manner (Freeman, 2013). Students need to be taught how to read through these texts like a road map, understanding things such as the color-coding of different text features, using a table of contents, and locating the various chapters. Often the academic language in a science classroom can be tricky to students because they might see words that are commonly used with one meaning in the vernacular, but then come to have a different meaning in a science class (Carr, 2007). One such term which demonstrates the challenge of academic language is the word “theory.” When using the term in casual conversation, the term theory may mean an idea that is deduced from an incomplete set of evidence or that may be supported by gut feelings. In a science class, however, a theory is quite the opposite. A commonly accepted theory is a well-supported idea that explains how something in the world works. The theory of plate tectonics is supported by a wealth of information and is so much more than a fleeting thought mentioned in passing. For a student who is learning the English language, there are many possible complications in our language that can hold them back from fully understanding content (Carr, 2007).

Common Teaching Strategies within a Science Classroom

Common teaching strategies in a science classroom often include the use of academic vocabulary language practice. Students who find themselves behind in their Language Arts class may struggle with the text and vocabulary found in a science

classroom (Herr, 2007). Herr suggests that science teachers employ the use of hands-on learning and visuals to demonstrate the concepts being discussed, including the use of hands-on labs. While labs and activities pose opportunities for students to gain deeper understandings of the content by putting a personal experience to them, the need for understanding the instructions and vocabulary acts as a foundation for the activity that EL student may not have if they are struggling with the content specific language (Bosworth, 2012). They could see the results of the activities and participate but they may not be able to communicate their understanding of the concepts or participate properly to begin with. Herr (2007) suggests the use of specific strategies such as using hand gestures and graphic organizers that will assist the students in learning science content in English.

Where EL Students Often Struggle in a Science Class

Students who struggle with understanding the academic language and content specific vocabulary of a science classroom may easily fall behind (NEA, 2008). The NEA (2008) also warns that a lack of understanding could lead students to quietly fall behind. Sometimes students are embarrassed to confess the fact that they are struggling and will participate and try their best to complete their assignments, but upon examining their work their answers contain incomplete ideas, and their lack of understanding of the concepts is notable in test scores and assessments (Barrera, 2006). Other instances may occur when students are able to listen and understand the ideas, but when it comes to communicating what they have learned, they grapple to find the words and formulate sentences with proper grammar (Barrera, 2006).

The struggles are mutually shared between the students and the teachers who are responsible for facilitating meaningful discussion. DelliCarpini and Alonso (2014) discuss commonly used effective teacher practices in U.S. schools. They begin by examining teacher preparation and state that “Despite the growing numbers of ELs in U.S. schools, there has been little change in how mainstream teachers are prepared to address the needs of these students,” and “77 percent of content-area teachers have no coursework or professional development addressing ELLs” (p. 156). DelliCarpini and Alonso (2014) also examine the findings of a graduate-level course preparing secondary level mathematics and science teaching candidates to work with EL students. They found that despite the graduate level course candidates did not feel prepared to work with ELs, although they did desire to learn more. That being said, the survey also found that the candidates did not believe they had a role in building language skills in their content specific classrooms, unless they were Language Arts teachers. One teacher who was surveyed shared that her struggle was in finding the balance between language support and content support: “Every class I teach, I have to introduce at least two new words and I have to review many of them as I explain a concept or procedure” (DelliCarpini & Alonso, 2014, p. 170). As a result of their study, DelliCarpini and Alonso state that teachers are not adequately prepared to meet the needs of the EL students. They deem that attitudes of teachers are moving in a positive trend towards wanting to understand and assist students, but only with additional professional development related to teaching strategies that support academic vocabulary and content specific vocabulary.

As professor of science education at California State University, Herr (2007), describes some strategies for teaching science to EL students. To assist EL students who have auditory difficulty understanding what they hear, teachers should speak slowly, distinctly and write down important terms during class lecture (Herr, 2007). Herr argues that what sounds like a normal pace to native English speakers will seem too fast and difficult to process for EL students. Herr's (2007) section on visualization in Chapter 24 is extensive and asserts that people around the world can interpret pictures, and with minimal linguistic skills, can interpret charts and graphs. Visual literacy, defined by Herr as the ability to evaluate, apply, or create conceptual visual representation, should be emphasized in a class with EL students through the use of graphic organizers, charts, graphs, diagrams, and photographs. If you have a classroom that is mixed with students of different language abilities, allowing students to work with small groups or discuss their ideas before presenting them to the class allows students a safe environment to experiment with their language skills and encourages EL students to express science concepts in English (Herr, 2007). Other suggestions to assist EL students from Herr's article include kinesthetic learning events such as hands-on labs with real life applications and asking students to use journals for notes(2007). Herr states that "students become better writers by writing" (2007, p. 24) and students should keep journals with their lecture notes, new terms, and responses to prompts that they can reflect on later.

Benefits of Handwritten Notes

In elementary and middle school classrooms, more and more schools are providing technology for students - in 2008, 97% of all U.S. classrooms had a computer for students to work with and 100% of all classrooms had an instructional computer with internet access (Gray, 2009.). Kinesthetic learners, by definition, best retain information when given the opportunity for movement amidst content (Kinesthetic-tactile, 1997). Houghton College defines a kinesthetic-tactile learning style as requiring “that you manipulate or touch material to learn ... kinesthetic-tactile techniques are used in combination with visual and/or auditory study techniques, producing multi-sensory learning” (Kinesthetic-tactile, p. 1). This type of kinesthetic-tactile learning could range from hand writing notes to performing tasks that require the students to move and walk around. Most students learn from a blend of learning styles, some students tend to lean more to one style than the other, but in the majority of cases it is clear that there is a benefit to handwriting notes rather than just listening to or reading the content alone(Gray, 2009).

Benefits of Hand Drawn Notes

EL students may not be able to communicate their thoughts in the language used for teaching in the classroom, but drawings can transcend language (Herr, 2007). Drawings offer EL students the ability to “write” their notes in a manner that does not require proper grammar. These notes can be used in the same way as traditional notes to review concepts previously taught. With time and opportunities for practice, EL students can make detailed drawings of live observations, diagrams, and activities just as a student

who is fluent in English would keep track of these with detailed adjectives and academic vocabulary (Adoniou, 2013).

In a study conducted by Bell (2014), college level Biology students used both digital and hand-drawn activities in their course. These 33 students were split into two groups, one that learned how to draw and label a cell, and the other learned the same content through a computer program. After the lessons, students were given post assessments and surveys. The post assessment scores showed a significant difference in the two groups - the group with the hand-drawn activity scored on average of 10 percent better than the group that did the computer based activity. An interesting point to note is that in the survey, students were asked how they perceived their learning after each of the activities and those who completed the computer activity felt that they had learned more. This may suggest how students perceive the value of technological assignments over traditional pencil and paper assignments, and that rudimentary methods are not as efficient as newer methods (Bell, 2014.). This study may hint at an important connection that has been lost in current classrooms that are striving to utilize newer, advanced technologies. However there is a new trend in education to integrate the arts back into the classroom.

S.T.E.A.M. and Arts Integration into the Science Curriculum

While creating art is an obvious outlet for students to use creativity to produce work, science often calls for the use of creativity as well in designing experiments and other methods of research (Mertel, 2011). There are many crossovers of the arts with science,

such as when a scientist is preparing cell material to observe its composition or the use of the computer imaging program Photoshop as a main tool to prepare the demonstration (Knochel, 2013). The scientific process of preparing tissues to be analyzed requires knowledge of image manipulating programs as tools for the scientist's work.

Visualization techniques within scientific professions that use common art programs to analyze and present data build a bridge between culture and science (Knochel, 2013).

Schools have recently begun employing STEM learning that blends science (S), technology (T), engineering (E), and math (M) (STEAM Implementation, 2015). Many other educators in California are taking it a step further and adding the arts to expand the acronym into STEAM that demonstrates that art and creativity have natural places among the otherwise technical subjects (STEAM Implementation, 2015). While the STEAM acronym has only recently begun to emerge in schools, the link between art and science has been studied for decades (Lutz, 1976). The arts can be used as methods of learning science subject matter and other content related skills, while stressing the use of creativity in assignments (Ediger, 2000). In a paper on the use of art in a science curriculum by Ediger (2000), the author gives multiple examples of how art lessons can be used to teach science content and engage learners on a higher cognitive level. Ediger explains that "science facts may be memorized with little/no understanding, but artistic endeavors cannot be memorized pertaining to a fact clarified which adds understanding" (2000, p. 4). Vallejo City Unified School District is one group of California schools that has implemented a STEAM program and has already reported increases in student performance (STEAM Implementation, 2015). This school district reported an overall 5%

increase in general math scores of 8th grade students in 2013 after eliminating remedial math courses and replacing them with STEAM electives in the district's middle schools. Two individual schools reported increases of 11% and 26%. The following year they expanded the program to all grade levels.

Another study on the integration of arts in a science curriculum looked at the benefits of art based activities on environmental education and Eco-Justice (Mills, 2013). Deborah Mills, a doctoral student at Wayne State University looked at the “over-all influence of a deeper understanding, appreciation, and partnership with one’s environment through the freedom of expressing personal creativity” (2013, p. 14). By using the place in which the students lived and learned as a learning tool, Mills was able to relate the learning experience to the students’ prior knowledge. Her qualitative results found that students had developed a better understanding of the environment around them and “became more aware of the importance of the plants, insects, and animals in maintaining the environment in Michigan” through the art based learning experience (Mills, 2013, p. 72).

Transference of learning between disciplines supports knowledge of both subjects (Rachford, 2011). In a case study by Maryann Rachford, a doctoral student at Azusa Pacific University, a science class was provided with a lesson that blended ceramics, physics, and chemistry, and an art class was given a lesson on the Fibonacci equation to look at the relationship between art and math. In the science class that included ceramics, students reported increased awareness of the physical properties of clay and how they related to content of their physics course. Rachford (2011) also noted that the lesson

attracted the attention of the students and they appeared to have a high level of engagement. One of the students commented that “Art integration is effective in the learning process analogous to the use of hands on lab experiments” and Rachford noted that “many students are turned off by the analytical nature inherent in math and science, and art may provide a way of alleviating that stress making the class more ‘fun’ and ‘creative’” (Rachford, 2011. p. 92).

EL Student Support in a Science Class With Drawing

There appears to be a lack of academic literature that specifically speaks to the use of art to support content retention and success of EL students in middle school science classes, however the literature from the Bell (2014) investigation shows a benefit for using visual teaching strategies. Exaggerated body language and graphic organizers help emphasize the meaning of a given text, but by providing in-person realia for students to observe, they are able to develop understandings that go beyond vocabulary words (Herr, 2007). Vocabulary is essential when it comes to communicating ideas within the classroom, but EL students who are exposed to the content can record their experiences through the use of hand drawings. Adoniou’s (2013) study of eight and nine year olds sought to examine the effect of drawing before writing about curriculum content on the quality of the students’ writing of explanations and procedures. The study showed that when students used hand drawing for content, their writing samples were rated at a higher level and included more details with use of higher level words. “Drawings also allow

children to explore learning via more concrete representations which become a reference point to which children can turn when writing” (Adoniou, 2013, p. 11).

Another study performed by the New York City Board of Education considered the impact of holistic learning for mathematics, art, science, and technology with students that were all of Hispanic background (Language development through holistic learning, 1990). About 85% of the students read below grade level and about 50% did not have adequate literacy skills in their native language. Students who were either recommended by their teachers or scored in the 40th percentile on the general language assessment were placed into bilingual classes that incorporated project based learning on different science topics. The results of the program showed significant improvement between pre and posttest scores in the students’ English language proficiency, math, and science (Language development through holistic learning, 1990).

Conclusion of Literature Review

In reflecting on the Bell (2014) and Adoniou (2013) studies, the data can be interpreted to support the idea that EL students would benefit from the use of visual teaching strategies in the classroom. Teachers who demonstrate a desire to learn more strategies can use visual learning techniques to make up for the loss of bilingual education programs and assist their EL students to build a bridge between academic vocabulary and meaningful understanding of content (DelliCarpini, 2014). A single word has the ability to conjure up an image in a student’s mind, but if they have no concept of the word they are then not able to obtain that underlying meaning. Teaching strategies

with EL students need to transcend language barriers to assure content retention as the ultimate goal (Matas & Rodriguez, 2014). By using visuals and kinesthetic strategies, students can observe the content through multiple senses, allowing them to take in a partial understanding of the content where language fails them (Kinesthetic-tactile, 1997). There appears to be a gap in holistic science experiences that students can help students build on their knowledge of scientific literacy through art (Hollenbeck, 2004). Students still need to learn academic vocabulary, but in order to effectively retain the content material, hand drawings can serve as a source of note taking for understanding.

METHOD

The curriculum presented in this project is based on current literature, the needs of the Mount Wilson Observatory, and an experiment conducted on the students in my middle school classes. The purpose of the experiment was to determine if students would better retain information if they were required to include drawings in their lecture notes. More specifically, I wanted to analyze the differences between the growth of English Learners and the rest of the class to see if there were any differences in knowledge acquisition in response to the required method of note taking. Approval was granted to use class lecture time to conduct the study and students who were given permission to take part in the study were put into one of two groups, a writing group and a drawing group. All of the 7th and 8th grade students were offered to participate which allowed for a natural variance in grade point averages amongst those participating. To prevent bias as to who was placed in each group depending on their academic abilities, the students' seats were simply used to designate the left half of the room to one study group and the other half of the room to the other study group. Students sit in previously assigned seats and are sat in accordance to their behavior and IEP accommodations, not by alphabetical order. All students, including those who were not participating in the study, were given the same pre and post-test that had 20 multiple choice questions created for this study as seen in the first figure below. To prevent preexisting knowledge from affecting the students' scores, a topic was chosen that was not presented in the textbooks and the students' individual growths were measured instead of overall scores.

Pluto Unit Test

Number: _____ Date: _____

- Pluto is made of:
 - Ice and Rock
 - Volcanic Lava
 - Nitrogen Gas
 - Toxic Waste
- Pluto is about 1/6 the mass of
 - Jupiter
 - Earth
 - Earth's Moon
 - Neptune
- Which of the following is not a moon of Pluto?
 - Styx
 - Hydra
 - ~~Erös~~
 - Charon
- The space craft New Horizons flew by Pluto in what year?
 - 1975
 - 1995
 - 2005
 - 2015
- The mission of New Horizons was to
 - Land on Pluto
 - Take Soil Samples
 - Photograph and Measure the Planet
 - Send Rovers to the Planet
- Pluto was discovered by
 - Ancient Greek Astronomers
 - Scientists at the Griffith Observatory
 - Scientists at the Lowell Observatory
 - Ancient Japanese Astronomers
- Pluto was officially announced and named in
 - 1876
 - 1905
 - 1912
 - 1930
- Pluto is a member of the
 - Kuiper Belt
 - Asteroid Belt
 - Andromeda Belt
 - Moon Belt
- Pluto was demoted to the classification of Dwarf Planet because it was
 - Smaller than a newly discovered object in the Solar System
 - Discovered to be a comet instead of a planet
 - Misidentified as a moon of Jupiter
 - Destroyed by a meteor shower
- Which of the following is not in the definition of a planet?
 - The object must be in orbit around the Sun.
 - The object must be massive enough to be rounded by its own gravity.
 - It must have cleared the area around its orbit.
 - It must be made of solid material.
- Hydrostatic Equilibrium causes
 - Planets to fly forward in orbit.
 - Planets to have volcanoes.
 - Planets to be round.
 - Planets to have oxygen.
- Pluto completes a full orbit around the Sun every
 - 15 Earth Months
 - 18 Earth Years
 - 248 Earth Years
 - 497 Earth Years
- Pluto's orbit
 - Is in a perfect circle
 - Is in an egg shape
 - Changes depending on other planetary factors
 - Moves in a zig zag pattern
- One day on Pluto is equal to
 - 3.9 Earth Days
 - 6.39 Earth Days
 - 12.1 Earth Days
 - 52.8 Earth Days
- Pluto is composed of more than 98%
 - Nitrogen Ice
 - Uranium
 - Carbon Dioxide
 - Boiling Sodium
- Pluto is
 - Blue and Purple
 - Green and Blue
 - Black, Orange, and White
 - Red, White, and Purple
- Pluto has an atmosphere made of
 - Nitrogen, Methane, and Carbon Monoxide
 - Nitrogen, Oxygen, and Hydrogen
 - Plutonium
 - Pluto has no atmosphere.
- It took New Horizons how many days to get to Pluto?
 - 52 Days
 - 400 Days
 - 768 Days
 - 3,462 Days
- The discoverer of Pluto, Clyde William Tombaugh, also wanted astronomers to research
 - Earth Worms
 - Volcanoes
 - Life After Death
 - UFO's
- Pluto has how many moons?
 - 2
 - 5
 - 7
 - 13

Figure 1: Multiple choice pre and post-test about Pluto that contains 20 multiple choice questions varying from the color of the planet to who discovered it.

If a student missed a day, they were removed from the study since they would not receive all of the information necessary to complete the post-test. There was no time limit given for the tests. Participating students were also required to sit through all 4 days of the presentations about the dwarf planet Pluto. Class sessions are 50 minutes long and the length of each presentation ranged between 6-8 slides with four minutes provided for each informational slide. Each slide in the presentations had an image or photograph provided along with typed notes as seen in the sample slide in Figure 2 below. For the presentations, students in group A were given lined paper to take notes on and instructed that they were not allowed to draw or doodle anything on the paper. Group B students were given paper with lines next to empty boxes. Students of group A could take as many notes as they wanted but they had to write down something for each slide of the Power Point presentations. Group B was instructed that they could write down as many notes and drawings as they wanted but that they had to have both words and drawings for each slide of the Power Point presentation.

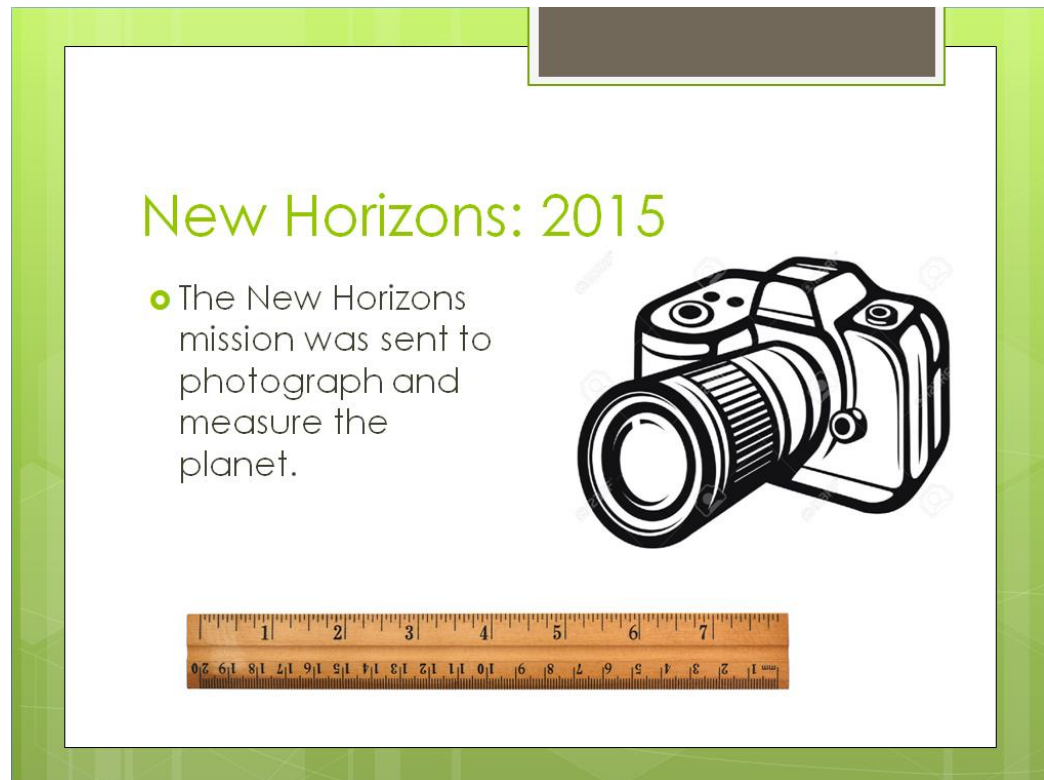


Figure 2: Sample slide from the Pluto Power Points. This reads “New Horizons: 2015. The New Horizons mission was sent to photograph and measure the planet.” It also contains images of a camera and ruler to correspond with the written facts.

RESULTS

After conducting the classroom experiment, where the students were given a pre and post test about the content, the changes for each individual student were noted along with their growth from the first test. The students' language proficiencies were noted either English Proficient (EP) or by their California English Language Development Test (CELDT) scores. I have chosen to use the term English Proficient instead of English Only because many of my students are bilingual but have either never been required to take the CELDT or they have been reclassified. The following tables show the individual scores for first the writing only group (Table 1: Writing Only Group) and then the second table shows the scores for the writing and drawing group (Table 2: Drawing and Writing Group).

Table 1: Writing Only Group (refer to text)

Student #	Proficiency	Pre Test Score	Post Test Score	Growth
1	EP	8	15	7
2	EP	8	18	10
3	1	5	9	4
4	EP	8	18	10
5	EP	9	20	11

Student #	Proficiency	Pre Test Score	Post Test Score	Growth
6	EP	6	18	12
7	EP	8	15	7
8	EP	8	13	5
9	EP	9	17	8
10	4	7	18	11
11	EP	8	12	4
12	EP	2	15	13
13	EP	8	17	9
14	EP	9	14	5
15	EP	1	14	13
16	EP	4	12	8
17	EP	5	10	5
18	EP	7	17	10
19	EP	12	17	5
20	EP	6	13	7
21	EP	6	10	4
22	2	12	15	3
23	EP	8	16	8

Table 2: Drawing and Writing Group (refer to text)

Student #	Proficiency	Pre Test Scores	Post Test Scores	Growth
24	EP	7	17	10
25	EP	10	17	7
26	2	4	12	8
27	4	7	19	12
28	EP	8	19	11
29	EP	3	6	3
30	EP	9	17	8
31	EP	7	13	6
32	EP	6	16	10
33	EP	7	20	13
34	EP	6	18	12

When examining the data, it can be noted first that there are more scores for the group that was only allowed to write. There are 23 students in the writing only group and 11 students in the drawing group. This can be attributed to the fact that students in all classes were split in half into the two groups. Originally the numbers of those who agreed to participate were equal at 25 students per group but some students either missed one or more of the days or decided to step out of the study part way through resulting in uneven

numbers of the total participants. For further applications of the study, it would be best to test larger groups of students from varying backgrounds with a more even number of students between the groups. To prevent the numbers from changing from the original totals, I would also suggest performing the study in a single day rather than over multiple days to prevent students from missing some of the content due to illness or family emergency.

Next, the averages of the individual scores were calculated. As seen in Table 3: Averages and Modes, the average point growth on the post test in the drawing and writing group was 8.833 and the average point growth on the post test in the writing only group was 7.783 showing a 1.05 difference favoring the group that included the drawing as part of the note taking format. While only having 5 participating EL students, the numbers are also clear that the drawing and writing group had a higher average point growth than the writing only group with a 4 point difference, the writing only group having an average of 6 and the drawing and writing group having an average of 10. To reduce the possibility of outliers skewing the overall view of the individual scores, the mode of each group has also been included. Most often in the writing group students increased their point scores by 5 while in the drawing and writing group students most often increased their scores by 10 points. In all three categories of analyzing the data, students showed more growth in the group that required drawing to be included as part of the note taking process.

Table 3: Averages and Modes (refer to text)

Data Set	Writing Group	Drawing and Writing Group
Average Growth in General	7.783	8.833
Average Growth of English Language Learners	6	10
Mode of Growth in General	5	10

Curriculum

After analyzing the previous literature and the data from the study, an activity book was constructed to support the needs of the English Learners and all other students living in Los Angeles County for use in day and overnight trips to the Mount Wilson Observatory. The activity book includes language support in the form of sentence stems, graphic organizers, and an English/ Spanish glossary. There are drawing and coloring activities that are meant to support lectures given by docents on the trips. The Mount Wilson Observatory, established in 1904, has a long history of making important discoveries about our universe. Those discoveries range from finding magnetic fields on the sun to measuring the expansion of the universe, a major piece of evidence supporting the Big Bang theory. Located in the Angeles National Forest above Pasadena, California,

the local light pollution and lack of funding have contributed to the decreased use of the observatory by research institutes. However, the lack of professional use has opened the grounds to local groups and field trips for educational purposes. Through collaboration with trustees of the observatory and scientists from Carnegie Science Laboratories, the educational outreach program has expanded from 3 hour field trips to overnight trips. The goals were to create a set of activities that could be expanded upon and replicated for multiple educational trips ranging from 5th grade through high school. The activities tie in to the required science standards for the state of California, the Next Generation Science Standards (NGSS). On top of those requirements, the activities include language supports such as word banks and sentence frames as well as including graphic organizers and opportunities for students to draw out and color code their own observations. Instructions have been chunked as needed and the use of font styling, such as bolding words, has been utilized to bring attention to specific parts. Lastly, a glossary is included in the back of the booklet and includes translations in Spanish to meet the needs of a large majority of English Learner Students in Los Angeles County.

CONCLUSION

The purpose of the study was to find a way to better assist my EL students in understanding and retaining the content in my science classes and further to develop activities using the data for the purpose of science education at the Mount Wilson Observatory. Often times, teachers will discuss the benefits of using EL strategies with a whole group because that strategy reaches out to more than just the targeted students. After comparing the scores of just the EL students to the proficient English speakers, the assumption can be made that the use of drawing in a science classroom with different levels of language skills can be beneficial to all students involved, not just those learning English. That being said, the numbers also suggest greater growth for the English Learners who participated in the drawing and writing group compared to the writing only group.

The activity work book is meant to be the beginning of a much larger curriculum. The activities are generalized to allow for multiple grade levels to complete the same work. The intentions are to later make specific workbooks for the varying grade levels. As the educational outreach program grows at the observatory, so too will the curriculum to fit the needs of the students as the visitor base grows to welcome more schools.

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15&SubGroup=All&ShortYear=1415&GenderGroup=B&CDSCode=0000000000000000&RecordType=EL.California Department of Education. (2015.) *Fingertip*

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APPENDIX

The following is the workbook project constructed as the result of the research conducted in this paper. Page intentionally left blank, the cover page of the booklet follows on the next page.

Mount Wilson Observatory

EST. 1904



Name: _____

School: _____

Trip Date: _____

Tour Guide: _____

Table of contents

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2. N.G.S.S. Middle School Standard.....	page 4
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N.G.S.S. Elementary School Standard

5-ESS1-1: Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.

1. Why do you think it says “apparent brightness” instead of just brightness?

2. Why do think the sun seems so much brighter to us than other stars?

3. List 3 facts you already know about the Solar System:

1.

2.

3.

4. List 3 questions you have about the Solar System:

1.

2.

3.

5. What do you think this standard is expecting you to know or be able to do by the end of your observatory tour?

6. What do *you* hope to be able to do or know by the end of your observatory tour?

NGSS Middle School Standard

MS-ESS 1-3: Analyze and interpret data to determine scale properties of objects in the solar system.

1. What does it mean to *analyze data*?

2. What does *scale* mean? (Hint: not the scale you step on to weigh yourself.)

3. List 3 facts you already know about the Solar System:

1. _____

2. _____

3. _____

4. List 3 questions you have about the Solar System:

1. _____

2. _____

3. _____

5. What do you think this standard is expecting you to know or be able to do by the end of your observatory tour?

6. What do *you* hope to be able to do or know by the end of your observatory tour?

N.G.S.S. High School Standard

HS-ESS1-2: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

1. How do you think studying light can tell you how old our universe is?

2. What kind of information would you need to explain how the universe was made?

3. List 3 facts you already know about galaxies:

1.

2.

3.

4. List 3 questions you have about galaxies:

1.

2.

3.

5. What do you think this standard is expecting you to know or be able to do by the end of your observatory tour?

6. What do *you* hope to be able to do or know by the end of your observatory tour?

History of the Mount Wilson Observatory

*Adapted from "History of Mount Wilson Observatory" at
www.mtwilson.edu*

Mount Wilson Solar Observatory was founded in 1904 by George Ellery Hale under the guidance of the Carnegie Institution of Washington (the word "solar" was dropped after the completion of the 100-inch telescope). In that year, Hale brought the Snow Solar Telescope from Yerkes Observatory in Southern Wisconsin to the sunnier and steadier skies of Mount Wilson to continue his studies of the Sun. With a small group of Yerkes scientists and engineers accompanying him, Hale started what would become the world's leading astronomical research facility.

Think about it: Why do you think Pasadena, CA is a better place to look at the sun than Wisconsin?

Is Pasadena, CA still the best place to look at the Sun? What about the stars at night?

Founding the new field of astrophysics (referred to at the time as the "New Astronomy") Hale sought to understand the physical processes that took place in the Sun and other more distant stars. Hale and his colleagues developed new technologies to extract the information encoded in the light from distant astronomical objects. Combined with earthbound laboratories where cosmic conditions could be duplicated, this small group of pioneering scientists began the long process of telling the difference between the light from objects that only new and powerful telescopes could detect which can unlock the secrets of the life and death of stars.

Think about it: Why do you think *astrophysics* was considered new in the 1900's?

Why do you think scientists can learn about the life and death of stars by studying their light?

The scientific process of astronomy that began more than a century ago at Mount Wilson Observatory continues today around the world and in space with such instruments as the Hubble Space Telescope, named for one of Mount Wilson's outstanding astronomers. When Edwin Hubble came to the observatory in 1919, the 100 inch Hooker Telescope was the world's largest telescope at the time. Hubble used this telescope to examine galaxies beyond the Milky Way and developed "Hubble's Law" that is considered the first observational basis for the expansion of the universe which also supports the Big Bang model.

Think about it: How does studying galaxies far away help us humans who are stuck on this little planet?

Use the line below to create a timeline of events from the article from 1904 to your field trip date.



Interesting ideas and/or questions from the reading:

KWL

Use this KWL chart before and during your trip. *Before* you go on your trip, fill out the K and W columns. *During* your trip, fill in your L column. If after your trip you still have unanswered questions, add them to your unanswered questions letter.

K What do you already <u>K</u> now?	W What do you <u>W</u> ant to know?	L What have you <u>L</u> earned?
Telescopes		
Astronomers		
The Sun		

K What do you already <u>K</u> now?	W What do you <u>W</u> ant to know?	L What have you <u>L</u> earned?
Planets		
Stars		
Galaxies		
Light in Space		

Quote a Scientist

Catch a quote from one of your tour guides while on your trip today.

What did the scientist say?

“ _____

 _____ ”

Who said it? _____

What is their job? _____

Where were they when they said it? (ex: Outside of the 150ft Solar Telescope)

Pick out some vocabulary words from the quote. Ask the scientist what the words mean or look them up in a dictionary after the trip.

Word from the Quote	Definition
1.	1.
2.	2.
3.	3.

“Elaborate” means to talk a little more about what was just said. Please elaborate on the quote in your own words:

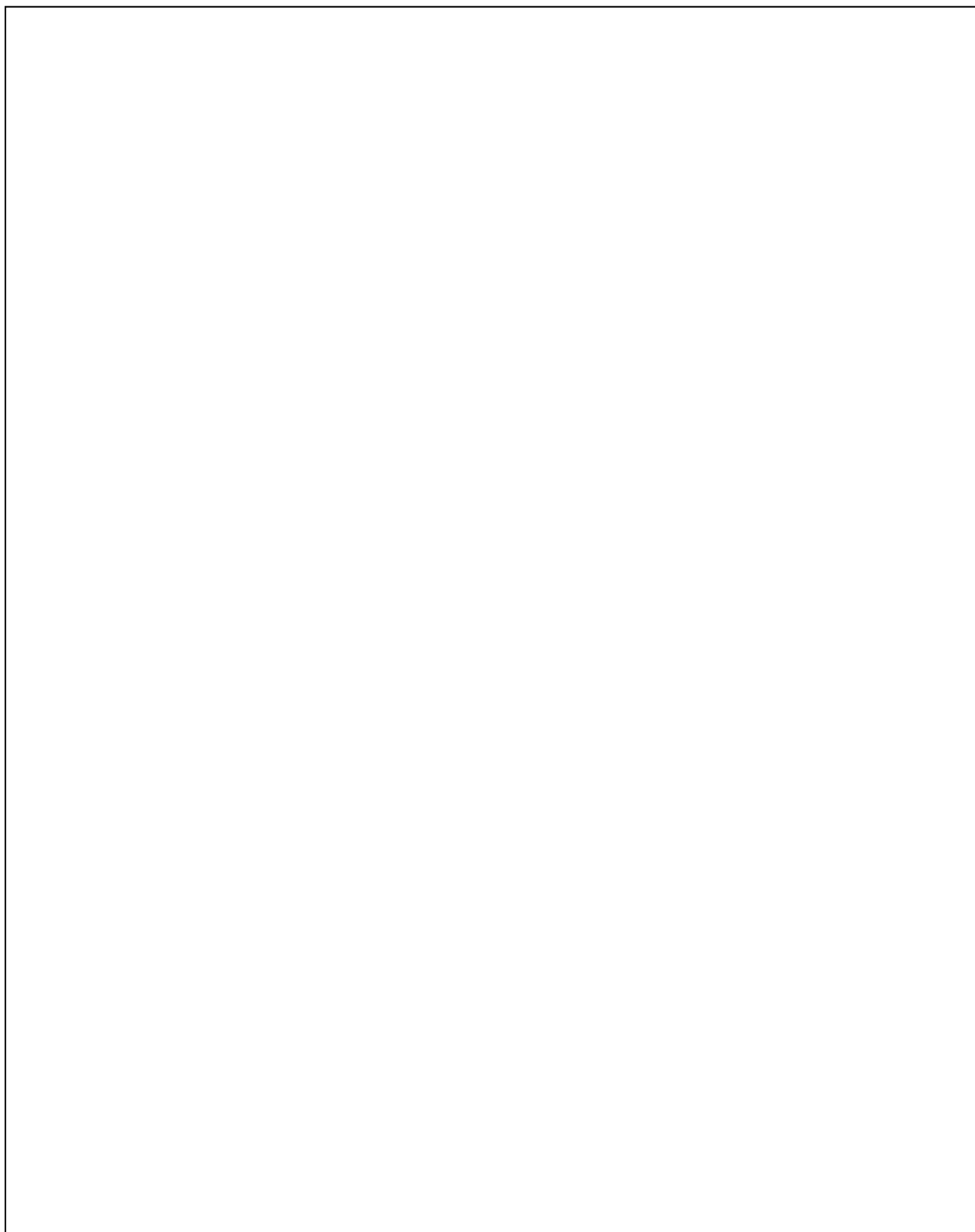
Diagram a Telescope

A diagram is a drawing that is meant to display specific information. Do not guess on the information; ask your tour guide to point out the parts of the telescopes if you cannot see them.

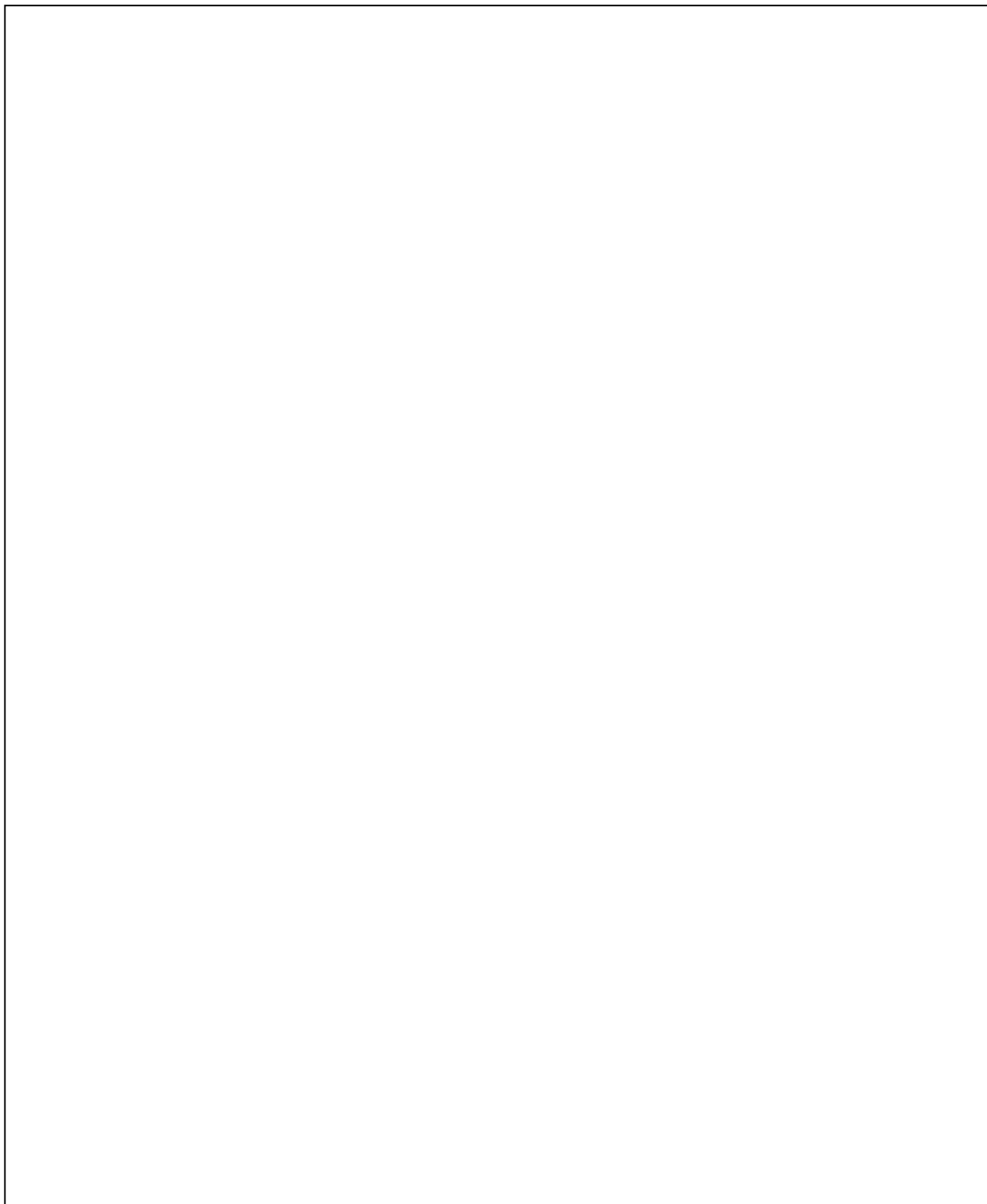
Use the following directions to make 2 diagrams in the spaces provided on the next 2 pages.

1. Choose 2 telescopes, one solar telescope and one night time telescope.
2. Draw a simple outline of each telescope using basic shapes like rectangles and circles.
3. Add any **mirrors** or **lenses** that are part of the telescopes and mark where the **eye piece** is that you look through.
4. Label as many parts of the telescope that you can.
5. Lastly, use arrows to draw the path of light from the sky to your eye.

Solar Telescope: _____



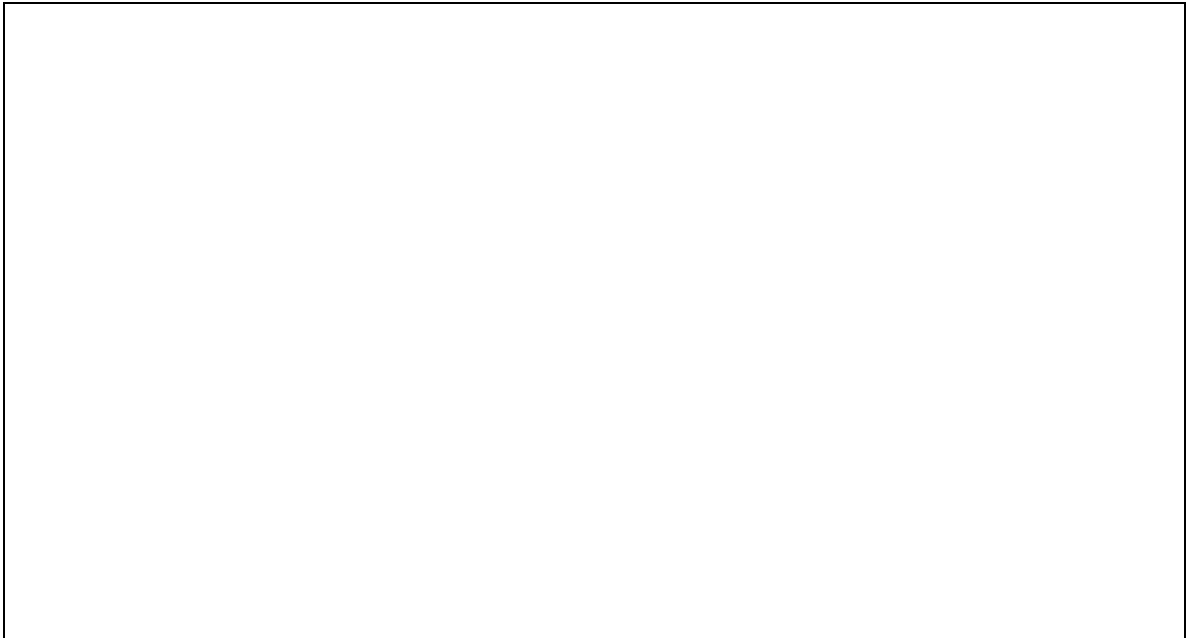
Night Time Telescope: _____

A large, empty rectangular box with a thin black border, occupying the lower two-thirds of the page. It is intended for a drawing or detailed notes related to the 'Night Time Telescope' activity.

Scale within our Solar System

1. What did the tour leader use to compare the sizes of the Sun and planets at the 150' Solar Telescope?

Draw a picture of what that looked like:



2. Did this surprise you? Why or why not?

3. If I give you a grape and say it represents the Earth, what other objects could you use to represent Jupiter and the Sun?

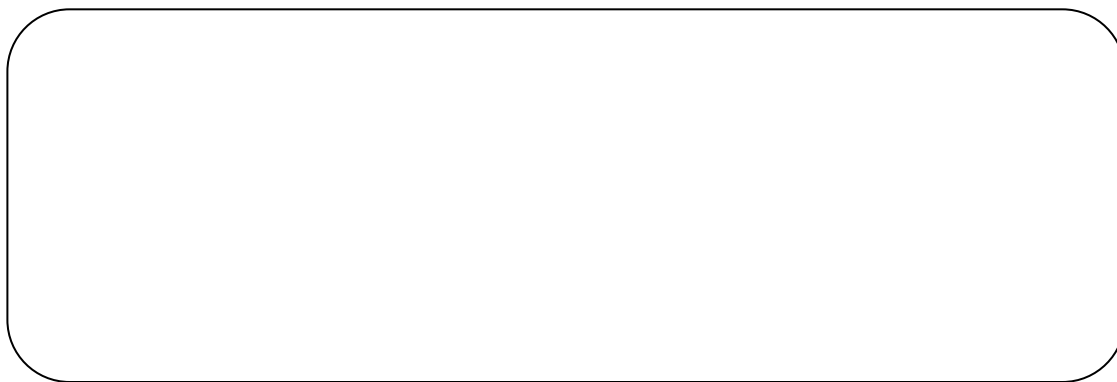
Galaxy Gallery

Vocabulary Check: Look at the words below. Underline the words that you definitely know, and circle the words that you do not know.

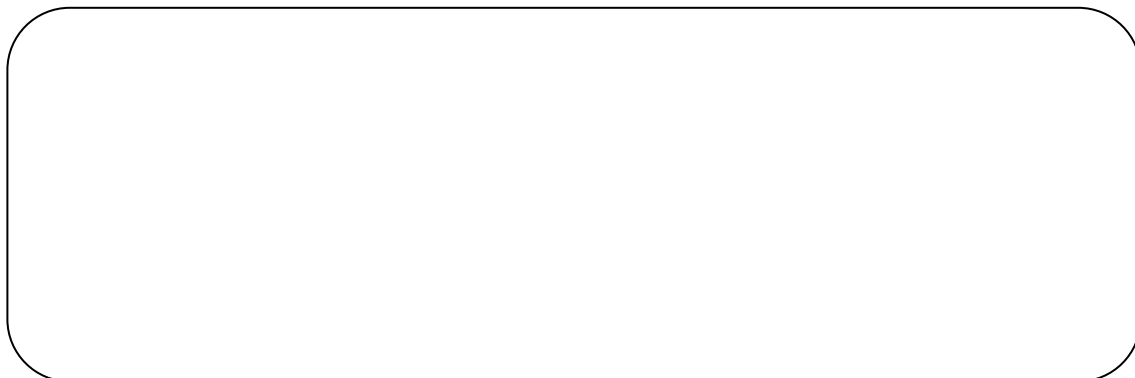
star galaxy Milky Way spiral spectrum light year
astronomical unit cluster luminous radiate planet
asteroid comet gravity orbit rotation clockwise
counterclockwise dark matter force acceleration mass
element

Choose 2 words that you underlined and write down what they mean, then draw a picture that represents each word.

1. _____:



2. _____:



Galaxy Gallery Walk

There are pictures around the room taken of outer space. As you walk around the room, use the sticky notes to mark things that you notice. Part of being a scientist is identifying what you are looking at when you get a piece of evidence or data. You should write down things that are big and small, bright and dark, colorful and dull, things that spin, things that are all by themselves, things that look natural and things that do not look natural.

During your walk, draw a few things that you observe in the pictures that you think are important. If coloring pencils are available, make sure to recreate the same colors.



After you finish looking at all of the photos, answer the questions below:

1. What was one image that was significant to you and why was it significant?

2. What were some of the things you saw in most, if not all, of the pictures?

3. How far away from Earth do you think these photos are showing?

4. What do you think took the pictures and where do you think those cameras are?

Light Diffraction Grating

There are many different ways to create *radiant energy*, or as you probably know it, *light*. Different elements can be burned or heated up to produce light and scientists know that these different elements are producing the light because of a practice call **spectroscopy**. A *spectroscope* is a tool that allows scientists to see the different visible wavelengths of light by spreading the colors out. At first, sunlight does not appear to have a particular color, but that is because a whole rainbow of colors blends together to make white light. A spectroscope can separate those colors using light diffraction so that observers can see what wavelengths of light make up the one color you can see with just your eyes.

Light diffraction grating materials have very fine lines marked into them that help break apart the wavelengths of light, causing the observer to see an array of colors. Each element has a different “barcode” of what colors of light are produced from it. Different stars may have different elements burning in them and will produce different wavelengths, or colors, of light and scientists use spectroscopes to tell what barcode each star or light source has. If they can read the barcode, they can tell what elements are in the star or in any other source of light.

What barcodes do you see?

For this activity you will need: light diffraction glasses and coloring pencils. Look at 5 different light sources and color in the “barcode” that you see for each source. Not all bars have to be filled in.

SOURCE #1

1. Light Source (ex: light bulb, tube of hydrogen gas, car headlight...): _____
2. What colors are brightest? _____
3. Draw your light source in the middle box and color it in with what you see with the glasses off. After you finish that, put your glasses on to see the light spectrum. Color in the bars on both the left and the right of the light source what you see.

10	9	8	7	6	5	4	3	2	1	Light Source	1	2	3	4	5	6	7	8	9	10
----	---	---	---	---	---	---	---	---	---	--------------	---	---	---	---	---	---	---	---	---	----

Light Diffraction Grating Analysis

1. Reflect on the data you just collected. What are your initial thoughts from just looking at all of these?

2. Which two sources look the most similar and how are they similar?

Source #___ is similar to source #___ because I noticed that _____

3. Which two sources look the most different?

Source #___ is different from source #___ because I noticed that _____

4. Why would it be useful to know what a light spectrum look like for a given light source?

5. Besides astronomy, what other professions could use this knowledge of reading light spectrums?

Design a Spectroscope

By now you know that a spectroscope is used to look at a spectrum of light waves that show up in the form of different colors. These different colors represent what light waves are either produced by a light or reflected off of a surface into your eyes instead of being absorbed.

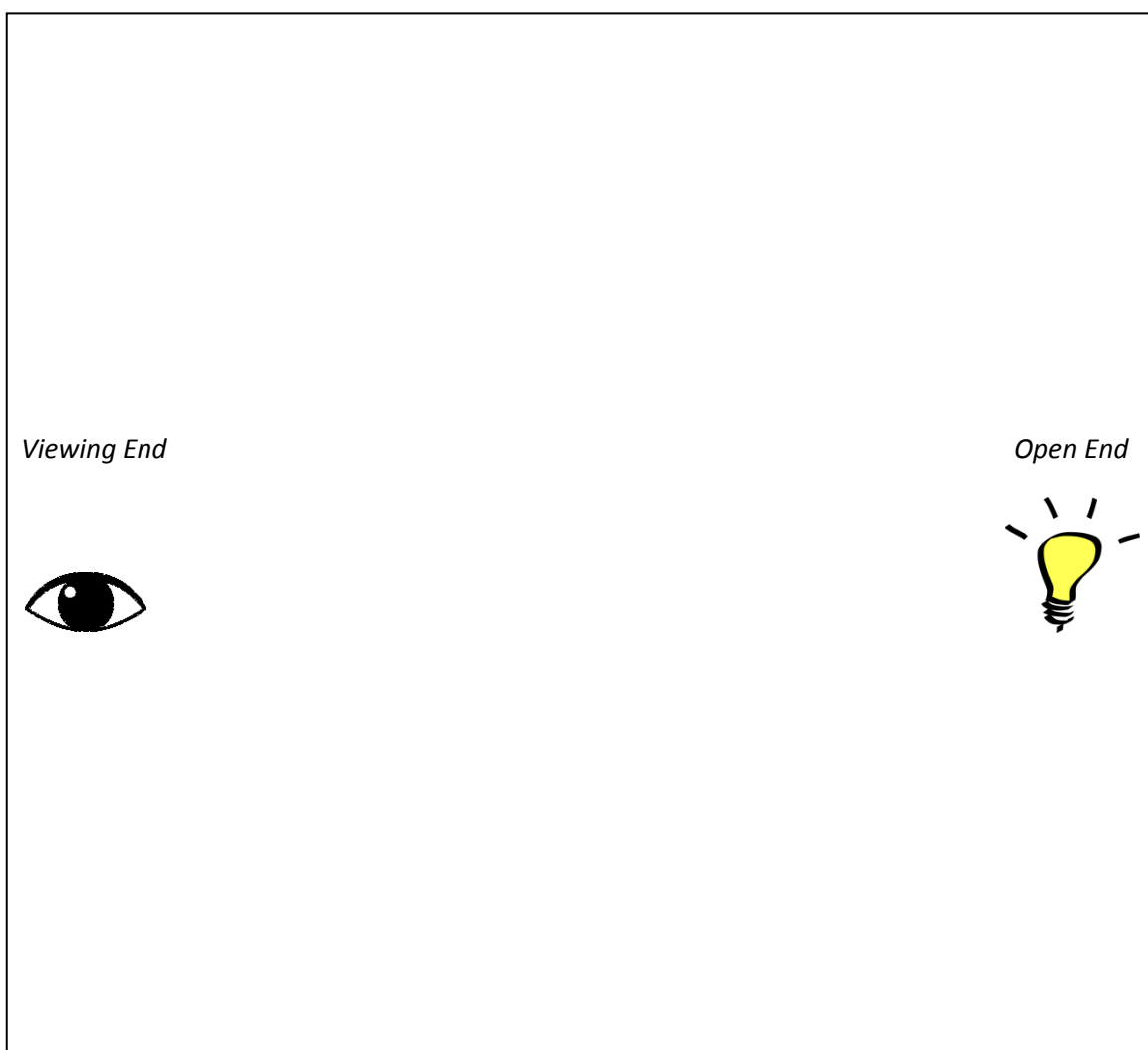
The Problem: We are surrounded by light from many different sources. How do you make sure that the spectrum of light that you are observing is only from a single source?

The Challenge: Create a spectroscope that narrows down a particular set of light wavelengths.

The Materials: You have the following materials to choose from to build a spectroscope.

Tape Cardboard Tube Light Diffraction Viewer Scissors Paper Markers

The Design: Draw out a diagram for a spectroscope using the provided materials. You do not need to use all of the materials if you don't want to. *Label the materials you use.*



S.T.E.A.M. Experiences

Where on the trip did you see examples of the different parts of S.T.E.A.M.?

1. Science- a systematic enterprise that creates, builds, and organizes knowledge in the form of testable explanations and predictions about the universe.

Examples:

2. Technology- machinery and equipment developed from the application of scientific knowledge.

Examples:

3. Engineering- the branch of science and technology concerned with the design, building, and use of machines and structures.

Examples:

4. Art- creative expression to present ideas.

Examples:

5. Mathematics- the science of numbers, quantities, and shapes and the relationships between them.

Examples:

Unanswered Questions

Letter Outline: Use this outline to help you write a letter to your tour guide after your trip.

Dear _____,

First I would like to say:

Something I found interesting was:

Also, something I learned on the trip was:

After the trip, I still had some unanswered questions such as:

1. _____

2. _____

3. _____

Lastly:

Sincerely,

Grade: _____ Date of the Trip: _____

School: _____

English/ Español Glossary

Asteroid: Small rocky body orbiting the sun.

Asteroide: Pequeño cuerpo rocoso orbitando el sol.

Astronomy: The branch of science that deals with celestial objects, space, and the physical universe as a whole.

Astronomía: rama de la ciencia que trata de los objetos celestes, el espacio y el universo físico en su conjunto.

Big Bang: The rapid expansion of matter from a state of extremely high density and temperature that according to current cosmological theories marked the origin of the universe.

Big Bang: La rápida expansión de la materia desde un estado de densidad y temperatura extremadamente altas que, de acuerdo con las teorías cosmológicas actuales, marcó el origen del universo.

Comet: A celestial object consisting of a nucleus of ice and dust and, when near the sun, a “tail” of gas and dust particles pointing away from the sun.

Cometa: Objeto celeste que consiste en un núcleo de hielo y polvo y, cuando está cerca del sol, una "cola" de partículas de gas y polvo apuntando lejos del sol.

Data: Facts and statistics collected together for reference or analysis.

Datos: Hechos y estadísticas recopilados en conjunto para referencia o análisis.

Diagram: A simplified drawing showing the appearance, structure, or workings of something; a schematic representation.

Diagrama: Un dibujo simplificado que muestra la apariencia, estructura o funcionamiento de algo; Una representación esquemática.

Diffraction: The process by which a beam of light or other system of waves is spread out as a result of passing through a narrow aperture or across an edge, typically accompanied by interference between the wave forms produced.

Difracción: El proceso mediante el cual un haz de luz u otro sistema de ondas se extiende como resultado de pasar a través de una abertura estrecha oa través de un borde, típicamente acompañado por interferencia entre las formas de onda producidas.

Engineer: A person who designs, builds, or maintains engines, machines, or public works.

Ingeniero: Persona que diseña, construye o mantiene motores, máquinas o obras públicas.

Galaxy: A system of millions or billions of stars, together with gas and dust, held together by gravitational attraction.

Galaxia: Un sistema de millones o miles de millones de estrellas, junto con el gas y el polvo, unidos por la atracción gravitacional.

N.G.S.S.: Next Generation Science Standards

N.G.S.S. : Estándares Científicos de Próxima Generación

Observatory: A room or building housing an astronomical telescope or other scientific equipment for the study of natural phenomena.

Observatorio: Sala o edificio que alberga un telescopio astronómico u otro equipo científico para el estudio de fenómenos naturales.

Scale: The relative size or extent of something.

Escala: El tamaño o extensión relativa de algo.

Scientist: A person who is studying or has expert knowledge of one or more of the natural or physical sciences. So that means you too!

Científico: Es una persona que está estudiando o tiene conocimientos especializados de una o más de las ciencias naturales o físicas. ¡Eso significa que tú también!

Solar System: The collection of eight planets and their moons in orbit around the sun, together with smaller bodies in the form of asteroids, meteoroids, and comets.

Sistema Solar: La colección de ocho planetas y sus lunas en órbita alrededor del sol, junto con cuerpos más pequeños en forma de asteroides, meteoroides y cometas.

Spectroscopy: The branch of science concerned with the investigation and measurement of spectra produced when matter interacts with or emits electromagnetic radiation.

Espectroscopia: La rama de la ciencia relacionada con la investigación y medición de espectros producidos cuando la materia interactúa o emite radiación electromagnética.

S.T.E.A.M.: Science, technology, engineering, art, and math.

S.T.E.A.M. : Ciencia, tecnología, ingeniería, arte y matemáticas.

Telescope: An optical instrument designed to make distant objects appear nearer, containing an arrangement of lenses, or of curved mirrors and lenses, by which rays of light are collected and focused and the resulting image magnified.

Telescopio: Un instrumento óptico diseñado para hacer que los objetos lejanos aparezcan más cerca, conteniendo una disposición de lentes, o de espejos y lentes curvados, mediante los cuales se recogen y enfocan rayos de luz y se agranda la imagen resultante.

Notes